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James Cloyne,[1] Ryland Thomas,[2] Alex Tuckett[3] and Samuel Wills[4]

Abstract

This paper sets out an empirical framework for examining the dynamics of money and credit at a sectoral level. Our purpose is to understand and monitor the transmission mechanisms of different policies that affect the financial sector, with an eye to practical policy analysis. We use the banking system's balance sheet as an organising framework and model the stocks of broad money and credit held by different sectors. Each sector is modelled as a separate block with money, credit, and sectoral expenditure modelled jointly together with the relevant financial yields. The sectors are then knitted together using aggregate relationships and identities. Overall the model can be thought of as an estimated disaggregated version of the IS-LM-CC model which additionally incorporates the principle that 'loans create deposits'. We illustrate, by example, how this framework can be used in practice: first by examining the sectoral transmission of quantitative easing and second, the effect of disturbances to credit markets. We also discuss how other policy tools, such as the Funding for Lending Scheme and macroprudential policies, could be examined in our framework.

Key words: Monetary policy, quantitative easing, business cycles, money, credit, sectoral modelling.

JEL classification: E40, E51, E52, E58.

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1. Introduction

This paper proposes an empirical framework that can be used to analyse, at a sectoral level, a number of disturbances and policies which are propagated from the banking sector to the real economy.

The financial crisis that began in late 2007 triggered a deep recession, the aftermath of which lasted over half a decade. In response to the unfolding events policy rates were cut dramatically and central banks around the world initiated unconventional policies involving large expansions in central bank balances sheets through the purchase of assets with newly created money. In the case of the United Kingdom, the Bank of England's quantitative easing (QE) programme primarily involved the purchase of government bonds and targeted buying them from the non-bank private sector. Over subsequent years, central banks deployed a range of other unconventional tools such as the Bank of England's Funding for Lending Scheme which offered banks access to cheaper funding provided they increased lending. Furthermore, some central banks began to acquire macroprudential responsibilities with a range of possible instruments.

Policymakers often look at, and monitor, a variety of disaggregated variables in assessing the effect of different policy actions and the state of the economy. And there are very good reasons for doing so: for example most unconventional policy interventions have an important sectoral dimension. QE starts with the purchase of assets from institutions such as insurance companies and pension funds. These assets are purchased with new central bank money; instead of a gilt, the counterparty has a deposit claim on a commercial bank, and matching that deposit liability the bank holds central bank reserves. Agents may start to rebalance their portfolios and, as a result, the effect of the policy intervention feeds through to other sectors. Understanding and monitoring the effects of QE in real-time is therefore aided by an understanding of how it may transmit across sectors.[1] Our main target audience is therefore policymakers and modellers, although we hope the results in the paper will still be of interest to those working in related literatures.

Motivated by these practical demands, our purpose is to set out an empirical framework with a rich enough variety of money, credit, financial and real variables to help us examine both the financial shock that was one of the causes of the recession, and the unconventional policies, such as QE, that were designed to combat it. The type of framework we will employ is used by a number of central banks, including the Bank of England, and methodologically follow a long tradition in the structural empirical literature on money and credit.

We motivate our framework using the consolidated banking sector's balance sheet. This in turn motivates our modelling of the household, corporate, and financial sectors separately as

[1] Studying the relationship between sectoral money, credit and real variables also makes practical sense as these relationships have tended to be clearer at a sector level in the UK. See, for example, Thomas (1997a,b).

a series of vector error correction models. It will also provide a number of identities that, together with the GDP identity and a Phillips Curve, allow us to join up the sectors in the aggregate. The resulting setup means we can study a wide range of monetary, credit and real variables of interest to policymakers while keeping the set-up tractable.

In principle, one might like to estimate all sectors and the aggregate relationships jointly, imposing as few restrictions as possible. This would suggest employing, for example, a pure structural vector autoregression (SVAR) approach. But, given the relatively short span of data available and the large number of variables of interest, this becomes practically challenging. Our framework is closest to an older literature on the relationship between money, credit and real activity at a sectoral level. For example, Thomas (1997a, b) presents models of the household and private non-financial corporate sectors which examine the joint dynamics of money and real variables, such as consumption and investment. Chrystal and Mizen (2005b) study the joint behaviour of money, unsecured credit and consumption for households. Bridges and Thomas (2012), the closest framework to ours, bring together money and real variables across sectors and also employ a consolidated balance sheet approach to deliver aggregate results. Our framework builds in a role for credit and lending at the sectoral level. That said, while the more recent empirical literature has focused on identifying the macroeconomic effects of specific policy interventions, our results clearly relate to these studies. For example, there is a developing literature on the macroeconomic effects of QE using structural VARs (such as Bridges and Thomas (2012) and Kapetanios et al (2012)) and event study methods (see Joyce, Tong and Woods (2011) for a survey of some of the methods used to estimate the impact in the UK). As an example of how to use the framework in this paper, we explore the transmission mechanism of QE and compare our results with this wider literature.

An alternative, more theoretical (possibly estimated) approach would be to construct a general equilibrium model featuring the sectors and variables that tend to be of interest to policymakers in real time. More structural research in recent decades has tended to focus on DSGE models, such as New Keynesian models with a range of nominal and real frictions. In particular, an active area of research has developed on the role of financial and credit frictions. Following general equilibrium setups such as Bernanke, Gertler and Gilchrist (1999), a large number of papers have sought to incorporate 'financial accelerators' and a credit channel for monetary policy. And recently these models have been used to examine the effects of quantitative easing, for example Eggertsson and Woodford (2003), Curdia and Woodford (2011), Gertler and Karadi (2011) and Chen, Curdia and Ferrero (2012). These papers also study a range of financial shocks and several papers estimate the impact of credit shocks as a driver of the business cycle. For example, Villa and Yang (2011) find that the banking sector shock in their model[2] explains about half of the fall of real GDP in the recent crisis and a credit supply shock accounts for most of the weakness in bank lending.

[2] Which is an estimated variant of Gertler and Karadi (2011) for the UK.

While appealing in theory, for practical reasons pursuing a DSGE approach has a number of drawbacks. First, there is a range of financial and credit frictions now employed in the literature and a work-horse model is yet to emerge, although there are a number of candidates that are becoming more and more widespread in use. Second, many of these frictions tend to produce relatively small additional real effects following changes in interest rates. Third, in the standard New Keynesian model, central bank balance sheet operations have no effect due to a Modigliani-Miller [3] style mechanism discussed in Curdia and Woodford (2011). However, even the additional mechanisms in Curdia and Woodford (2011) that create a role for targeted asset purchases still leave no effect from the purchase of government securities, the form of QE implemented in the UK. One would have to include features that allow for market segmentation, preferred habitats, costs of adjusting portfolios or heterogeneity among different agents. These effects have only recently been incorporated into DSGE models; see for example Andrés *et al* (2004) and Harrison (2012). Finally, and perhaps most importantly, incorporating rich sectoral structures that would allow us to explore a wide range of variables and possible transmission mechanisms is technically demanding, especially given the complicated nature of existing models.

Weighing up all these considerations, we employ the encompassing VAR methodology of Hendry and Mizon (1993), which makes a number of simplifying identification assumptions that makes separate sectoral estimation attractive. In this sense the model is part empirical, part theoretical and is based on an older tradition of building structural econometric models (SEMs) which can be thought of as a hybrid of the more theory-free VAR methods and a more structural model-based approach. As such, we gain tractability and richness, which is useful for policy analysis, but will be more subject to Lucas critique issues and will need to make some stronger identifying assumptions than are typical in the SVAR literature. This trade-off has been the subject of much discussion in the modelling community[4] given that the financial crisis has increased the need to incorporate a number of new features into macroeconomic models. Incorporating more micro foundations, especially more forward-looking behaviour in the aggregate model, poses interesting potential questions for future work.

The remainder of this paper is structured as follows. Section 2 outlines the modelling strategy, focusing on the overall approach, the different sectors we consider and how they are brought together into an aggregate model. Section 3 then uses the model to study the effects of QE. Section 4 presents results from using the model to simulate the effects of the 2007/08 credit crisis. Section 5 discusses qualitatively how the model can be used to study the effects of macroprudential policy and some other forms of 'unconventional' policy, including the Funding for Lending Scheme (FLS) and liquidity policy. Section 6 concludes.

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[3] The original Modigliani-Miller theorem - see Modigliani and Miller (1958) – is concerned with corporate finance, and how the mix of debt and equity a company finances itself with does (or does not) affect its overall cost of capital. However their ideas can in principle be used to analyse any institution that faces risk, including banks and governments.

[4] See the discussion by Simon Wren-Lewis at http://mainlymacro.blogspot.co.uk/2014/07/methodological-seduction.html and http://mainlymacro.blogspot.co.uk/2012/09/what-type-of-model-should-central-banks.html .

2. Modelling money, credit and real activity

2.1 A consolidated balance sheet approach

Our modelling approach involves constructing separate empirical models for different sectors of the UK economy and linking these together using some aggregate assumptions and identities. To organise and motivate our framework, we consider the consolidated aggregate balance sheet of UK-resident banks. Specifically our banking system includes all UK-resident banks and building societies (known collectively as monetary financial institutions or MFIs) including the branches and subsidiaries of overseas banks operating in the UK as well as the Bank of England. We consolidate it by netting out claims between all UK-resident MFIs, so all interbank loans and deposits are netted out on the balance sheet. Furthermore, as the central bank balance sheet is consolidated with that of the commercial banking system, central bank reserves (deposits of the commercial banks with the central bank) do not appear on the asset side of the balance sheet. Instead holdings of government debt by both the Bank of England and the commercial banking system appear, as well as notes and coin held by the UK non-bank private sector on the liability side.[5] But note that loans and deposits to and from non-UK resident banks are not netted out even if they are part of the same banking group.

The assets and liabilities of the banking system are then split up by sector and asset type. Specifically, we model sectoral credit and banks' gilt holdings on the asset side of the balance sheet and sectoral money and non-deposit liabilities on the liability side. This setup is illustrated in Figure 2.1 and is analogous to modelling the broad money[6] counterparts that feature widely in many central banks' analysis of the money supply. First, we estimate separate sectoral vector error correction models for money, credit and real activity in the household, private non-financial corporation (PNFCs) sectors. These variables are shown in red and blue in Figure 2.1. Estimation of these sectors is in the spirit of previous research which has used estimated sectoral structural VECMs to examine the linkages between money and credit on the one hand and asset prices and spending on the other.[7] Relative to this wider literature, our goal - as in Bridges and Thomas (2012) - is to embed these estimated systems into a wider macroeconomic model to examine the sectoral and aggregate effects of macroeconomic policy changes. In addition to estimated systems for households and PNFCs, we will also estimate a sectoral VECM for the banking sector and non-intermediate other financial corporations (NIOFCs). NIOFCs collectively contain non-bank financial companies such as asset managers and institutional investors including insurance companies and pension funds. These institutions will be important in our analysis of the impact of QE in section 3. The banking and NIOFC sectors provide dynamic equations describing the money demand of

[5] But we discuss the unconsolidated balance sheets of the central bank and the commercial banking system in section 3 when we look at the impact of QE.

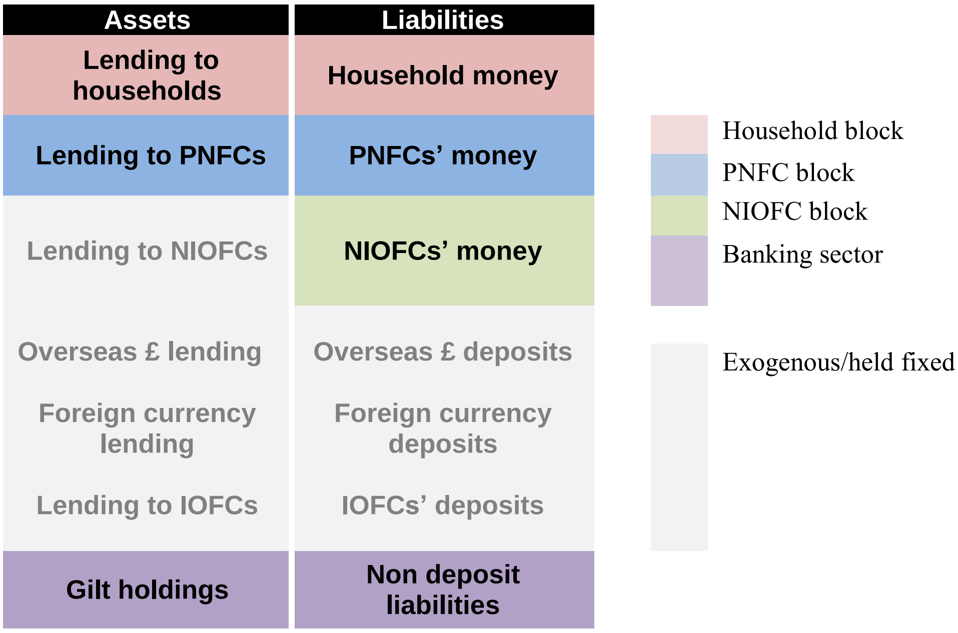
[6] Broad money here consists of notes and coin held by the UK-non bank private sector, plus sight and time deposits, sale and repurchase agreements and bank-issued securities of up to and including five years original maturity.

[7] See, for example, Thomas (1997a,b), Brigden and Mizen (2004), Chrystal and Mizen (2005a,b), Bridges and Thomas (2012).

NIOFCs and the evolution of banks' holdings of gilts and their net non-deposit liabilities (shown in the green and purple bars in Figure 2.1).

Having estimated these sectoral systems, we use the consolidated banking system's balance sheet identity to determine NIOFCs' holdings of money as a residual. Essentially in our model loans and other transactions by the banking system (including QE) lead to the creation of deposits (as discussed in more detail in Benes and Kumhof (2012) and Mcleay, Radia and Thomas (2014)).[8] Our estimated equations for household and PNFC deposits pin down how much of the money created flows to these sectors. What remains must be held by NIOFCs and asset prices and yields in the economy must adjust to make that happen, as we discuss below. This is the key link in our model between money and credit quantities on the one hand and financial yields and asset prices on the other. We assume that other elements on the banking system's balance sheet are fixed and not affected in our simulations. These elements comprise lending to NIOFCs, the lending and deposits of IOFCs,[9] foreign currency lending and deposits and overseas residents' sterling borrowing and deposits. So at the moment we are only modelling the components of the domestic-facing part of the UK banking system. In future work we intend to model the additional elements on the banking system's balance sheet.

Figure 2.1: **A stylised consolidated banking sector balance sheet**



As well as including an appropriate rate (or rates) of return, each 'real economy' block

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[8] Our measure of loans includes any household or corporate debt that is subsequently securitised. As a result of this the non-deposit liabilities on the consolidated balance sheet will include the mortgage backed securities issued on the back of those securitisations.

[9] In addition to NIOFCs there are also a collection of institutions known as intermediate OFCs or IOFCs which represent institutions that are offshoots of the banking system (such as bank holding companies) or that intermediate between banks (such as central clearing counterparties like London Clearing House).

includes at least one spread variable, the difference between lending or deposit rates over the risk free rate. These are treated as exogenous to each block. We use changes in these spread variables as proxies for credit shocks, as described in section 4.

Overall our overall model can be thought of as an estimated disaggregated version of the IS-LM-CC model of Brunner and Meltzer (1978) and Bernanke and Blinder (1988). We model money, credit and spending by sector as a function of interest rates and a variety of spreads. And money, bank loans and other assets (bonds and equities) are the three groups of assets which are modelled as imperfect substitutes.

2.2 The empirical sectoral modelling methodology

The different sectors of the economy are modelled *separately* as vector error correction models. While in principle we could estimate a conventional VAR, our tests suggest that co-integrating relationships exist between our variables; in the presence of co-integration the most appropriate representation of the data is then a cointegrated VAR or CVAR which is also known as a vector equilibrium correction mechanism or VECM. This methodology allows us to explicitly examine long run relationships versus short-term dynamics. As noted in Thomas (1997), the modelling of sectoral money naturally fits into this framework. Money may be held for short-term reasons – such as temporarily accepting higher money balances as a buffer stock – and so the level of money holdings may differ from that desired in equilibrium.

For each of the sectors we will consider the joint behaviour of money, credit and real activity as a function of prices and other aggregate variables, estimated using quarterly data from 1977 to 2013. Appendix A gives more detail on the data we use. Our systems will contain a number of variables relevant for the monetary transmission mechanism. However, the system rapidly becomes cumbersome without some further assumptions. Following Thomas (1997a,b) and Chrystal and Mizen (2005a, 2005b) we employ the encompassing VAR approach of Hendry and Mizon (1993), where the emphasis is on making simplifying exogeneity and identification assumptions that make estimation more tractable. A more recent presentation of this methodology can be found in Garratt et al. (2006). Specifically we start from the following unrestricted VAR:

$$\boldsymbol{B}(L)z_t = \boldsymbol{\varepsilon}_t \tag{1}$$

where $\boldsymbol{B}(L)$ is a lag polynomial of order p, $\boldsymbol{z}$ is a vector containing all the variables on interest and $\boldsymbol{\varepsilon}$ are the serially uncorrelated reduced form errors. This forms the basis for the Johansen (1992) maximum likelihood approach to cointegration, which we employ. Equation (1) can be rewritten in vector error correction form as follows.

$$\Delta\boldsymbol{z}_t = \alpha\beta' z_{\mathrm{t}-1} + \boldsymbol{C}(L)\Delta z_{\mathrm{t}-1} + \varepsilon_t \tag{2}$$

where the Johansen (1992) procedure can be used to estimate the number of cointegrating vectors and the long run matrix $\Pi = \alpha\beta'$. The matrix of cointegrating vectors is then $\beta' z_t$ and these are interpretable as the deviation of variables from their long-run equilibrium levels.

The rank of the Π matrix is used to determine the number of cointegrating vectors. A reformulation of the above system can then be estimated under the assumption of a particular number of cointegrating vectors.

If, as in our case, a large number of variables is being considered it is common in the literature to try and partition the z_t matrix into a set of endogenous variables and a set of variables assumed to be weakly exogenous. We therefore partition the reduced form in each sector in the following way:

$$\Delta y_t = \alpha\beta' z_{t-1} + \Gamma_1(L)\Delta y_{t-1} + \Psi_1(L)\Delta x_t + \xi_t \qquad (3)$$

Where *y* are the endogenous variables and *x* are the variables that are assumed to be weakly exogenous. These conditioning variables are described by the following system:

$$\Delta x_t = \Gamma_2(L)\Delta y_{t-1} + \Psi_2(L)\Delta x_{t-1} + u_t \qquad (4)$$

The computational advantage of this partitioning is that the maximum likelihood estimates of β and Ψ_1 are independent of whether we estimate equation (3) or whether we estimate (3) and (4) jointly. The disadvantage is that we need to make some implicit assumptions to justify this split: the x_t variables need to be contemporaneously exogenous in equation (3) (ie the x_t are uncorrelated with ξ_t); and the exogenous variables should not affected by the error-correction terms as implied by equation 4. These restrictions can be tested as discussed in Urbain (1995). In our framework we make the prior choice of the x_t variables based on the assumption that certain aggregate variables are likely to be treated as given by a particular sector. Having estimated the cointegrating vectors, OLS can then be used to estimate the dynamics from the VECM (3).

This procedure alone still does not fully identify the structural form. For example, there could be contemporaneous correlation among the endogenous variables. We therefore need some further identifying assumptions. Let matrix $\boldsymbol{A}$ contain the coefficients governing the contemporaneous relationships. Multiplying equation (3) by $\boldsymbol{A}$ produces the structural VECM representation (5).

$$\boldsymbol{A}\Delta y_t = \boldsymbol{A}\alpha\beta' z_{t-1} + \boldsymbol{A}\Gamma_1(L)\Delta y_{t-1} + \boldsymbol{A}\Psi_1(L)\Delta x_t + \boldsymbol{A}\xi_t \qquad (5)$$

This implies a relationship between the structural and reduced form residuals $\epsilon_t = \boldsymbol{A}\,\xi_t$. We then provide the required restrictions on the variance-covariance matrix of ξ_t by restricting how the long-run relationships enter the dynamics (restrictions on the matrix $\boldsymbol{A}\alpha$) and by directly imposing restrictions on the contemporaneous relationships – setting elements of $\boldsymbol{A}$ to zero. The structural VECM is then estimated with Full Information Maximum Likelihood (FIML) methods. For more on this approach to identification in the context of cointegration see Thomas (1997a).

Finally, it is worth noting that the exogeneity treatment of the x_t variables discussed above is mainly of importance for the identification and the estimation of the econometric model in each sector. But, our overall framework proceeds by estimating separate sectoral blocks and then joining them together by specifying aggregation relationships and accounting identifies. In the simulation examples considered later, we will therefore allow feedback from aggregate variables to the x_t variables in each sector. The x_t variables should not, therefore, be considered to be completely invariant to the dynamics of the economy. In this sense they are treated as weakly exogenous for the estimation of each block but not strongly exogenous in the context of the system as a whole.

2.3 The household sector

Ideally we would like our household sector to include secured and unsecured credit, money holdings, household consumption, dwellings investment, household wealth (both housing and financial) and a range of aggregate variables together with the lending and deposit rates facing households. This system is potentially large so, following Chrystal and Mizen (2005b), we first consider a sub-block for unsecured credit, money and consumption. We then consider a second block for secured credit, dwellings investment and housing wealth. To our knowledge, and despite its prominence as a source of funding for households, we are the first to include secured lending in such an approach.

Households: a model of unsecured credit

Our unsecured household system is very similar to that of Chrystal and Mizen (2005b). Using a number of lag lengths, our tests suggested a wide range of estimates for the number of cointegrating vectors. This uncertainty is not unusual in the literature. In theory we would like to identify a money demand function, a consumption function and a lending relationship. Without a clear steer from the rank tests, we follow Chrystal and Mizen (2005b) in imposing three vectors and allow money *(m4h)*, consumption *(hc)* and unsecured lending $(m4l^u)$ to be endogenous variables. The system is then conditioned on a lag polynomial of real household income (y), Bank Rate (i), real housing wealth and real other financial wealth (w), aggregate consumer price inflation (π), a credit conditions index (derived by Fernandez-Corugedo and Muellbauer (2006)) (*CCI*) which picks up the stochastic trend in credit, and three credit spreads for mortgage lending, unsecured lending and deposits (s_m, s_u and s_d). This implicitly assumes, as discussed earlier, that the movements in spreads are not affected by sectoral endogenous variables within the quarter. Later, when we join the model up in the aggregate, we will assume that spreads are determined by banks with reference to underlying reference rates.[10]

Mortgage interest rates are a weighted average of 2 year fixed rate interest rates at 75% and 90% loan to value ratios and the rates charged on Bank Rate Tracker products. Including the two year products allows us to capture longer maturity products. Unsecured interest rates are

[10] We are implicitly assuming that money, consumption and lending do not affect these conditioning variables within the same quarter. This is consistent with a view that lending rates are sticky.

a weighted average of personal loan, credit card and overdraft interest rates. These data are quoted rates data collected by the Bank of England. However, due to data limitations, the deposit rate series is the effective household deposit rate. Our credit spread series are then mortgage rates, deposit rates and unsecured rates relative to Bank Rate.

To identify the cointegrating vectors β, we need to impose at least r^2restrictions, where r is the number of endogenous variables. The implied over-identifying restrictions are tested using a χ^2 likelihood-ratio test and are not rejected (at the 10% level). The resulting estimated cointegrating vectors are as follows:

$$hc_t = \underset{(-)}{0.030 m4h_t} + \underset{(0.189)}{0.023 m4l_t^u} + \underset{(0.065)}{0.54 y_t} - \underset{(0.002)}{0.0076 i_t} - \underset{(0.004)}{0.004 s_t^m} - \underset{(0.001)}{0.006 s_t^u} + \underset{(0.026)}{0.18 w_t}$$

$$m4h_t = \underset{(0.609)}{0.50 hc_t} - \underset{(-)}{0.027 \pi_t} + \underset{(0.028)}{0.064 s_t^d} - \underset{(0.012)}{0.022 s_t^u} + \underset{(0.286)}{0.21 w_t}$$

$$m4l_t^u = \underset{(0.344)}{1.66 y_t} + \underset{(0.017)}{0.11 s_t^d} - \underset{(0.007)}{0.069 s_t^u} + \underset{(0.179)}{0.054 w_t} + \underset{(0.553)}{2.27 CCI_t}$$

The relationships imply a long-run consumption-to-labour income elasticity of around 0.5 and that increases in Bank Rate and lending spreads lower long-run consumption. Consumption, money and unsecured lending are all positively related to wealth (w, which is defined as net total wealth excluding money holdings). The annual propensity to consume out of wealth is around 0.03 which is close to an estimate of the real interest rate in steady state and is if anything a touch lower than micro estimates for the UK. Money holdings also increase with higher deposit rate spreads as one would expect.

Having estimated these long-run relationships, we then estimate the dynamics in equation (3) by OLS. As discussed earlier in order to identify the structural matrix $\boldsymbol{A}$ we need to make structural restrictions on how the error-correction terms enter each equation and how the variables are contemporaneously related. We assume that in the structural form (see equation 5 earlier) the disequilibrium term in consumption does not feedback directly onto money but works indirectly through a contemporaneous effect of consumption on unsecured lending and money holdings. Similarly the money and lending disequilibria do not feedback directly on to consumption in the structural form of the model but work indirectly through a contemporaneous effect of money and unsecured lending on consumption. The restrictions we place on the contemporaneous impact matrix $\boldsymbol{A}$ both directly and indirectly, via the structural loading matrix $\boldsymbol{A}\alpha$, are sufficient to identify the structural form of the model.

Additional simplifying and structural restrictions are then placed on the equations and tested. For example in the dynamics we also allow the separate components of net total wealth to enter the equations. This means that gross housing wealth and other financial wealth can have different wealth effects on the dynamics of consumption, unsecured credit and money. We also allow secured lending to enter the dynamics for consumption, in addition to money and unsecured lending, creating a role for liquidity, debt and collateral channel effects on household spending. The final model is estimated by Full Information Maximum Likelihood (FIML). The full estimated dynamic system is available from the authors on request.

Households: a model of secured credit

For a range of lags, the Johansen procedure finds between 2 and 7 cointegrating vectors for the secured system which is problematic for pinning down the number of long-run relationships in the data. Again, from theory we would like to identify long-run dwellings investment, house price and lending relationships. We therefore impose three vectors and choose secured credit *($m4l^s$)* (real household secured lending), dwellings investment (*idkp*) and gross housing wealth *(ghw)* as the endogenous variables. The conditioning variables are real household income (y), the composite mortgage interest rate (r^m), the associated mortgage spread (s^m) (relative to Bank rate) and the same credit conditions index as above.

Once again, we impose some restrictions on the long run relationships to identify the β vector for the secured lending system. The resulting long run relationships are as follows where, again, the over identifying restrictions were not rejected by a χ^2 likelihood-ratio test at the 10% significance level.

$$ghw_t = 0.8y_t - 0.13r_t^m$$

(-) (0.021)

$$idkp_t = -0.013ghw_t - 0.017s_t^m$$

(0.031) (0.011)

$$m4l_t^s = h_t + 0.68ghw_t - 0.011r_t^m + 3.85CCI_t$$

(-) (.09) (0.011) (0.552)

Real gross housing wealth (ghw) depends positively on income but negatively on mortgage rates. Dwellings investment (h) depends negatively on gross housing wealth and mortgage spreads. Secured lending ($m4l^s$) depends positively on dwellings investment and negatively on mortgage rates. Once again, the credit conditions index captures a stochastic trend in secured lending.

To estimate a structural form for the dynamic system, we assume a diagonal structure for how the disequilibria feed into the dynamics – each disequilibria affects only the dynamic equation for that variable. We assume a recursive structure for the contemporaneous relationships, with dwellings investment affecting mortgage lending contemporaneously and mortgage lending affecting house prices contemporaneously.

2.4 Private non-financial corporations

The PNFC system uses a three equation setup based on Brigden and Mizen (2004). For the PNFC sector we again detect a wide range of estimates for the number of cointegrating vectors depending on the lag structure, but following Brigden and Mizen (2004) we impose a rank of three and choose real PNFC money holdings ($m4p$), real private investment (inv), and real lending to PNFCs ($m4lp$) as the endogenous variables. We then condition the system on a lag polynominal of real GDP, the effective rate paid on firm deposits (rdp), the effective rate charged on firm lending (rlp), the price of commercial property (pcp), the cost of capital (rcc), the degree of utilisation ($util$) and the rate on corporate bonds (rcb). The estimated cointegrating vectors are as follows:

$$m4p \;=\; gdp \;+\; \underset{(0.059)}{0.23}\,(rdp \;-\; rlp) \;+\; \underset{(0.604)}{1.0632}\,(pcp)$$

$$inv \;=\; gdp \;-\; 0.5\,rcc \;+\; \underset{(0.13572)}{0.45269}\,util$$

$$m4lp \;=\; \underset{(0.139)}{2.287}\;gdp \;+\; \underset{(0.052)}{0.20737}\;rdp \;-\; \underset{(0.053)}{0.18951}\;rlp \;+\; \underset{(0.012053)}{0.058219}\;rcb$$

Money holdings are positively related to the spread between deposit and lending rates and the level of commercial property prices (which create wealth and collateral effects). Investment is related to GDP, negatively to the real cost of capital (with an implied elasticity of substitution between capital and labour of 0.5) and positively to utilisation. Lending to PNFCs depends positively on GDP and negatively on the lending rate. The positive effect of corporate bond yields on lending allows for a capital market substitution effect on borrowing which will be important in discussing the impact of QE in section 3.

Conditional on these vectors, we then estimate the dynamics. Again the full details of the estimated system are available on request. To identify the structural form we exclude the investment error correction term from the money equation, the money and lending error correction terms from the investment equation and the investment and lending error correction terms from the lending equation. This implies restricting the contemporaneous interactions such that money and lending can affect investment contemporaneously and investment also affects lending within the same period.

2.5 The banking sector

Bank loan and deposit rate setting

One key set of inputs into the household and PNFC sectoral systems are the loan and deposit rates and spreads. For most simulations, we assume that banks are price setters in the loan and deposit markets. In order to calibrate how banks price loans and deposits we follow a loan price framework set out in Button et al (2010). Lending and deposit rates are related to the relevant underlying funding costs. In principle, this is the sum of, for example, a swap rate (for fixed term products) or Libor (for variable rate products) and a further credit risk component such as senior unsecured funding spreads or Credit Default Swap premia. Due to data limitations associated with the latter two series, we estimate pass-through equations from Bank Rate (for variable rate products) and the 2 year Libor swap rate (for fixed products). Harimohan et al (forthcoming) investigates loan pricing empirically from a bank-by-bank point of view.

However, this leaves open the issue of how the shock or policy we are simulating affects the bank funding costs. For example, by reducing term and other risk premia at a time when banks had shifted their preference towards issuing longer-duration liabilities, QE may have reduced bank funding costs. As our model of the banking sector is simple, careful consideration needs to be given to how each shock may affect bank funding costs. Sections 4 and 5 discuss these issues in more detail.

Our composite mortgage rate comprises of a variable rate product and 2 year fixed rate products. So we first estimate the long run relationship between the mortgage rate and both Bank Rate and the 2 year swap rate, imposing full pass through overall (the coefficients on Bank Rate and swap rates are restricted to add up to 1). We assume that unsecured lending rates are priced off Bank Rate, with full pass through in the long-run (although we have confirmed this by estimating the cointegrating vector). The deposit rate series is based on effective rates data. We therefore estimate the cointegrating vector since pass through may not be complete in the long-run depending on the share of products that earn little or no interest. We then estimate the dynamic relationship between deposit rates and Bank Rate.

We also estimate a pass-through equation for the PNFC loan rate, assuming that it is related to Bank Rate and the corporate bond spread (relative to gilt yields). For simplicity, and due to a lack of good data, we tie the PNFC and NIOFC deposit rates mechanically to Bank Rate.

In the simulations in section 4 we also introduce additional shock terms into this block of the model (treated as exogenous) that allow us to increase spreads exogenously for a given level of Bank Rate.

Banks' asset and liability management

We also need a description of how banks' non-deposit liabilities (capital and long-term debt) and government debt holdings evolve (the purple cells in Figure 2.1). In keeping with the previous sectors, we estimate a VAR for the banking sector. To motivate this, we assume that banks are price takers in asset and gilt markets, at least in the short run. So the identifying assumption is that banks are price takers within the same quarter. Elsewhere, where we specify other relationships between conditioning variables in the systems, we will allow feedbacks from quantities to prices (specifically, for example, gilt yields will be driven by the money holdings of the NIOFC sector which are themselves indirectly affected by bank's lending decisions).

The banks' non-deposit liabilities (capital and long-term debt) (*nndls*) and government debt holdings (*bgilts*) are therefore modelled as two endogenous variables and the system is then conditioned on 5 year gilt yields (*r5*), and NIOFCs' deposit rate (*rdi*). The VECM is estimated with gilts and (net) non-deposit liabilities expressed as a ratio of sterling liabilities (*sterliabs*), as shown in the appendix. In other words, the endogenous and exogenous variables y and x are:

$$y_{B,t} = [nndls, bgilts]'$$

$$x_{B,t} = [r5, rdi, sterliabs]'$$

Our estimates suggest that a fall in gilt yields or a higher NIOFC deposit rate lowers banks' gilt holdings.[11] In addition, higher asset prices and lower bond yields may lead banks to favour equity issuance over deposit funding which will act to reduce the money stock. These mechanisms will be important in assessing the impact of QE in section 3.

2.6 Non-bank financial corporations

The NIOFC sector is modelled as a four variable VECM which includes NIOFC real money holdings (*m4i - p*), real asset values (*wi - p*), a weighted average of the estimated rates of return on NIOFC assets (*rg*)[12] and the interest rate on NIOFC deposits (*rdi*). We take this estimated system from Bridges and Thomas (2012) who use data on insurance company and pension funds to proxy the NIOFC sector data given a lack of adequate time series on NIOFC money holdings and assets. Bridges and Thomas (2012) find that NIOFCs' money holding can be treated as weakly exogenous to the system. They therefore treat real total sterling asset values and their real rate of return as endogenous and condition the system on real money holdings and the (banking sector determined) NIOFC deposit rate. That implies equilibrium in asset markets is determined by letting the price of financial assets adjust so that NIOFC money demand is line with the stock of NIOFC money holdings at any one time. In the third part of the paper, which discusses the impact of QE, we consider two versions of the model, one using the full dynamic system – where asset prices adjust slowly to any gap between NIOFC money holdings and their long run demand for money – and one where we consider only static relationships to simulate the case where asset prices adjust immediately to a change in NIOFC money holdings.

In the static case real asset values are determined by inverting the long-run money demand equation:

$$wi - p = m4i - p - \underset{(0.042)}{0.104} * (rdi - rg)$$

where the component yields of *rg* are also related (negatively) to *wi* according to standard asset pricing relationships between the prices and yields of the relevant assets.

[11] The lack of data on expectations of future deposit rates means that we cannot be sure the dynamic coefficients on *r5* relative to *rdi* in the VECM reflect banks' willingness to hold fewer gilts because term premia relative to deposit spreads are fundamentally lower or because banks are just responding to headline yield differentials that simply reflect the slope of the term structure.

[12] We use the dividend yield of the FTSE all-share index plus trend nominal GDP growth for the return on equities, and 10 year zero coupon government bond yields as the return on bonds.

In the dynamic case real asset values and yields jointly respond to the gap between the actual money holdings of NIOFCs and their long run demand for money so that (and ignoring nuisance terms such as constants):[13]

$$\Delta(wi-p)_t = \underset{(0.030)}{0.067}\,\Delta(m4i-p)_t + \underset{(-)}{0.067}\,\Delta(m4i-p)_{t-1} + \underset{(0.0295)}{0.088}\,ecmm4i_{t-1}$$

$$\Delta rg_t = -\underset{(0.235)}{0.23}\,\Delta(m4i-p)_t - \underset{(0.146)}{0.389}\;\; ecmm4i_{t-1}$$

$$ecmm4i_t = \ (m4i-p)_t - \ (wi-p)_t - 0.104 * (rdi-rg)_t$$

As described earlier, although NIOFC deposits are treated as weakly exogenous to the sector for estimation, we pin down the stock of NIOFC deposits *in the system as a whole* by residual, having already determined the other components of the banking sector's consolidated balance sheet. So the stock of NIOFC money holdings (*m4i*) is determined as the residual of the log-linearized consolidated banking sector's balance sheet identity:

$$\omega_i m4i = \theta_h m4lh + \theta_p m4lp + \theta_i m4li + \theta_q qe + \theta_b bgilts$$

$$-\omega_h m4h - \omega_p m4p - \omega_n nndls - \omega_h nosd$$

In other words NIOFC money holdings (*m4i*) are determined by the sum of household, firm and NIOFC lending (*m4lh, m4lp, m4li*), the central bank's holdings of government debt (*qe*) and private banks holdings of government debt (*bgilts*), less household and firm money holdings (*m4h, m4p*), non-deposit liabilities (*nndls*) and net overseas deposits (*nosd*). As discussed earlier, we hold net overseas deposits fixed in our simulations. This equation implies that an exogenous increase in central bank gilt holdings (*qe*) will initially lead to an increase in NIOFCs' money holdings forcing asset prices to adjust to ensure those holdings are in line with money demand via either the static or dynamic asset pricing equations.

2.7 The aggregate model: linking the sectors

A number of conditioning variables across the sectors have already been linked together. For example, the interest rates charged and paid to households and PNFCs have been linked to the pricing behaviour of the banking sector.

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[13] Please note a correction here from earlier drafts of this paper where the reported equation for *rg* had been written as $\Delta rg_t = -0.0023\,\Delta(m4i-p)_t - 0.00389\;\; ecmm4i_{t-1}$ based on an initial scaling of *rg* that was subsequently changed for later drafts of the paper.

However, some of the remaining aggregate variables still need to be defined, notably GDP, inflation and Bank Rate. Our aggregate system closely follows Bridges and Thomas (2012). Our model is primarily one of expenditure, so the relevant identity for GDP is the National Accounting expenditure identity (or its log-linearised version):

$$gdp = \gamma_c hc + \gamma_d idkp + \gamma_i inv + \gamma_g g + \gamma_x nx$$

That is, GDP is the sum of consumption (*hc*), housing investment (*idkp*), business investment (*inv*), government (*g*) and net exports (*nx*). We assume that exports do not move in response to the simulations we consider and link imports to the components of GDP.[14] This implies the current account itself (*nx*) moves with GDP. To fully tie this up with the balance sheet approach, we should link overseas deposits to the current account as well, although in this version of the model we hold them fixed in the simulations.

To capture price dynamics we assume that quarterly inflation follows a simple Phillips Curve relationship, which is estimated on a HP filter-based measure of the output gap as follows:

$$\hat{\pi}_t = \underset{(0.12)}{0.25}\hat{\pi}_{t-1} + \underset{(0.03)}{0.1}\hat{y}_{t-1}$$

where $\hat{y}_{t-1}$ is the output gap and $\hat{\pi}_t$ the deviation of inflation from target. These two equations make the aggregate structure of the model (an assumption that planned expenditure equals aggregate demand combined with a traditional neoclassical synthesis Phillips Curve) closer to a Keynesian model than a modern DSGE model. While some forward-looking behaviour will be captured in the estimated coefficients of the sectoral VECMs, the aggregate block currently does not include forward looking terms.

Although a statistically filtered-estimate of the output gap is used in estimation we attempt to allow for a feedback of investment on to the output gap by introducing a simple potential output relationship. This has the spirit of Woodford (2003) where we use a concept of potential output which takes the current state as given. This implies that potential output – which we label *gdpstar* – and the dynamics of inflation are linked to the inherited capital stock from the previous period. Specifically, we then use a log-linearised production function relationship and define:

$$gdpstar_t = 0.2k_{t-1} + 0.8lstar_t$$

$$k_t = (1 - 0.02)k_{t-1} + 0.02inv_t$$

where the coefficients reflect the labour share of income and the depreciation rate of capital.[15]

[14] This is done using weights from the ONS' Input-Output tables – see http://www.ons.gov.uk/ons/rel/input-output/input-output-analytical-tables/index.html.
[15] Our coefficient for depreciation is consistent with an annual rate of 8%. See Wallis (2009) and Fraumeni (1997).

As we show in the next section, this will provide a crude way of ensuring the impact on inflation from a rise in activity is not overstated by assuming no effect on the capital stock from higher investment. But care must be taken in interpreting any persistent change in the measure of potential supply relevant for inflation over the horizon of our simulations as a steady state result. In particular we make no allowance for the fact that steady-state labour input (*lstar*) might also respond to QE. This is treated is exogenous in our system. And we do not attempt to model how shocks to the financial system could affect the allocation of resources within the economy. More generally the idea that QE is non-neutral in steady state is clearly contentious, especially given the irrelevance result of Curdia and Woodford (2011) discussed in the introduction. As we discuss below a steady-state impact on potential supply could only emerge if there is a permanent effect of QE on the cost of capital. That in turn implies the shift in the ratio of money to other assets induced by QE persists forever in our portfolio balance framework. In reality of course that will depend on future QE operations and other monetary policy, fiscal policy and debt management decisions.

3. Understanding the impact of Quantitative Easing

We now use the model described in the previous section to study the effects of QE in the UK at a sectoral and aggregate level. Between March 2009 and November 2012 the Monetary Policy Committee purchased £375bn of government bonds in three phases. The aim of the policy was to increase the money holdings of the non-bank private sector (specifically pension funds and asset managers) that would induce a rebalancing of portfolios, and so lead to an increase in the prices of government bonds and other close substitutes and a fall in their yields. In turn, the implied rise in the value of portfolios and the lower cost of external finance should lead to a boost in consumption and investment spending in the economy. In addition to this portfolio rebalancing channel, a number other possible channels of transmission were also suggested (see Joyce, Tong and Woods (2011) for a survey).

3.1 Relationship to previous research

Our model is well suited to investigate the portfolio rebalancing effects of quantitative easing (QE). Like the earlier work by Bridges and Thomas (2012) the money holdings of NIOFCs are explicitly modelled and the portfolio re-balancing implications for yields and asset prices can be explored. And like Bridges and Thomas (2012) and Cobham and Kang (2012) we can examine the implications of the increase in money holdings and asset prices that result from QE for nominal spending in the economy. A sectoral approach also allows us to trace through how the money created by QE flows through to households and non-financial companies which is important in monitoring the effectiveness of QE over time. But our model also contains a number of useful features that allow us to study some additional mechanisms.

First, as we noted in section 2, there are a variety of ‘leakages’ in the banking and PNFC sectors that offset the injection of money from QE. In particular, we model the portfolio re-balancing by banks and non-financial companies explicitly. Bridges and Thomas (2012) and

Cobham and Kang (2012) used counterfactual evidence from the money counterparts and flow of funds to try and estimate the impact of QE on the money supply over the course of the first £200bn of purchases made by the MPC. Both concluded that because of various 'leakages' the impact of QE on broad money was significantly less than £200bn. And those leakages reflected portfolio re-balancing by both banks and private non-financial companies. We build on both these studies. Rather than treating them as an exogenous offsetting impact on the money supply, we can 'endogenise' the QE leakages and examine their implications on the economy more explicitly.

Second, our model explicitly includes lending, unlike Bridges and Thomas (2012). This allows us to explore the role of lending in the transmission of QE, building on the recent work of Joyce and Spaltro (2014) and Butt et al. (2014). A common misconception about QE, at least as carried out in the UK, is that the main aim of the policy was to increase bank lending by increasing reserves and setting off a money multiplier-driven increase in bank lending. In fact it was the direct effect of asset purchases on the broad money stock and the subsequent portfolio rebalancing by non-banks that was the main aim of the programme. QE in the UK was not seen as dependent on any increase in bank lending, as illustrated in Figure 3.1. Notwithstanding this, there could be indirect effects, both positive and negative, on bank lending that might occur as a result of the portfolio rebalancing.[16] On the one hand, portfolio re-balancing in response to the initial increase in the money supply might lead asset managers to invest in the long-term debt and equity issued by banks which could lower the spreads on these instruments and the marginal cost of raising these funds in the market. That in turn might affect loan rates and the supply of credit. On the other hand the lower cost of finance in capital markets might lead non-financial companies to substitute capital market finance for bank debt leading to fall in the demand for credit. Additionally QE could affect the demand for credit through raising activity and GDP. Our model allows us to explore these offsetting effects.

Third, one interesting question is whether QE may have *non-neutral* effects on output over the longer-run (in ways that conventional interest rate policy does not). One strand of the literature based on Modigliani-Miller type arguments raised by Wallace (1981) and, more recently, by Curdia and Woodford (2010) regarding the irrelevance of the central bank balance sheet would argue that open market operations are neutral, even in the short run. But other theoretical models that include money suggest an increase in the money supply is only perfectly neutral in the long-run if two assumptions hold:[17]

(a) the money supply increase is introduced as a helicopter drop

(b) the drop is distributed proportionately in line with existing money holdings.

But QE is a particular kind of open market operation that involves an outright purchase of bonds in exchange for money. So it is not a helicopter drop of money and a proportionate

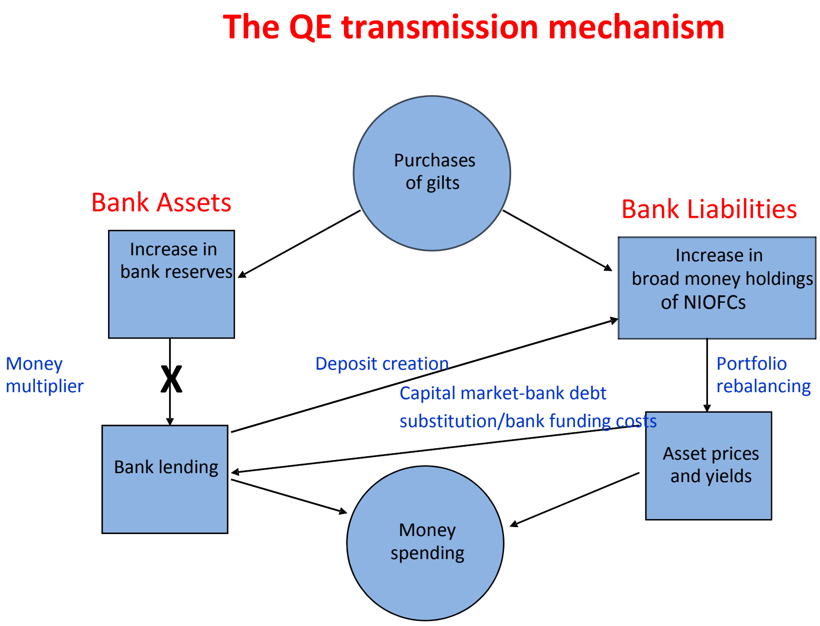
[16] See Mcleay et al (2014), and Butt et al. (2014).

[17] See Gale (1982) for example.

change in prices will not be sufficient to restore all real variables back to their initial levels in this type of model. A shift in the ratio of money to bonds that is not subsequently unwound may require permanently lower bond yields which will affect the cost of capital and the capital stock in the longer term.

QE also implies that the initial increase in money is concentrated in the financial sector of the economy. That is likely to lead to a short-run non-neutrality, even if prices are flexible – the liquidity effect similar to that in the limited participation models of money (see Fuerst (1992) Christiano and Eichenbaum (1992)). That non-neutrality may persist over a longer period. Even though the money created by QE will get transferred to households and companies as they increase their spending, it is likely to lead to some permanent change in the distribution of money holdings in the economy unless very special circumstances hold or if QE is unwound at some point in the future. Overall our model makes clear all the different channels you would have to assume are not operational in order to make the argument that QE has a neutral effect on the economy.

Figure 3.1: Stylised diagram of QE transmission mechanism



3.2 Simulating the effect of QE on the economy

We now simulate the effect of QE in the UK using our model. The richness of our model allows us trace the effects of QE at a sectoral level. As discussed earlier, an increase in QE represents an exogenous increase in the money holdings of NIOFCs. To explore the effects of QE using our model we will build up the channels and sectoral effects in different stages.

First, we start with the initial increase in deposits that arises from QE and look at the portfolio-rebalancing channel by non-bank financial companies *holding other elements of the banking system's balance sheet fixed*. Second, we allow the household and PNFC sectors to respond to the asset prices and wealth effects generated by portfolio rebalancing by NIOFCs. We then look at the offsetting impact of portfolio re-balancing by banks and non-financial companies, *holding loan rates and the supply of credit fixed*. Finally we look at the impact of QE through the various bank lending channels. In each case we discuss the implications for output both in the short run and in steady state.

Stage 1: QE and portfolio rebalancing by non-bank financial corporations

A. Non-bank financial companies (NIOFCs)

We first look at the effect of asset purchases in the NIOFC sector in isolation, holding the other elements of the banking system's balance sheet fixed.

The aim of the programme of asset purchases in the United Kingdom was to purchase gilts and other assets from the non-bank private sector. These purchases were implemented through the creation of the Asset Purchase Facility or APF (see Benford et al (2009)) which obtained a loan from the Bank of England with which to purchase the assets. These purchases were settled in terms of bank deposits. As such, the initial first-round impact of APF asset purchases was an increase in reserves on the asset side of private banks' balance sheets and, as a counterpart, an increase in their deposit liabilities to the non-bank private sector – that is an increase in broad money. These balance sheet impacts are summarised in Figure 3.2. When the APF, Bank of England and Private bank balance sheets are consolidated the initial impact shows up as an increase in gilt holdings on one side of the balance sheet and non-financial company money holdings on the other as in Figure 3.3.

Figure 3.2: The impact of QE purchases on different sectors' balance sheets

BoE balance sheet

Assets	**Liabilities**
+Loan to APF	+ Additional reserves

APF balance sheet

Assets	**Liabilities**
+ Gilt purchased	+Loan from BoE

Non-bank balance sheet

Assets	**Liabilities**
- Gilts sold + Deposits	

Private bank balance sheet

Assets	**Liabilities**
+Reserves	+Deposits

Figure 3.3: Implications for the consolidated balance sheet of the banking system

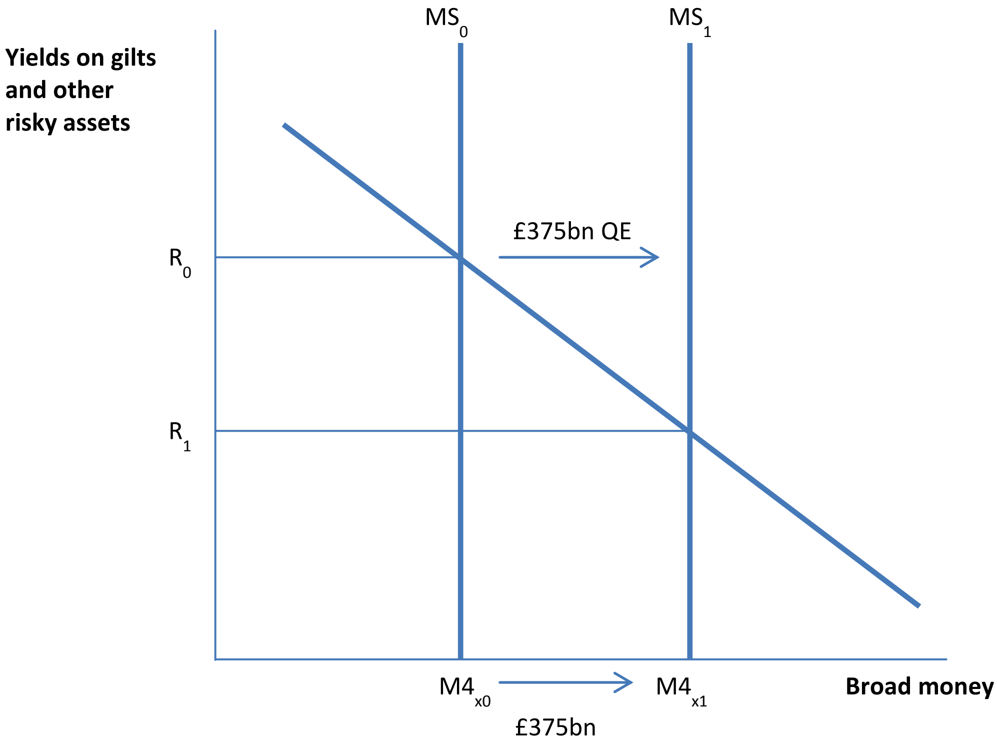
Assets	Liabilities
Lending to households	Household money
Lending to PNFCs	PNFC money
Lending to NIOFCs	↑ **NIOFC money**
Other assets	Other liabilities
↑ **Gilt holdings**	Non deposit liabilities

Between March 2009 and November 2012 the MPC purchased £375bn of government bonds in three phases, as shown in Chart 1. In Phase 1, between March 2009 and February 2010, the MPC purchased £200bn of assets, in phases 2 and 3 the MPC bought an additional £175bn of assets between October 2011 and November 2012. To look at the portfolio rebalancing by NIOFCs in isolation, we introduce the implied 'phased in' sequence of asset purchases into the aggregate money supply identity holding other elements of the balance sheet constant, other than NIOFCs money which, as noted earlier, is treated as a residual element of the balance sheet. As outlined earlier, this means we calculate the effect of QE on the two endogenous variables in the system, holding any additional money and the deposit rate unchanged This ensures that the QE increase leads to an equivalent rise in NIOFC deposits, for this partial experiment. We also assume QE is not subsequently unwound over the simulation period.

In the NIOFCs system of equations the prices and relative yields of non-monetary assets (the determinants of financial companies' demand for money) now need to change to make financial companies willing, in aggregate, to hold the higher stock of deposits. Note that Bank Rate and other safe rates of return are assumed to be held fixed here. That means deposit rates are also fixed so the change in relative yields is entirely due to changes in term and risk premia on bonds and equities.

Some of this change in yields would happen instantaneously with the initial purchases of gilts. But some sellers of gilts may not want to simply swap gilts for money, but rather exchange money for gilts as an intermediate step to purchasing other assets such as equities and corporate bonds. Given that these asset purchases would in turn transfer money to other financial companies, the initial purchases would set in motion a whole set of transactions that may spill over into many asset markets until yields and prices move sufficiently to make the financial sector willing to hold the extra deposits – the so called 'hot potato effect'.

Figure 3.4: Portfolio rebalancing and the demand for money



The lags in the NIOFCs' VECM system are consistent with frictions so that this 'hot potato' effect takes some time to filter through the asset markets. Chart 3.2 shows this effect when simulated from our model. The £375bn of QE would, under the assumptions that there are no leakages, lead to around a gradual 30% increase in the value of assets held by the household sector by the end of 2013. That in turn is made up of around a 60% increase in net financial wealth and a 6% rise in housing wealth. In financial yield space the increase in financial asset prices leads to a peak reduction in the average yield on risky assets of around 250bps by the start of 2014. But if markets were efficient and frictionless, you might assume that prices should adjust immediately in anticipation of this process to stop anyone wanting to do any transactions.

This might seem a more appropriate assumption for the case of QE. The policy of asset purchases was transparently announced following each MPC decision, such that market participants knew on announcement the scale of the purchases being made at each stage. In contrast, the average lagged relationship that is picked up in the VAR is likely to reflect the impact of a wide range of unanticipated increases in NIOFC money holdings occurring in the past, which may have taken more time to filter through the system as a whole. In the case of QE, one might therefore expect asset prices to jump or move more quickly to eliminate any incipient monetary disequilibrium in the financial company sector. That would imply ignoring the dynamics in the VECM and using just the long-run demand for money by NIOFCs to work out the impact on asset prices – i.e. it would involve inverting the long-run money demand function for NIOFCs. That implies a more immediate impact on asset prices, also shown in Chart 3.2 where the pattern of asset price increases matches the pattern of NIOFC money holdings.

B. Spillovers to the household and PNFC sectors

The rise in asset prices and financial wealth in turn raises desired consumption and investment spending plans by households and PNFCs (by increasing wealth and lowering the cost of capital). In simulations from our model the (local) peak effect on GDP from the increase in consumption and investment is around 2% after the first phase of QE and occurs around the middle of 2011. The subsequent asset purchases during QE2 and QE3 then lead to an eventual peak impact of 3.5% in the level of GDP by the end of 2013.

As in Bridges and Thomas (2012) we conduct this exercise holding lending fixed and not allowing further money creation by banks. To finance higher spending plans, households and firms ultimately need more money balances. Given the assumption that there is no additional money creation by banks, households and PNFCs can only obtain the additional money balances they need from the non-bank financial sector. They cannot borrow against their higher financial wealth. Households have to tap into their higher wealth directly by cashing in investments that they have with an investment fund, and PNFCs respond to the lower cost of capital by issuing on the capital markets to the non-bank financial sector directly. This leads to a gradual transfer of money holdings from the NIOFC sector to the household and PNFC sectors. Our model suggests that around a half of the aggregate increase in money holdings gradually moves out of the financial sector and into the household and corporate sectors as a result of the portfolio rebalancing effects. This can be seen in Chart 3.1. It is important to note that, at this stage, we are still keeping Bank Rate and loan rate spreads unchanged.

Chart 3.1: The sectoral transfer of money under QE

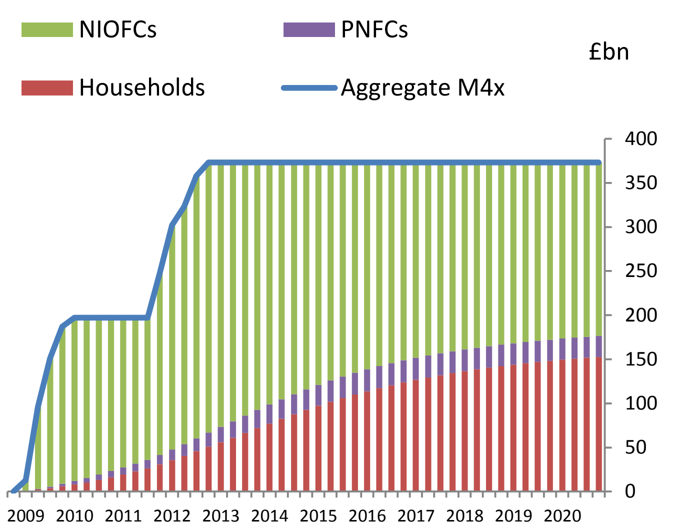


Chart 3.2: The impact on asset prices and yields

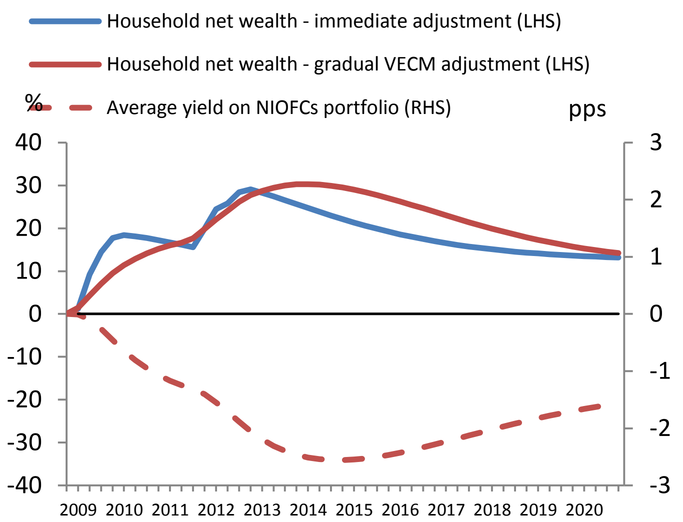


Chart 3.3: The GDP response of QE by component

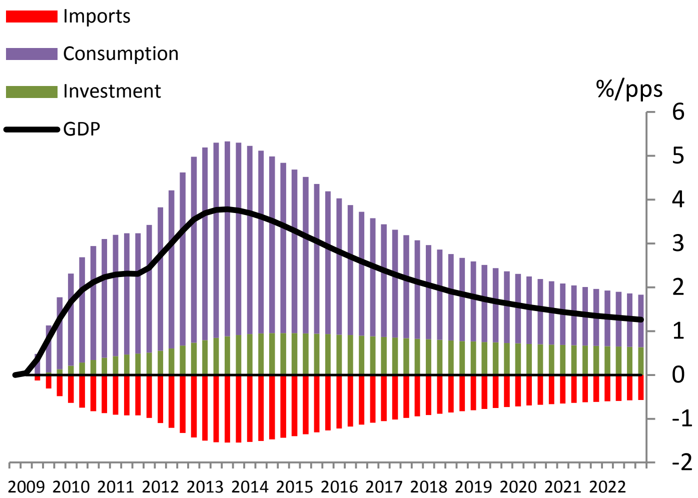
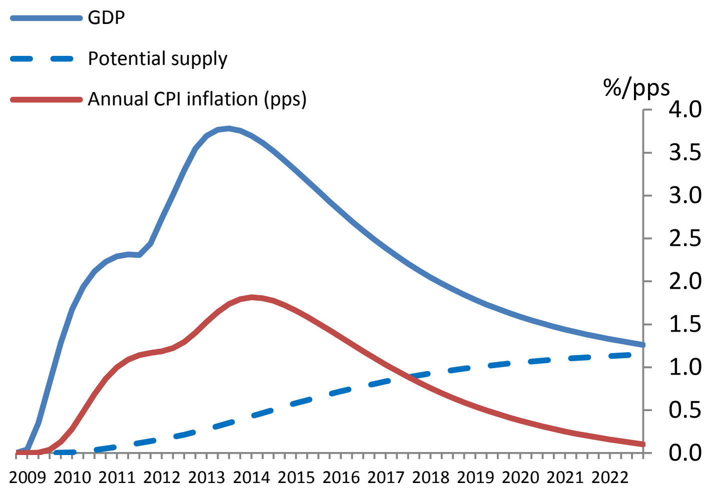


Chart 3.4: The response of the output gap and inflation

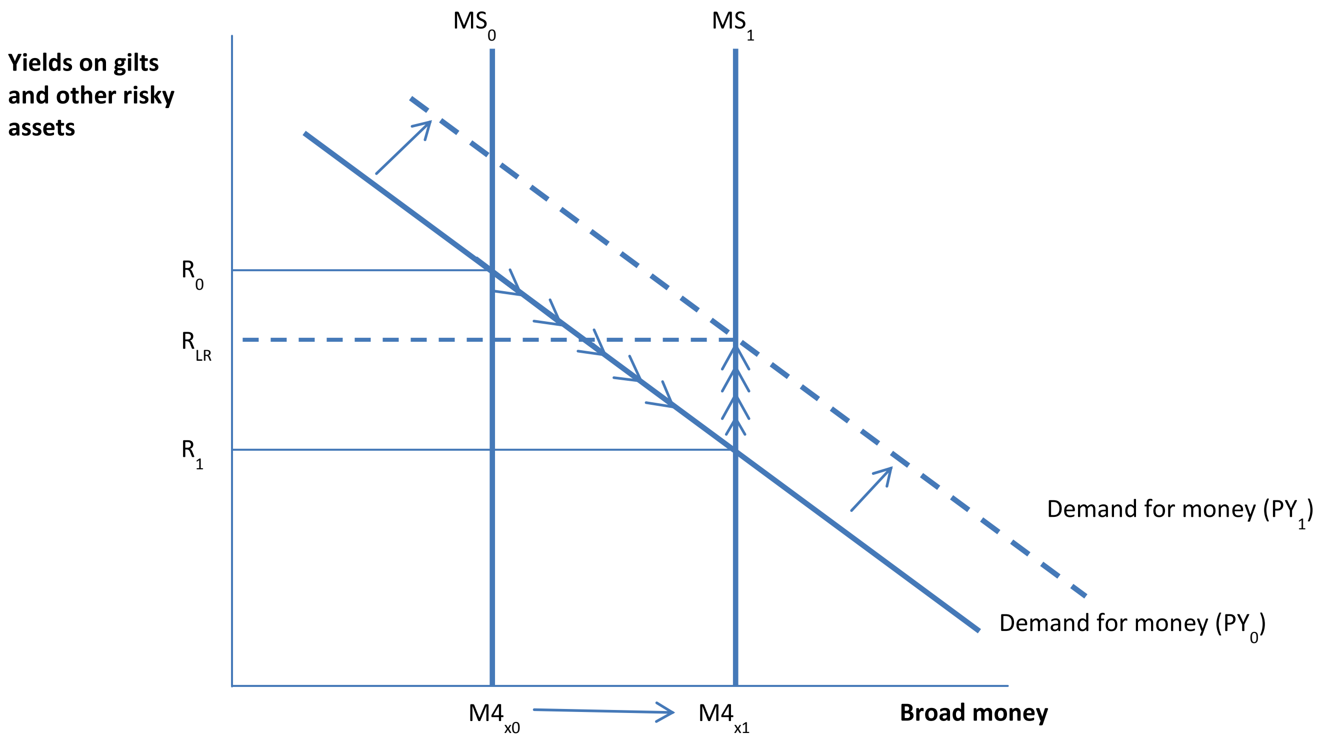


Charts 3.1 – 3.4 show the difference from baseline at each point in time, simulated by the model in response to QE

As corporates issue more bonds and the amount of money the NIOFC is required to hold declines so too do asset prices. This leads to asset prices declining somewhat from their peak and yields. So asset prices and financial market yields exhibit overshooting (Chart 3.2) and start returning to their initial level. This is almost exactly the liquidity effect predicted by limited participation models, where money is initially injected into asset markets which forced real yields down, but the yields then subsequently rise as money spreads to the other sectors of the economy. This is demonstrated in Figure 3.5 in aggregate money demand space. As spending responds to the initial fall in yields and higher asset prices, this raises the demand for money (by households and companies) and forces yields back towards their initial level.

Chart 3.4 shows the effect on our definition of potential output and inflation. The estimated peak impact on inflation of QE which occurs at the start of 2014 is 1.8%. The effect of higher investment on the capital stock is sufficient to increase potential output by just over 1%. That reflects the fact that yields (term and risk premia) are permanently reduced as a result of QE (assuming it is not unwound), which in turn affects the cost of capital and potential output. The velocity of circulation of money (the ratio of nominal spending to GDP) is also permanently affected by QE. Of course, in a deeper sense, whether this can be sustained as a long-run steady state depends on the factors mentioned in section 2.

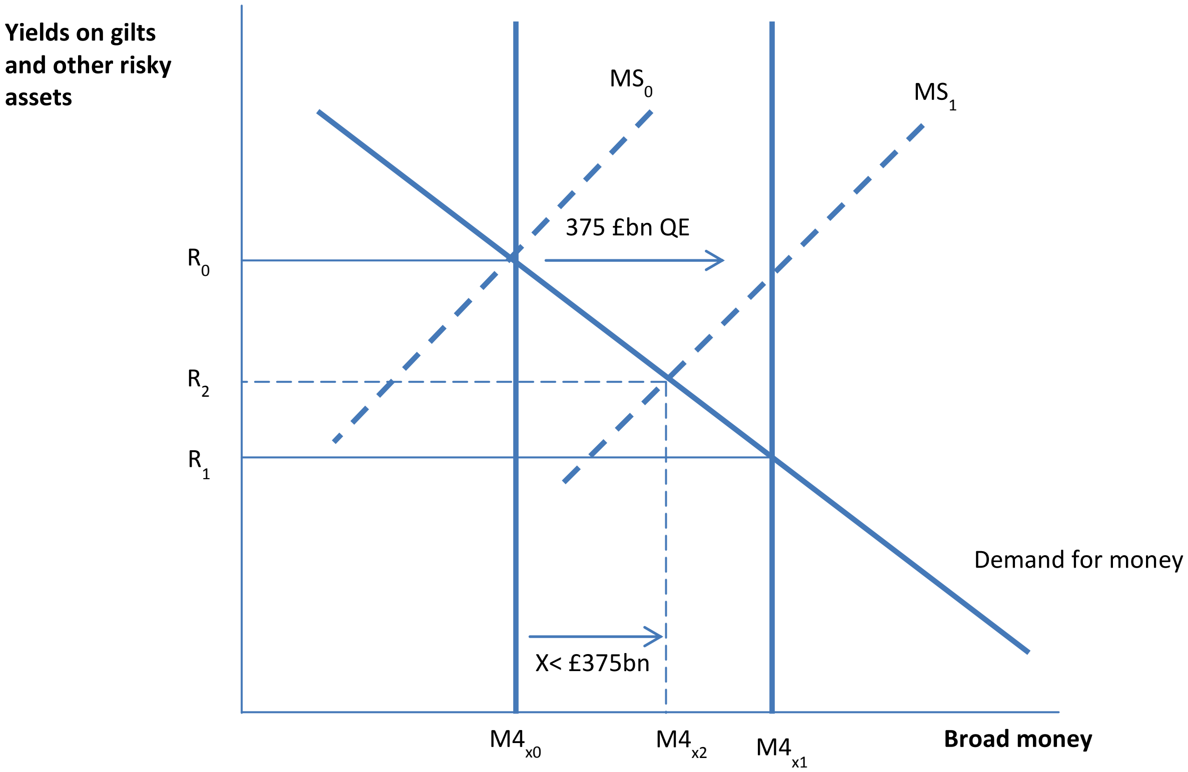
Figure 3.5: The liquidity effect of QE



Stage 2: Portfolio rebalancing by banks and PNFCs – is the rise in aggregate one-for-one?

Whilst QE directly injects money into the NIOFC sector, the impact on broad money of QE is likely to be less than the 'one for one' assumption of the previous section as discussed in Bridges, Rossiter and Thomas (2011), Cobham and Kang (2012) and Bridges and Thomas (2012). In particular the fall in yields and increase in asset prices resulting from QE is likely to lead to portfolio rebalancing by other agents in the economy, most notably banks and non-financial companies. And that might induce an offsetting fall in the supply of money. This is shown in Figure 3.6 where the money supply schedule is positively related to yields on risky assets. In this case QE is likely to lead to a smaller increase in the money supply and a smaller fall in yields than the simple inelastic case shown in Figure 3.4. In Stage 1 we did not allow any endogenous change in the aggregate stock of money. We now examine what further mechanisms are at work and how our model captures them.

Figure 3.6: Portfolio rebalancing by banks and PNFCs – upward sloping money supply



First, consider the effect on PNFCs. QE leads to a fall in yields on corporate debt and a rise in equity prices. This would lower the cost of borrowing for companies in capital markets. Consequently, this may encourage corporates to use this cheaper source of funding to repay existing loans from banks, thus reducing the level of bank lending in the economy. The non-bank purchasers of corporate debt and equity would ultimately have to pay for this by reducing their deposits with banks. These would be transferred to non-financial companies who would use them to pay down debt and reduce the supply of money. This effect is captured in the PNFCs' lending equation where we estimate that lower corporate bond yields have a negative effect on bank lending, as shown in the equations in the appendix.

Next, consider the portfolio rebalancing behaviour of banks. Earlier we discussed two effects QE may have on the structure of the bank balance sheet. First, QE may lead to commercial bank sales of government debt. As yields fall (and prices rise) on gilts, banks may be induced to change the composition of their liquid asset holdings. If banks sell gilts to the non-bank private sector, this will increase non-bank private sector gilt holdings and, in aggregate, a drawdown of their deposits, again reducing the supply of money. As noted earlier the equation for banks' holdings of gilts suggest they are negatively related to the yield on 5 year gilts relative to wholesale deposit rates.

In addition, higher prices and lower yields on risky assets apply as much to bank-issued debt and equity as they do to non-bank issuers. If banks' respond to lower yields by increasing their long-term bond and equity issuance that would work to reduce the money supply in the short run,[18] as the domestic purchasers of bank bonds and equities would ultimately have to pay for these by reducing their deposits with the UK banking system. This would be reflected in a shift between deposit and non-deposit instruments on the liability side of banks' balance sheets and again would work to offset the initial effect of QE in increasing the money stock. Again, as noted earlier, our system captures this by relating banks' non-deposit liabilities negatively to the spread between 5 year yields and deposit rates.

In the longer term, to the extent that bank issuance improves the capital and lowers the funding costs of the banking system, that may influence loan rates and the willingness of banks to lend. We discuss this effect more in the next section. Here we concentrate on the short-run destruction of money that occurs when banks issue more long-term debt and equity.

Chart 3.5: QE leakages and the impact on money

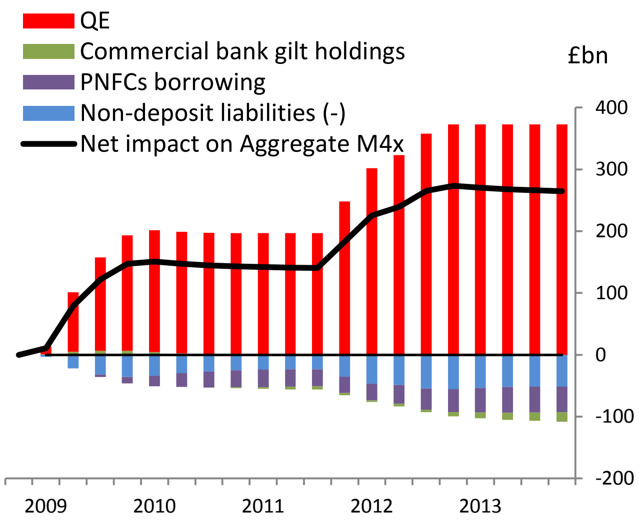
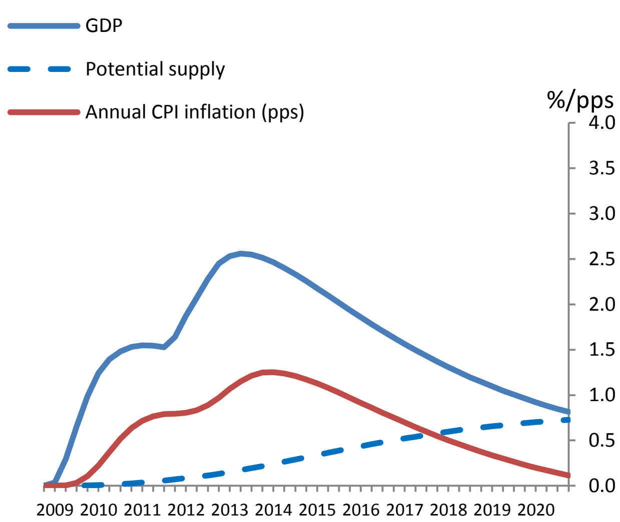


Chart 3.6: The impact on GDP and inflation with endogenous leakages



Charts 3.5 – 364 show the difference from baseline at each point in time, simulated by the model in response to QE

In summary, there are likely to be indirect effects on the money supply as a result of the various portfolio rebalancing effects of QE. Although QE increases the aggregate demand for bonds and equities as asset managers in the NIOFCs sector rebalance their portfolios, the resulting increase in asset prices may induce an increase in the issuance of these assets that might work to offset the original boost to the money supply and reduce the asset price adjustment required. As discussed in Butt et al (2012) these indirect factors were all very much apparent in the data during the crisis.

Chart 3.5 shows how our sectoral model predicts these different effects will play out in terms of their impact on the money supply. It shows that the impact of QE on the money supply is

[18] Provided that the liabilities are of sufficiently long tenure. Bank debt instruments of less than 5 years maturity held by NIOFCs are treated as M4 deposits.

only about 70% of the amount of asset purchases made – £375bn of QE leads to an increase in the broad money supply of just over £260bn. By 2014 the main leakage comes from an increase in banks' non-deposit liabilities of around £50bn reflecting an increased issuance of debt and equity by banks relative to what otherwise would have been the case. It also suggests there was capital market substitution by PNFCs of around £40bn and a reduction in commercial bank gilt holdings of around £15bn. These leakages are similar in size to the leakages found in Bridges and Thomas (2012) and Butt et al (2012) using a simple counterfactual analysis of the relevant M4x balance sheet counterparts.[19] They found that the impact of QE on the money supply amounted to around 60% of the amount of the asset purchases made – around £225bn. The main difference is that the leakages here are modelled explicitly and are spread out over time rather than confined to the period over which the purchases were made, which is a weakness of the counterfactual counterparts approach. But the fact that the estimates are similar gives some support to our empirically estimated relationships for banks holdings of gilts and non-deposit liabilities.

The leakages we have identified imply that the GDP and inflation effects of QE will be 70% of the impacts found in Stage 1. The impact on equity prices and GDP now peak at just over 40% and 2.5% respectively and the impact on our definition of potential output is reduced to a long-run effect of 0.75%. These results, when appropriately scaled, are in line with the range of macroeconomic estimates discussed Joyce, Tong and Woods (2011) but are slightly weaker and have more persistent effects than Bridges and Thomas (2012) who used a simpler set of sectoral models.

Stage 3: QE and the role of bank lending

In the previous two subsections we simulated our model holding lending fixed.[20] The results have shown that that QE can increase broad money and spending in the economy without directly leading to, or requiring, a boost to bank lending. This is important because one commonly heard criticism of QE is that it has failed to encourage banks to lend in large quantities based on the fact that bank lending has been weak since 2008, including during QE periods. This is supported by the empirical results of Joyce and Spaltro (2014) and Butt et al (2014). But increasing the provision of credit from the banking sector was not central to the policy as designed in the United Kingdom.

Importantly, the reserves created in the banking sector do not play a central role in the transmission mechanism of QE even though this is often cited as the key mechanism through which QE affects the economy. This is because banks cannot directly 'lend out' reserves. Those banks can use them to make payments to each other, but they cannot 'lend' them on to consumers in the economy, who do not hold reserves accounts. Moreover, the new reserves

[19] The M4x counterparts approach uses the banking system's balance sheet identity to expresses movements in M4x in terms of all the other balance sheet items on the banking system's balance sheet. To estimate the QE leakages Bridges and Thomas (2012), Cobham and Kang (2012) and Butt et al (2012) looked at the relevant M4x counterparts over the period asset purchases were made and compared them with an appropriate historical counterfactual to work out how much might be attributable to the impact of QE.
[20] Mechanically, we have also held lending and deposit rates fixed.

are not mechanically multiplied up into new loans and new deposits as predicted by the money multiplier theory. The newly created reserves may not, by themselves, meaningfully change the incentives for the banks to create *new* broad money by lending. There are at least two reasons for this:

First, it is a bank's stock of liquid assets relative to their liquidity needs, rather than the amount of liquid assets per se, that matters for lending. The reserves created by QE already have a liability against them — the bank deposits held by the non-bank private sector. If these were largely held by portfolio investors who might easily withdraw or transfer these deposits, then an individual bank may not feel that its overall liquidity position has improved sufficiently. This issue has been investigated in detail by Butt et al. (2014) who find evidence of this behaviour.[21]

Second, in order to increase the provision of bank lending, QE would need to directly incentivise the banking system to add not only more loans to its balance sheet, but also more liabilities. As banks are price setters when they lend more they typically have to lower loan rates. Those loans automatically create additional liabilities which they pay interest on. So unless reserves directly affect the loan price setting decision then they will not at the margin increase the incentives to lend. This is captured in our framework as loan rates are set as a mark-up on funding costs and so any increase in reserves resulting from QE will not directly affect this marginal decision.

Even if the increase in reserves does not *directly* affect lending, QE can lead to an *indirect* increase in bank lending. First, the increase in activity and asset prices from portfolio rebalancing may increase the demand for credit by households and companies. Second, the reduction in yields on bank debt and equity discussed in the previous section may affect bank funding costs at the margin and lead banks to charge lower loan rates. The first of these factors is already built into our sectoral lending equations. The second can be accommodated by allowing the reduction in financial market term and risk premia shown earlier to feed into our loan pricing equations over and above the impact of Bank Rate and swap rates.

Charts 3.7 and 3.8 show the consequences of allowing these lending feedbacks to operate. These additional channels lead to an increase of bank lending of £175bn by 2014. Most of the positive impact comes from lower funding costs, but higher activity and asset prices also contribute positively to lending. These offset the impact of capital market substitution discussed in the previous section. If we combine the lending impact with the endogenous leakages of the previous section it would suggest QE could have increased the money stock by around £435bn by the start of 2014, in other words by more than the amount of asset purchases made (Chart 3.8). That is enough to increase the peak GDP impact to just under 6% and increase the longer-term effect on potential output to over 3% given the effect of lower loan rates on the cost of capital (Chart 3.10)

[21] See Butt et al (2014).

Chart 3.7: The potential impact of QE on bank lending

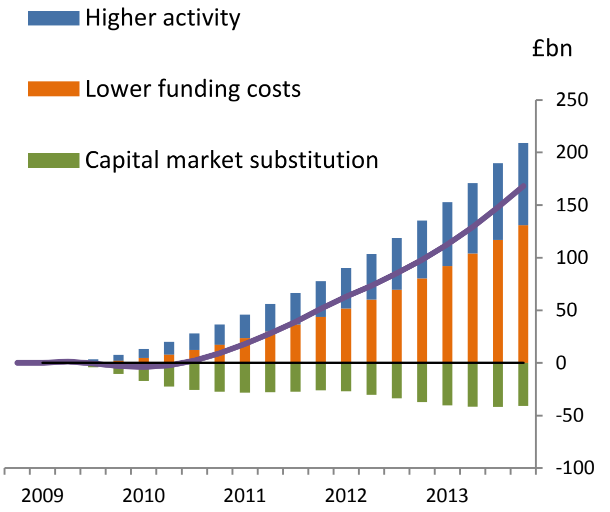


Chart 3.8: The impact on money when QE affects bank lending

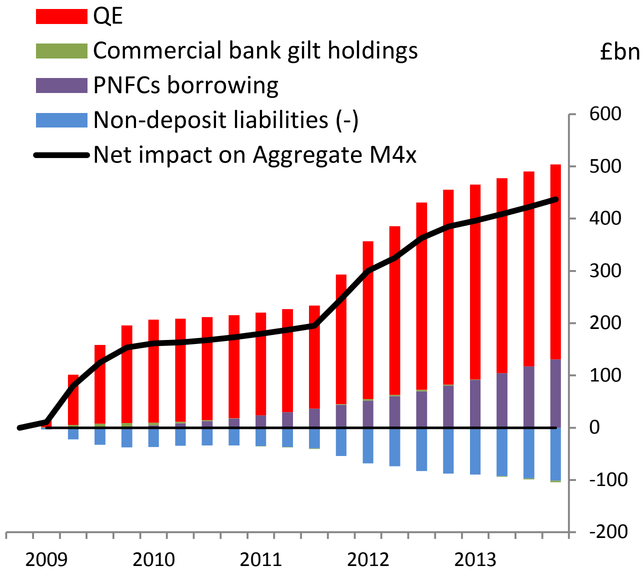


Chart 3.9: The effect of lower funding costs on loan rates

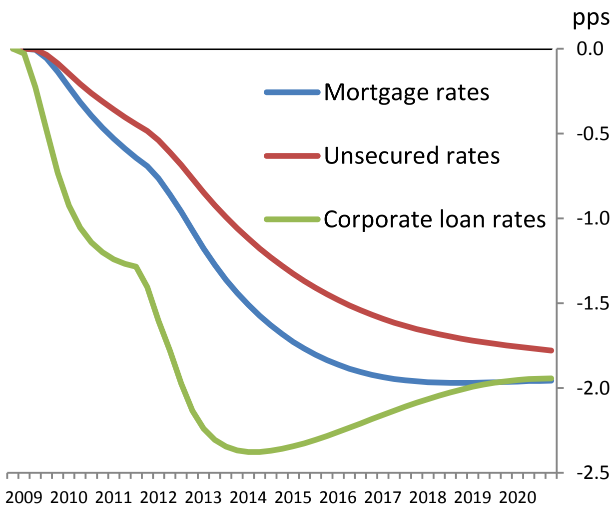
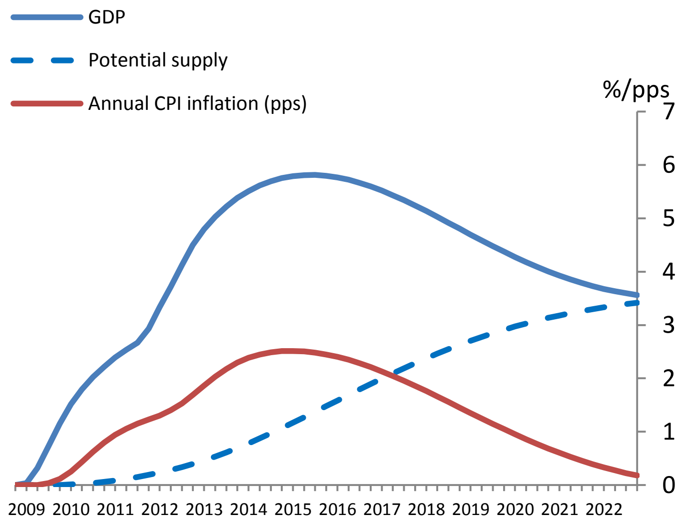


Chart 3.10: The GDP impact when QE affects bank lending



Charts 3.9 – 3.10 show the difference from baseline at each point in time, simulated by the model in response to QE

This suggests the lending channel of QE could potentially be quite powerful even if it is not working through a money multiplier mechanism. But how plausible are these effects especially in the light of existing empirical results which find little evidence that QE affected bank lending to any great degree ? Chart 3.9 shows that these effects depend upon loan rates falling by 200bps as a result of QE. Given loan rate spreads have remained high over the recent crisis this might seem implausible and so an impact on this scale might be viewed as unlikely. In future work better modelling of bank funding costs and how they respond to financial market yields more generally should produce better estimates of the size of this effect. Another way of evaluating the plausibility more systematically it is important to look at what they imply for the counterfactual path for the economy, in other words, what would have happened in the absence of QE. We turn to this next.

3.3 GDP growth, money and credit: the role of QE over the crisis

In this section we evaluate what our sectoral model suggests about the impact of QE by looking at the counterfactual – what would have happened to money, credit and activity in the absence of the policy if our results are representative of the impact. Charts 3.11 to 3.16 show the data for GDP growth (real and nominal), credit growth, money growth, credit spreads and velocity compared to a counterfactual where the impact of QE from our sectoral model is removed. We look at two counterfactuals. The first counterfactual removes the impact that embodies the endogenous QE leakages discussed in Stage 2. The second counterfactual additionally removes the possible impact of QE on bank lending.

The results suggest that the recovery in GDP growth from 2010 would have been much weaker and annual GDP growth would have been negative throughout 2012. Money in the absence of QE would have fallen by over 5% on either counterfactual in 2010. These are similar to the results of Bridges and Thomas (2012) and Cobham and Kang (2012). And our second counterfactual would have suggested the stock of credit would have fallen by around 3-4% over the past year rather than remaining flat. That of course is highly dependent on QE affecting funding costs and loan rates. Chart 3.14 shows that for this to be plausible QE would have to account for most of the fall in loan rate spreads since the peak of the crisis. Given that other policies and factors were also influencing loan rate spreads over this period, this is likely to be an overestimate of the impact of QE on credit. So the results here probably represent very much an upper bound of the effect of QE on credit over the crisis, but it is useful all the same to be able to model this channel to gauge how big such effects could be if bank funding costs fall in line with the other yields affected by QE.

Chart 3.11: Real GDP counterfactuals

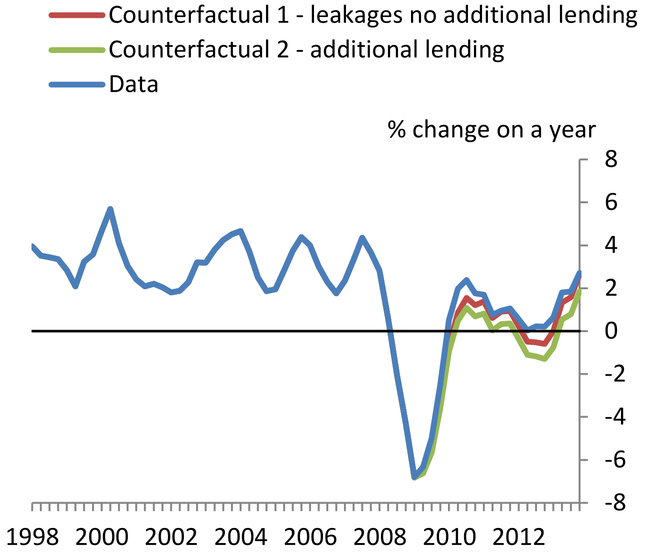


Chart 3.12: M4x counterfactuals

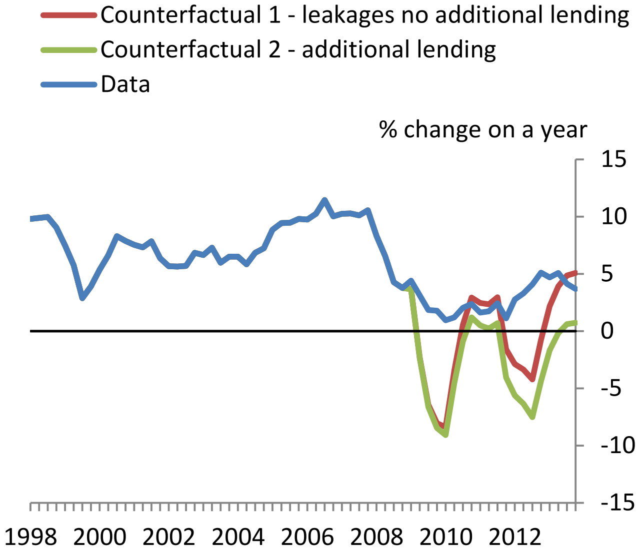


Chart 3.13: M4 lending counterfactuals

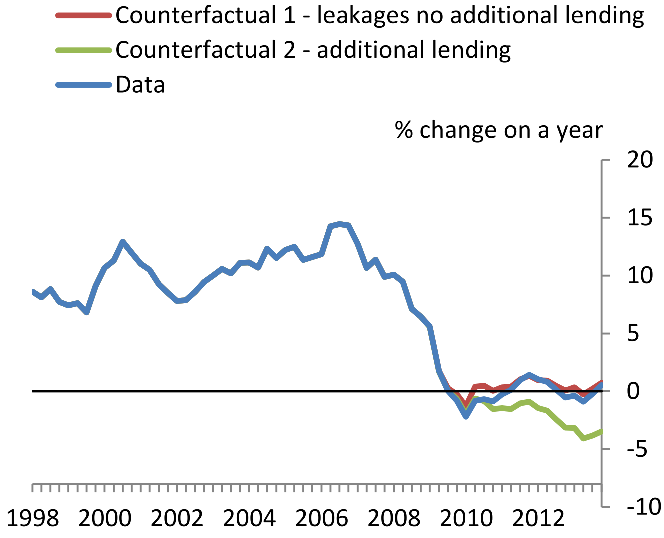


Chart 3.14: Nominal GDP counterfactuals

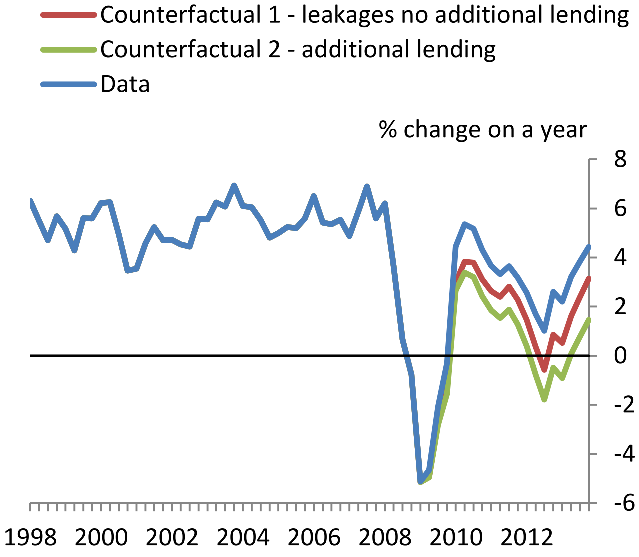


Chart 3.15: Loan spread counterfactuals

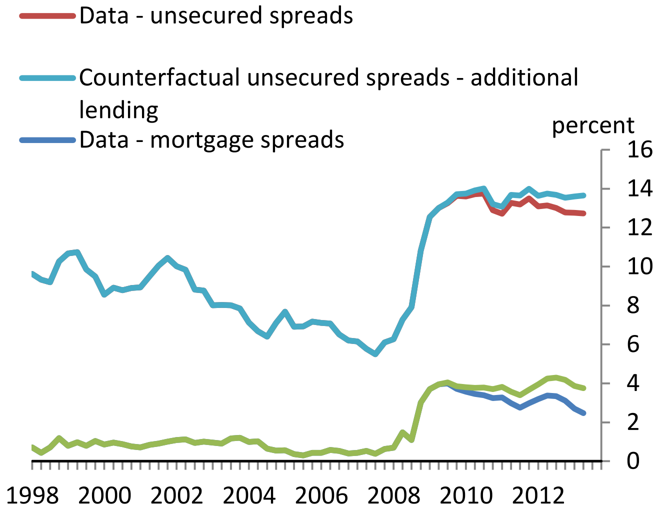
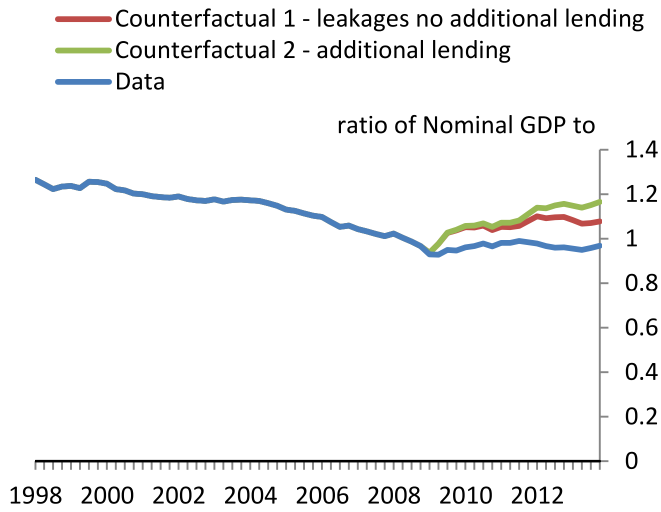


Chart 3.16: Velocity counterfactuals



4. Estimating the impacts of the credit shock

The relative flexibility of our model also allows us to investigate the effect of shocks to the banking sector that result in changes in the supply of credit to the real economy. The co-incidence of many large banks failing or needing public support with steep falls in GDP in many advanced economies strongly suggests that credit supply shocks can be an important driver of the economic cycle. Evidence on how much these shocks matter is, therefore, potentially valuable to policymakers and others seeking to understand both the financial crisis in particular and the relationship between the banking sector and the real economy in general.

Because there are a number of channels through which credit shocks can have macroeconomic impacts, empirical models with looser theoretical structures are an attractive way to estimate impacts from credit shocks that are consistent with the data. However, any empirical method must make identifying assumptions about the causal relationships between variables, or at least the timing of those relationships. For example, Barnett and Thomas (2013) use a mixture of sign restrictions and timing restrictions to identify credit shocks. Sign restrictions are theoretically attractive, but would be difficult to implement given the more disaggregated structure of our model.

One way in which to simulate a credit supply shock in the model would be to make assumptions that would allow us to identify structural shocks within each block – for instance, timing restrictions on the relationships between the endogenous variables. We could then simulate structural shocks to real credit quantities in each block, and solve the whole model to generate the impulse responses of all endogenous variables.

However, it is far from clear in this case what the appropriate set of timing restrictions is.[22] Furthermore, even if we can settle on a set of identifying restrictions, it would not be clear what the shocks we identified meant. For example, would a structural shock to the quantity of mortgage lending be a credit demand shock, or a credit supply shock? In reality the estimated shocks would reflect some mixture of the two, so treating such an exercise as a credit supply shock would not really be correct.

An alternative approach is to use credit spreads as a proxy for credit supply (in essence, the intercept of the credit supply curve). These spreads enter as exogenous variables in each block alongside Bank Rate.[23]

This approach has pros and cons. It is tractable: to simulate a credit supply shock, we simply alter the path of these exogenous variables, then solve the model dynamically for the paths of all endogenous variables. Using spreads allow us to measure and specify shocks in 'units' (that is, basis points) that are familiar and easy to understand. Our model allows us to map changes in the credit spreads that we monitor on an ongoing basis – see Butt and Pugh (2014) - into impacts on the expenditure components of GDP, as well as money and credit aggregates, which we can use to inform the MPC and help them make their forecast.

A drawback is that spreads do not directly capture changes in non-price credit conditions (for instance, collateral requirements, credit scoring, limits on income gearing, covenants), which may be important when there is asymmetric information. Additionally, in some markets the interest rate may not be the only – or even the principle – parameter with which banks compete for business. Unfortunately data on non-price conditions are more difficult to collect than data for prices, but what data we do have suggests (for instance, from the Credit Conditions Survey – see Driver (2007)) that they are well correlated with spreads, so the latter should be effective at picking up these extra features that tend to characterise credit supply shocks. This is discussed in more detail in Butt and Pugh (2014).

Perhaps a more serious drawback is that our assumption that spreads are exogenous to the endogenous variables in each VECM may not be valid. On reason why this would be true would be if shocks to the demand for credit are an important cause of variation in spreads. Another reason would be that some of the variables in our system may have a bearing on how risky lending is perceived to be by banks. For example, when house prices fall, there is a greater risk of mortgage loans becoming under-collateralised, and banks may charge higher spreads to compensate for this risk. To put it another way, perhaps we observe something which is actually a financial accelerator effect and mistakenly describe it as a credit supply shock.

Fortunately these two potential sources of bias are offsetting. The first one – pricing power in loan and deposit markets - will push our estimates of the impact of credit supply shocks towards zero. The demand curve for credit probably shifts downwards during recessions,

[22] There is more discussion of this in section 2.

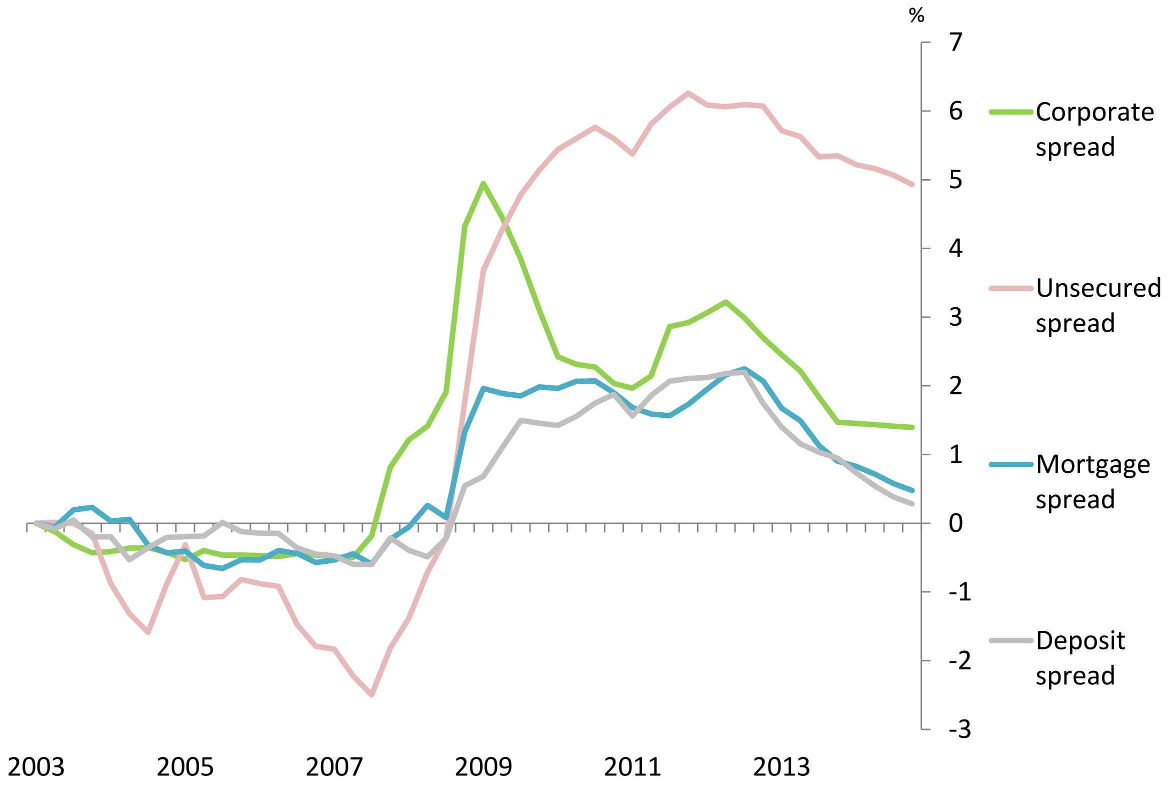
[23] We don't find significant effects for *all* spreads in *all* blocks – but every block features at least its 'own' spreads. See the appendix for the full structure of the model.

perhaps particularly during credit-driven recessions; this will have (all else being equal) *reduced* spreads.[24] The second one – financial accelerator effects – will tend to exaggerate our results. Spreads may also take time to respond to endogenous variables, which strengthens our identification strategy.

Whether quantity shocks, spread shocks or some mix of the two are the most appropriate tool to use will ultimately depend on the specifics of the shock or policy experiment we are trying to simulate. In the rest of this section, we present in detail some results from implementing a set of spread shocks that we think represent a reasonably good summary of the credit shock that hit the UK economy during the financial crisis.

Accepting the caveats regarding possible biases, the credit spreads we use for estimation tell a definite story of a step change in credit conditions in 2008-09, relative to the preceding five years. Chart 4.1 below shows how the spread series we use in our simulation have behaved since 2003.

Chart 4.1: Loan and deposit spreads (relative to 2003)



In early 2007, before the disruption to financial markets began, all the spreads had fallen somewhat relative to 2003. All spreads then rose in 2008 and 2009. Initially the largest move

[24] Another way of putting this is that, because spreads rose *despite* a probable fall in credit demand, we can be fairly sure that credit supply contracted. Barnett and Thomas (2013) use sign restrictions on the response of spreads to help identify credit supply shocks, and identify large negative shocks to credit supply during the crisis.

was in corporate spreads[25] and unsecured spreads, but the increase in unsecured spreads proved more persistent. Both deposit and mortgage spreads also increased significantly.

As explained above, we can run these series through our model as shocks to the relevant spread variables (s_d, s_u, s_m and *rlp)*. As explained in section 2, these profiles for spreads feed into each VECM. Taking the paths for these variables as given, we can solve for all the endogenous variables in each block (and for the endogenous equations in the aggregate block, such as GDP and inflation) period by period. As each VECM has a reduced-form representation, such simulations are always feasible.

For these simulations we hold asset prices fixed. As explained below, the credit shock reduces lending to households and PNFCs by more than it reduces deposits from these sectors. By residual, the money accounting approach of our model would reduce NIOFC money, as banks would have less need of this source of funding. In turn this would reduce asset prices, accentuating the negative impact on GDP of the tightening in credit. However, we think this result may be partial and misleading. To some extent it is an artefact of the closed economy structure of our model – during the pre-crisis decade much of the increase in the Customer Funding Gap was probably financed from overseas through securitisation and other non-deposit wholesale instruments. More generally it is because our NIOFC system is set up to deal with a shock – such as QE – to the structure of NIOFC portfolios, rather than a shock to the demand for wholesale funding by banks. In theory, we could attempt to construct a series of flows to bank non-deposit liabilities and deposits from overseas that would represent the changes to bank funding behaviour brought about by the credit shock and the implications that might have for a range of asset prices including the exchange rate. However it is not clear how to calibrate such shocks, so for the sake of simplicity we have simply held asset prices fixed for these simulations.

The results of this exercise suggest that the tightening in credit supply had a significant effect on GDP. Chart 4.2 shows the impact on GDP over time. On the eve of the crisis, the progressive loosening in credit conditions over the previous five years had increased the level of GDP relative to what it would have been had credit conditions remained at 2003 levels. Lower unsecured spreads played the greatest role in this.

[25] Although this may illustrate data limitations. Because of the lack of mix-adjusted loan rates, our measure of corporate spreads is partly informed using bond yields. See Butt and Pugh (2014) for more detail.

Chart 4.2: The simulated effect of credit shocks on GDP

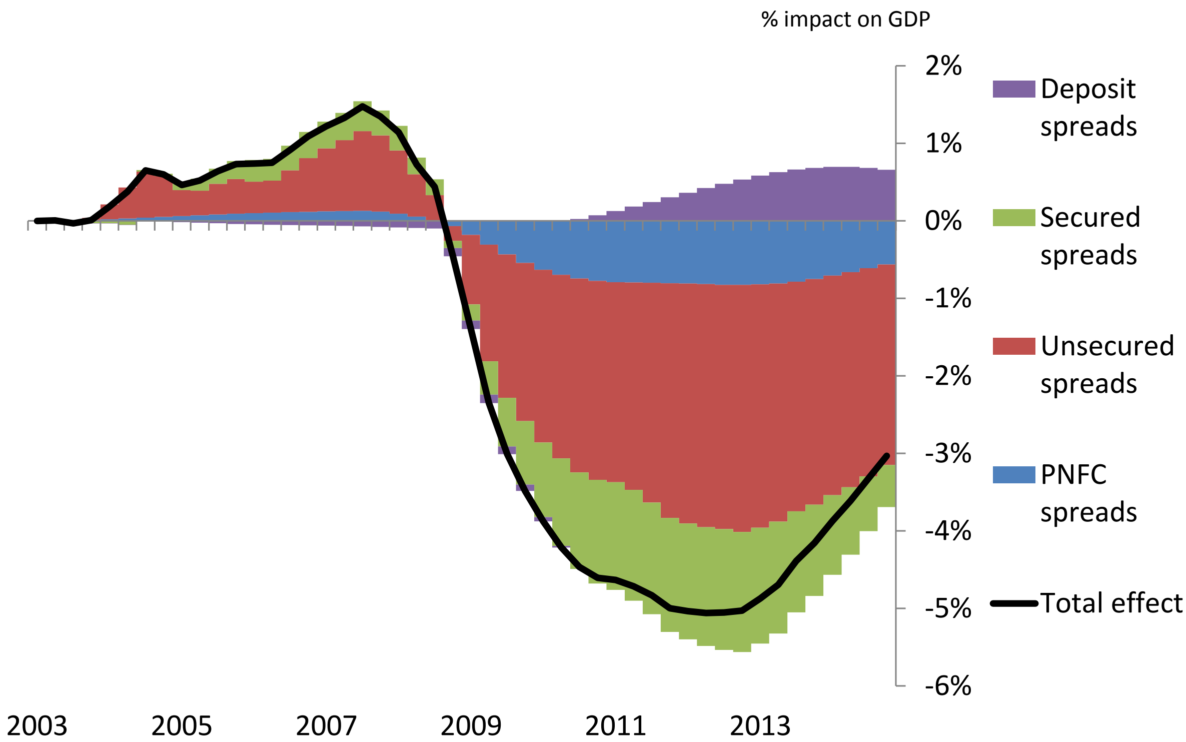


Chart 4.2 shows the difference from baseline at each point in time, simulated by the model in response to deviations in spreads relative to 2003Q1

This contribution quickly reversed, as the tightening in credit conditions shown in Chart 4.4 fed through to activity in the economy. At peak, in 2012, the effect of the credit shock was reducing the level of GDP by around 5%, relative to a world in which credit conditions had stabilised at 2003 levels (and by more than 6% relative to late 2007). Depending on the definition used of trend, real GDP is around 16% below its pre-crisis path. So our simulations suggest that the credit shock explains a substantial part – perhaps one third – of the shortfall in output.

By 2013, this effect had started to unwind – so though the effect on the *level* of GDP was still negative, credit had started making a positive contribution to *growth.*

These impacts of the credit shock on GDP are within the range of previous estimates. They are smaller than some estimates – for example Villa and Yang (2011) – but are within the range of estimates found by Barnett and Thomas (2013).

In the UK there has been significant debate about whether problems in the financial sector have had an effect on the supply potential of the economy, motivated primarily by the very significant falls in productivity compared to the pre-crisis trend, as well as the lack of disinflation in response to such a large fall in output. Barnett et al (2014) summarise the issue. As noted earlier, our treatment of potential output is necessarily limited. In other recent work Franklin, Rostom and Thwaites (forthcoming) offer evidence based on firm-level data that the credit shock had a negative effect on within-firm productivity; however other channels through which credit shocks could affect aggregate productivity are harder to measure. The contribution of credit shocks to the UK's productivity shortfall is unlikely to be known with any confidence for some time, if ever.

As Chart 4.1 shows, there is a high degree of correlation between the different spreads. For these reasons we would be cautious about interpreting the results from a shock to any individual spread; estimation of the separate effects will be quite imprecise. Furthermore, it may not be the case that these spread-specific shocks represent *distinct* shocks. Portfolio responses by both lenders and borrowers may mean that changes to one spread have impacts on other spreads as well. However, looking at the contributions from each spread can help us understand a bit more about the channels through which a credit shock works in our model.

Unsecured spreads have the impact on GDP with largest magnitude. The partial effect peaks at 3% of GDP in 2012. Unsecured spreads enter directly into the long-run solution for private consumption; a 100bp increase in spreads lowers consumption in the long-run by 0.5-0.6%. In turn the reduction in consumption and GDP has knock-on, accelerator effects on business investment. Unsecured spreads rose steeply in the crisis, and so account for a significant part of the fall in GDP. Over the past two years, the effect has begun to unwind in levels terms.

According to our model, the tightening in mortgage spreads also had a significant impact, peaking at around 1½ % of GDP in 2012. A given basis point change in mortgage spreads has a smaller role than a change in unsecured spreads in the long-run relationship for private consumption, and the increase in spreads was less dramatic. Furthermore, we suppress the long-run effect that house prices (which are sensitive to mortgage spreads) have on consumption.[26] However, shocks to mortgage spreads do have significant temporary, but highly persistent, impacts on consumption through a number of channels, which we interpret as picking up collateral effects, liquidity effects and other impacts relating to credit frictions. Additionally, mortgage spreads affect dwellings investment. Liquidity in the housing market may be an important driver of housebuilding, and mortgage borrowing is likely to be a common source of funding for home improvements.

Corporate spreads also play a significant role in the impact on GDP; the direct channel is through business investment. The impact of corporate spreads builds gradually over time to around ¾% of GDP, and has been diminishing more slowly than the impact from household spreads.

The rise in deposit spreads actually increases the level of GDP in our model – though the effect is small. This reflects two main points. Firstly, we found no significant role for deposit

[26] Unlike financial assets, which are ultimately claims on other sectors, increases in house prices do not really represent increases in the wealth of the household sector – they simply cause transfers of wealth between current owners and future first-time buyers. Econometric work with micro-data finds support for liquidity effects but not wealth effects, suggesting that the strong correlation between house prices and private consumption is driven mainly by common factors – see Attanasio et al (2005) and Disney et al (2010).

spreads in the long-run relationship for private consumption. This may partly reflect data limitations; because the Quoted Rates data are only available towards the end of the sample, we use effective rate data, which are not ideally suited for capturing the substitution effect on consumption. The effective rates data should also be *more* effective at picking up cashflow effects, which work (for deposits) in an opposite direction to substitution effects. Secondly, this is a very partial simulation. Deposits represent an important source of funding for banks, and deposit spreads should in principle feed into banks' marginal funding costs alongside other sources of funding. Shocking deposit spreads in isolation is therefore a very partial exercise; in reality any such shock would be likely to also increase loan rates.

The disaggregated structure of our model also allows us to break down the impact on GDP by the contribution of each expenditure component. This is done in Chart 4.3.

Chart 4.3: The contribution of expenditure components to GDP (net of imports)

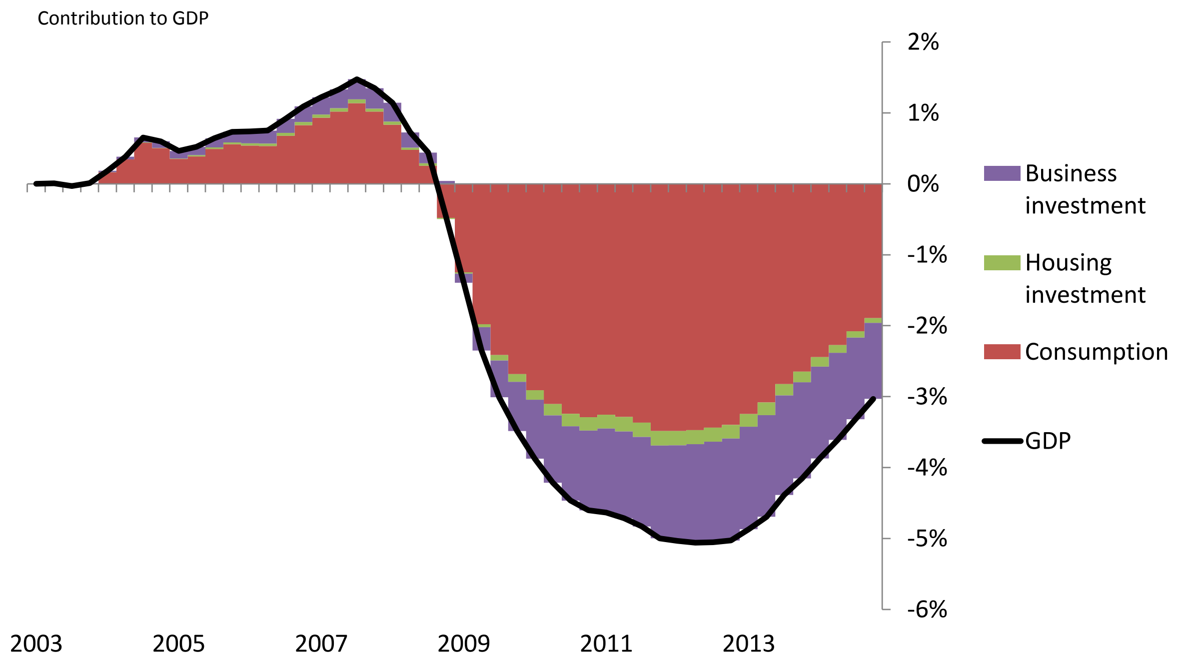


Chart 4.3 shows the difference from baseline for at each point in time, simulated by the model in response to deviations in spreads relative to 2003Q1

The majority of the fall in GDP is accounted for by consumption. At peak impact, most of the effects come from the rise in unsecured spreads, with a substantial additional role for mortgage spreads. Corporate spreads also reduce consumption. The effect of higher deposit spreads actually boosts consumption, but as discussed above this is a partial result that should not be taken out of context. Depending on the exact point of reference and definition of pre-crisis trend, our simulation explains around one third of the shortfall in consumption.

Business investment also accounts for a significant part of the fall in GDP. The largest effect comes from the rise in corporate spreads, which are still depressing business investment by around 8% by end-2014. However there are also large effects from both unsecured and mortgage spreads. The latter reflect how cyclical investment is; shocks that affect other components of GDP have significant knock-on effects for business investment.

On the face of it, our simulation can more than explain the shortfall in business investment against pre-crisis trend at the trough of the crisis. However, the appropriate counter-factual is particularly difficult to assess for business investment; after recent revisions by the ONS, business investment exhibits little if any upward trend in the ten years before the crisis.

Falls in housing investment account for only a small part of the total GDP picture. The rise in mortgage spreads reduces the level of housing investment by around 7-8% at peak, and unsecured spreads have a further effect of around 1% during the depth of the crisis. However these effects unwind, and spread shocks can only explain a small part of the 20-30% (at trough) fall in housing investment, illustrating the difficulties in modelling this component of GDP.

We can also use our model to estimate what changes in credit conditions have done to stocks of money and lending in each sector. Chart 4.4 shows what has our model suggests the credit shocks has done to lending aggregates.

Chart 4.4: Effect of all spread changes on lending

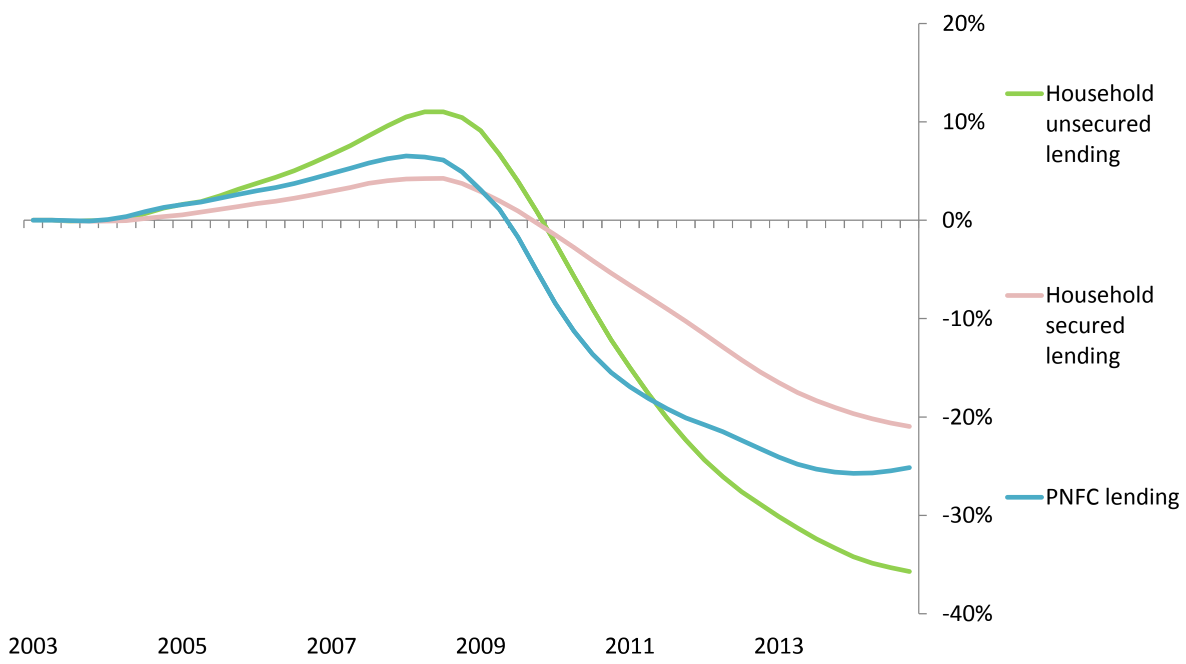


Chart 4.4 shows the difference from baseline at each point in time, simulated by the model in response to deviations in spreads relative to 2003Q1

On the eve of the crisis, falls in credit spreads had boosted both money and lending – although our model can explain only a limited part of the deviation from trend in money and lending aggregates.[27] As credit conditions tightened, our model can explain significant falls in lending to all three of the sectors we examine. Most dramatically, unsecured lending falls in our simulation by around 30-35% relative to its pre-crisis peak. This compares to an actual fall of around 60-70% against pre-crisis trend.[28] According to our model, by far the most important impact on unsecured lending comes from unsecured spreads themselves, with a more modest impact from secured spreads. The increase in deposit spreads actually offset the fall in unsecured spreads. Partly this is because of the counter-intuitive result, discussed above, that deposit spreads have a positive effect on GDP – unsecured lending is quite strongly pro-cyclical. Deposit spreads also enter directly into the equation for unsecured lending, which may indicate that they proxy for the opportunity cost of paying off unsecured debt.

The model also simulates a large fall in lending to PNFCs of around 25% against the pre-crisis peak, compared to a fall in the data of around 50-60% against pre-crisis trend. In our model, both corporate and household spreads make an important contribution to this, reflecting the highly cyclical nature of lending to PNFCs. Through indirect effects on the wider economy, household spreads affect corporate lending. The model simulates a more modest fall in secured lending – of around 20% (against a 45% fall against pre-crisis trends). The contribution to this is split roughly two thirds secured spreads and one third unsecured spreads, with a small offset from deposit spreads (reflecting similar channels as for unsecured lending).

The profiles in the simulations show household lending still falling, and corporate lending having only stabilised - relative to the counterfactual - in late 2014. This contrasts with the impact on GDP of credit shocks (see Charts 4.2 and 4.3), which has started to unwind in levels terms. Of course this contrast should not be over-interpreted – there have been many other shocks affecting both output and financial balance sheets. But it corresponds broadly to what we have observed in the data over the past 2 years; GDP has started to grow at rates more typical of the recovery phase of the cycle, whilst credit has remained very weak. Our model suggests that a credit shock of the magnitude of 2008/09 will have large and long-lasting impacts on GDP, but impacts on credit that are even greater and more persistent.

Finally, our model can be used to simulate what the credit shock has done to stocks of money (M4 deposits) in the household and corporate sectors. This is shown in Chart 4.5.

[27] Based on the measures we model, the stock of credit to the real economy grew by around 70% between end-2002 and end-2007. The ratio of credit to GDP increased from around 88% to around 124%. Other factors contributing to the strong trend in lending aggregates may have been the low level of global interest rates, changes in credit conditions that are not picked up by the spread data which we have used, or the long period of stable growth reducing perceptions of risk - see McCleay and Thomas (forthcoming).

[28] The range depends on how the 'pre-crisis trend' is defined – either by fitting a log linear trend to the data from 1997-2007, or by projecting the average growth rate over this period forward from 2007Q3 onwards. Of course, to the extent that there were influences in the pre-crisis period that had a secular effect on credit growth and which are not captured in our spread variables, this will not necessarily be the most appropriate counterfactual.

Chart 4.5: Effect of all spread changes on deposit balances

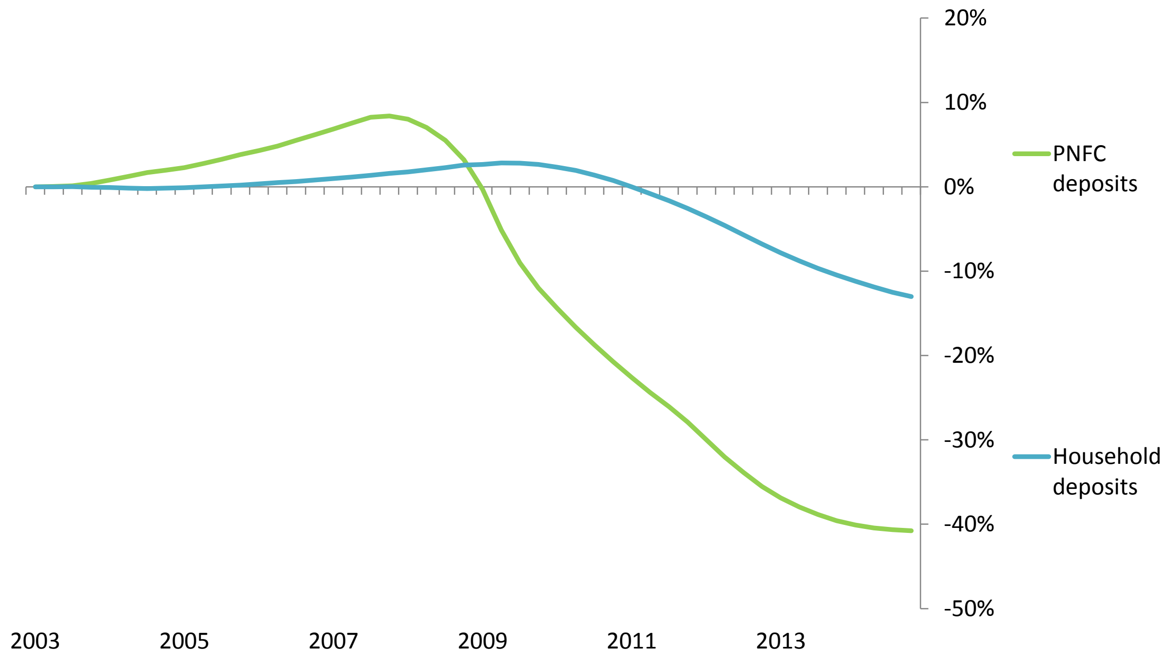


Chart 4.5 shows the difference from baseline at each point in time, simulated by the model in response to deviations in spreads relative to 2003Q1

In our simulation, household deposits fall modestly. Higher mortgage spreads have a relatively powerful negative effect on deposits, as the reduction in mortgage lending reduces deposit creation, whilst the knock-on effects on GDP further reduces transactions demand for deposits. However in the short run there is some offset from unsecured spreads. Most likely this reflects a precautionary demand for safe, liquid assets that is correlated with credit shocks. The positive substitution effect of deposit spreads on deposit volumes builds gradually.

The effect of the shocks on corporate deposit stocks is more dramatic. Principally this reflects the fact that we estimate corporate deposits to be much more cyclical than household deposits; as the shocks to lending spreads push down GDP and investment, corporate money falls too. There is also a channel from asset prices. Commercial real estate prices have a significant effect on corporate money, and we assume these move in line with house prices as a proxy for asset prices more broadly.[29] Unfortunately we do not have good data on how the marginal rates banks pay on corporate deposits changed during the crisis.[30] It may be that banks bid up the relative return on corporate deposits and offset some of the impacts of the

[29] In further work we plan to model the Commercial Real Estate (CRE) sector mode explicitly; a large part of the stock of lending to PNFCs is associated with CRE.
[30] Although the ONS data on interest flows can be combined with data on the stock of debt to calculate an implicit average interest rate, this is an effective stock rate, rather than a marginal rate. The BoE also collect data on corporate deposits, but again this tries to measure effective rates. The effective rate data do show rates increasing relative to Bank Rate, but we don't know to what extent this reflects the zero lower bound binding for non-marginal deposits.

other shocks. However it is worth noting that the increases in household deposit spreads do not translate into large predicted increases in deposits for households, because of the relatively long lags. The response of corporate deposits to spreads would have to be faster for this to be quantitatively important.

As explained in section 2, our model of the banking sector is simple, and we do not attempt to model the ultimate source of the credit shock itself, simply its impact on how banks interact with the real economy. However, our model can say something about what happens to some aspects of banks' balance sheets. The Customer Funding Gap (CFG) – defined as the difference between loans to and deposits from the real economy[31] – is defined by the paths of the money and credit variables in our model. The CFG is an interesting statistic because it shows the extent to which banks are using wholesale sources (for example, deposits from non-bank financial institutions, overseas financial institutions or securitisation) to fund domestic real economy lending. It can illustrate the extent to which strong lending is leading to financial fragility; it can also be an indicator that strong lending is related to financial imbalances at the sectoral level.

The CFG rose substantially during the expansion of the 2000s, from a position close to zero in 1999 to a peak of around 22% of annual GDP in late-2008 and early-2009. It has since fallen to around 3% of GDP as of end 2014.

As Charts 4.4 and 4.5 show, the simulation predicts that both lending from the banking sector to the real economy, and deposits from the real economy to the banking sector, fall as the credit shock hits. But lending falls further than deposits. This means the CFG in our simulation falls, by around 13ppt from its peak (in early 2009) to end 2014. Qualitatively at least, the path looks similar to the data.

However, whilst our simulation seems to fit well with the behaviour of the CFG in the tightening phase of the credit cycle, it does not come close to explaining the magnitude of the CFG's rise in the loosening phase. As credit spreads fall from 2003 (see Chart 4.1), this does generates an increase in the CFG which peaks in mid-2008, but only of around 3% - approximately one fifth of the rise observed in the data. This may indicate that credit conditions in the pre-crisis period loosened in dimensions that are not captured by our credit spreads. Another possibility is that the widening CFG was the symptom of a different kind of shock – for example, low and falling real interest rates, or lower perceived risk.

In summary, under some assumptions about the causal information contained within credit spreads, we can use our model to simulate the effects of both the pre-crisis loosening in credit conditions and the sharp tightening in 2008-09. We can trace out the effects on GDP by each component, and on money and credit in each sector. Our simulations suggest that the credit shock explains a substantial part of the falls observed in GDP and credit.

[31] Note this is a particular definition of the CFG; broader definitions are often used to monitor financial stability risks.

5. Other applications of the model

Sections 1 and 2 explained that one advantage of our disaggregated framework is flexibility. This flexibility means the model can potentially be used to estimate the impacts of a broader range of policy tools such as QE and Bank Rate (discussed in Section 3). This section sketches out how the model could be used to assess three other classes of policies: policies that are intended to reduce bank funding costs, regulatory liquidity policy, and some macroprudential tools.

Because there is not a single, straightforward mapping of these policies into shocks to the model, we do not present explicit simulations in this section as we do in section 4. Rather, we draw on results from elsewhere in this Working Paper to explain qualitatively how the model *could* be used to analyse the effect of these policies on money, lending and activity. We also discuss some of the complications involved in translating such policies into shocks that our model can interpret.

Regulatory liquidity policy – polices designed to reduce the liquidity risk borne by banks – encourage banks to hold more liquid assets, or to fund themselves with less flighty liabilities. Liquidity policies such as the Liquidity Cover Ratio (LCR) and Net Stable Funding Ratio (NSFR) have formed an important part of the regulatory response to the financial crisis at both an international and domestic level.

In one respect, the asset side of liquidity policy can be thought of as having a similar effect to QE. For a fixed stock of illiquid assets, the banking sector in aggregate will purchase more safe assets such as gilts and T-bills from the non-bank sector, and in doing so will create deposits and lead to portfolio rebalancing. In itself, this would stimulate activity in the economy, or so the results presented in section 3 would suggest. But there will be other effects also. On the liability side, banks will seek to issue more non-deposit liabilities, which will need to be bought by the non-bank financial sector. According to our estimated equations for the NIOFC sector, this will require a fall in asset prices, which is contractionary for spending in the economy. Finally, liquidity regulation may induce banks to simultaneously change the structure of both sides of their balance sheets, to reduce the ratio of loans to deposits. The results presented in section 4 suggest that an increase in spreads on both loans and deposits would achieve such an aim – and would also reduce GDP.

The overall effect on the economy would depend on the balance of these factors. To calibrate the shocks would require some relatively detailed analysis of how regulation would alter the incentives facing banks. This would be complicated if different constraints bind for different banks – which is likely to be the case in general.

Policies designed to reduce funding costs – for example, the BoE's Funding for Lending (FLS) scheme or the ECB's Long Term Repo Operations (LTROs and TLTROs) – can also be simulated in our model. Such policies – if successful – should have three main effects. Firstly, the direct effect of the funds made available from the Central Bank is to lower the marginal funding cost for banks. There are also indirect effects; as the funding provided by the Central Bank is a substitute to deposit funding, spreads of deposit rates relative to risk free rates should fall. Similarly, banks will need to issue fewer non-deposit liabilities to the non-financial sector, and the required rate of return on these assets will fall. Together with the direct effect on funding costs, all this means that the policy reduces the marginal funding cost that banks incur to finance lending, and so credit spreads should fall.

Lower spreads on both loans and deposits constitute a shock with the opposite sign to the credit shock simulated in section 4, and so should be positive for activity.[32] In addition, the reduction in the non-deposit liabilities of banks could be thought of as having a QE-like effect – non-bank financial institutions will substitute into other assets and so push up their price. Which channel – marginal funding cost or the reduction in funding requirement – is more important will depend on the incentive structures of the particular policy. Policies such as the FLS – modest relative to the size of bank balance sheets, but with a structure designed to closely target marginal cost – will tend to work more through the first channel. Policies that are larger in scale but where there are fewer conditions tied to the funding – for example the LTRO announced by the ECB in late 2011 – might be thought of as closer to QE in their effect. In any case, simulating a specific funding intervention with our model would first require a careful and detailed analysis of how it affects the incentives of banks, and of investors in markets for bank liabilities.

Other macroprudential policy

In the UK, the Financial Policy Committee (FPC) has been charged with designing and implementing macroprudential policy. This can include recommendations on liquidity policy, modelling the effects of which has been discussed in an earlier section. More broadly, macroprudential policy can include recommendations on such things as overall levels of capital, capital requirements for particular asset classes, or exposure limits. Whilst microprudential policy tries to ensure that each regulated institution has appropriate levels of capital and liquidity to protect it against the risks on its balance sheet, macroprudential policy attempts to ameliorate systemic risks that arise from the externalities inherent in bank behaviour. To do this generally involves employing tools that affect the whole banking sector. More detail on the institutional set up of the FPC, and the tools it has at its disposal, can be found in Hall et al (2013).

If financial frictions are important, then changes to macroprudential policy can have effects on aggregate output. Research to understand the impact on GDP of macroprudential policy is at an early stage. Partly this is because of the plurality of macroprudential policy (there are many more possible tools and dimensions than monetary policy), but also because the empirical modelling of credit frictions and default (without which macroprudential policy is not a first-order concern for output and inflation) is still in its infancy.

[32] Provided that the increase in deposit spreads is not so large that it outweighs the effect of lower spreads on loans. Whilst it is plausible the change in deposit spreads in response to the policy could be larger than the change in loan spreads – for instance if banks' net interest margins have fallen below their equilibrium, or if the level of competition is different in deposit compared to loan markets – our estimated multiplier for the effect of deposit spreads on GDP is of a much smaller magnitude than the multipliers for loans spreads.

When macroprudential policy changes are likely to result in changes to credit spreads, our model can potentially be used as a tool to assess the macroeconomic impacts of that policy. For example, changes to capital requirements at either an aggregate or sectoral level can be mapped into impacts on loan spreads, under certain assumptions.[33] Although such analysis should take into account the specifics of the policy, Harimohan and Nelson (2014) present a framework for thinking about how those macroprudential policies that relate to capital will affect credit conditions and spreads. Some of the effects of the policy can, therefore, be captured as a spread shock and simulated in a similar way to the experiment set out in section 4.[34]

Great care needs to be taken in considering how any particular policy will affect incentives. Whilst the fact that our model is sectoral gives it a lot of flexibility, macroprudential tools will often have noticeably different effects on different agents within a single sector. For example, some policy actions could affect high LTV mortgages more than low LTV ones. If high LTV lending only accounts for a modest share of mortgage lending, the effect on the average spread may be small; but this will obscure the compositional effects which may be an important part of the story.

Other macroprudential policies may try to tackle the build-up of debt more directly – for example the recommendations made in June 2014 on limiting the share of lending made at high loan-to-income ratios. Such policies are probably easier to think about in terms of what they do to the quantity of credit, rather than the price; that is, we have reasonable certainty about the magnitude of the leftward shift in the credit supply curve, even if we don’t know the elasticities of either supply or demand curves. Estimates of the quantity effect can be based on careful use of micro data, such as distributional data.

One option for simulating the macroeconomic impacts of such ‘quantity-based’ policies is to directly shock the quantity equations for the relevant kind of credit. However, as explained in sections 2 and 4, our identification strategy does not give us enough information to be confident that shocks to the quantity of lending represent shocks to either the supply or demand for credit; they are likely to be some mixture of the two. So it may be preferable to proxy the shock using credit spreads. This involves calibrating a shock to credit spreads that is sufficient to bring about the appropriate fall in the quantity of credit, and then observing what this shock does to output, in the same way as the simulations in section 4.

[33] There is no consensus about these assumptions. Ultimately the question comes down to what extent the Modigliani-Miller theorem holds strictly, and if it does not, in what ways it is violated. See Harimohan and Nelson (2014).

[34] There may be other considerations with capital policy that are less easy to map to spreads. Changes in capital policy have a marginal ‘substitution’ effect – each extra loan must be financed with more capital, which is more expensive. They also have an average ‘income’ effect – more capital must be held against the existing portfolio of assets. Banks that do not want their capital ratios to fall and are unable, or unwilling, to raise capital at the market price, may decide to deleverage more than would be implied by the increase in marginal cost and the demand schedule for loans. Such quantity effects are more difficult to relate into changes in spreads. See Harimohan and Nelson (2014) for more details.

A few important caveats should be noted. Firstly, great care needs to be taken in ensuring the simulation is as consistent as possible with the assumptions used to construct the micro-founded estimates of the quantity shock. In some circumstances, it may be preferable to 'switch-off' certain channels when calibrating the shock to credit spreads. For example, if the micro-based estimates of the impacts of a particular policy have been constructed under the assumption that house prices are fixed, then the initial spread shock should be calibrated by running a simulation in which the response of house prices is similarly suppressed. The house price channel could then be switched on again when the shock is run to gauge the impact on GDP.

Secondly, as with all modelling that uses historic data, the impact of a policy will differ from the simulations if the sample of data used does not include instances when the policy has been used. The policy may change the relationship between variables – for instance spreads, lending quantities and output – such that the past is not a good guide to the future. The best way to address this issue is to build an effective as possible understanding of how the policy works at a microeconomic level.

Finally, it may be difficult to map implications for output to implications for monetary policy. Any implications for monetary policy depend crucially on what a policy change does to aggregate supply relative to aggregate demand, which as we discuss in section 4 the model is agnostic on.

To summarise, our sectoral approach to modelling gives us the flexibility to estimate the impacts of a number of 'unconventional' policies. However, because our model of the banking sector is very simple, detailed consideration needs to be given to the microeconomics of each policy to determine the appropriate shocks to implement in our macro model.

6. Conclusions

This paper has outlined a sectoral empirical framework for modelling money and credit in the UK and exploring the transmission mechanism of various unconventional policies that affect the financial sector. In addition, we have given an example of how the model might be used to explore the damage caused by financial disturbances.

Our approach allows us to explore the sectoral inter-linkages between money, credit and real variables and builds on a range of previous papers looking at specific sectoral relationships. By modelling sectors individually we gain useful tractability that allows us to include a wide range of variables and possible transmission channels. By linking up the sectors using some aggregate relationships and identities, we are able to look at the joint impact of policies and disturbances on both the prices and quantities of different assets, their subsequent effects on GDP and the feedback loops from higher activity back on to the quantities and prices of assets.

As we noted in the introduction, the main motivation for this is driven by practical need to understand and monitor the transmission mechanisms of policies and shocks on different sectors, thrown up by the recent crisis. In the second half of the paper, we illustrate how our framework might be used to simulate the transmission of quantitative easing and disturbances in financial markets. Finally, we discussed how our framework could be modified to explore other policy interventions.

In our simulation examples, our baseline results support the estimates of the impact of QE found by other studies, such as event study impacts on asset prices and GDP. We show that QE may have important real effects both in the short term and over a longer horizon. We also discuss whether QE could have an effect on potential output over the longer term. That said, our results suggest the simulated effect of QE is sensitive to the assumption about whether, and to what extent, QE may have affected bank lending, through both the feedback effect from higher activity on to the demand for credit and the potential effect QE may have had on bank funding costs. In our simulation of the credit crisis, the tightening in credit conditions seen in 2008/09 in the UK can explain a substantial proportion of the subsequently observed shortfall in GDP. Depending on the sector, the shock can also explain a large part of the fall in credit extended to the real economy, and much of the contraction in the Customer Funding Gap.

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Appendix A: Data sources

Variable	Name	Real/nominal	Units	Source	Identifiers	Notes
				Household unsecured system		
M4H	Household M4	Nominal	£m	BoE (Bankstats)	VVHR, VVHS	SA, BA
HC	Real private consumption	Real	£m	ONS	ABJR+HAYO	SA, includes NPISH
M4LU	Unsecured lending to households	Nominal	£m	BoE (Bankstats)	BC46, VWAN	SA, BA
				Household secured system		
M4LS	Secured lending to households	Nominal	£m	BoE (Bankstats)	BC55, VWAH	SA, BA
IDKP	Housing investment	Real	£m	ONS	DFEG	SA, prior to 1997Q1 spliced backwards using growth rates of previous vintage data
GHW	Personal sector residential housing wealth	Nominal	£bn	BoE		Staff estimates based on ONS data and house price indices
				PNFC system		
M4P	PNFC M4	Nominal	£m	BoE (Bankstats)	VVHM, VVHL	SA, BA
INV	Business investment	Real	£m	ONS	GAN8	SA
UTIL	Capacity utilisation		Proportion of firms	CBI		Proportion of firms answering 'yes' to "Is your present level of output below capacity?"
M4LP	PNFC M4Lx	Nominal	£m	BoE (Bankstats)	BC57, VWNQ	SA, BA
PCP	Commercial Property prices	Nominal	Dec 1986 = 100	Investment Property Databank		Capital growth index
				Non-intermediate OFC system		
M4I	NIOFC M4	Nominal	£m	BoE (Bankstats)	TDFR, TDDR,NBSK,NBSM ,NIHY,NIYJ, VVHG, VVHF	SA, BA. BoE data on industrial depositsfrom 1997Q4; prior to this the data is spliced back with ONS data
RG	10 year gilt yield/return on shares	Nominal	%	BoE/ONS	AJLW, IUQAMNZC, FTSE all share dividend yield	See Bridges and Thomas (2012) for more details.
				Bank system		
STERLIABS	Total sterling liabilities of banks	Nominal	£m	BoE (Bankstats)	B54Q, B53Q, VZNN, VRHV, VZNS	Excludes IOFCs from 1997Q4 onwards
NNDLS	Banks' non-deposit liabilities	Nominal	£m	BoE (Bankstats)	VZNN, VRHV, VZNS	
BGILTS	Banks' holdings of gilts	Nominal	£m	BoE	VTMI,VRLO	
NOSD	Bank sterling net deposits from overseas	Nominal	£m	BoE (Bankstats)	VZNL, VZNQ	

				Aggregate system		
GDP	Real GDP	Real	£m	ONS	ABMI	SA
NGDP	Nominal GDP	Real	£m	ONS	YBHA	SA
PC	Personal Consumption deflator	Nominal	2010 = 100	ONS	ABJR, HAYO, ABJQ,HAYE	SA
P	GDP deflator	Nominal	2010 = 100	ONS	ABMI, YBHA	SA
HY	Labour income	Real	£m	ONS	MGSI, MGSL, MGRZ, RPHS, AIIV, CUCT, ROYJ	Households income, post tax and National Insurance contributions, from labour, self-employment and transfers ex unemployment benefit, deflated by PC (see above), SA
UR	Unemployment rate	Real	%	ONS	MGSX	
IM	Imports	Real	£m	ONS	IKBL	SA
				Spreads and rates		
RGA	Bank Rate	Nominal	%	BoE	BEDR	
RU	Composite unsecured rate	Nominal	%	BoE	BX67, HPTL, CCTL, ODTL, VWAZ, VWAY, VVYF, VVYI	A weighted average of £5k and £10k personal loans, overdraft and credit card rates. Data for £5k PL only available from 2005, data for overdrafts from 1995. Data for prior to 1995 based on historic advertised rates for credit cards and personal loan rates. Weights are based on stock data.
RMORT	Composite mortgage rate	Nominal	%	BoE, CML, BSA	BV34, B482, IUM2WTL, BV24, TLMV	A weighted average of rates for 75% LTV 2y, 90% or 95% LTV 2y, Bank Rate Tracker and Standard Variable Rate mortgages. Prior to 1987, spliced back using the CML Building Society Basic Mortgage Rate (see BSA Yearbook). Weights are based on Butt and Pugh (2014) - see pg 140.
RDHH	Household deposit rate	Nominal	%	BoE	VRWI, BF99, BF96, B3F3, B2F8, B4F2-3, B3F6-7, BC36, B4F7, B5F2, B5F4-9, B6F2	Average rates for sight, time and non-interest bearing deposits, weighted by value
RLP	Corporate loan rate	Nominal	%	BoE, ONS	HSDC, VUGJ, BC57	From 1999, BoE effective rates data. Prior to this, effective rate from Brigden and Mizen (2004)
RDP	Corporate deposit rate	Nominal	%	BoE	B5F3, B5F5, B5F8, VRVS, B2F7, BF98, B3F5, B3F2	Average rates for sight, time and non-interest bearing deposits, weighted by value
RB	Corporate bond rate	Nominal	%	Bank of America Merril Lynch, Global Financial Data, BoE		GFD used for spreads prior to 1996, BAML data after. Spreads are added to gilt rates (BoE) to get bond rates.
				Other variables		
CCI	Credit Conditions Index		Index	Fernandez-Corugedo and Muellbauer (2006)		
GFW	Gross financial wealth	Nominal	£m	ONS	NNML, ALDO	Prior to 1987 uses discontinued code ALDO

SA Seasonally adjusted
BA Break-adjusted. Stocks are calculated by cumulating flows, with the effects of transfers, write-offs and similar one-off transactions excluded.