BANK OF ENGLAND

Staff Working Paper No. 614

A dynamic model of financial balances for the United Kingdom

Stephen Burgess, Oliver Burrows, Antoine Godin, Stephen Kinsella and Stephen Millard

September 2016

BANK OF ENGLAND

Staff Working Paper No. 614

A dynamic model of financial balances for the United Kingdom

Stephen Burgess,[1] Oliver Burrows,[2] Antoine Godin,[3] Stephen Kinsella[4] and Stephen Millard[5]

Abstract

We construct a new scenario analysis model for the United Kingdom using ONS data from 1987 to the present. The model links decisions about real variables to credit creation in the financial sector and decisions about asset allocation among investors for a wide array of financial assets. We develop, estimate, and calibrate the model from first principles as well as describing the stock-flow coherent database we construct to validate the model. We impose several scenarios on the model to test its usefulness as a medium term scenario analysis tool, including increases in banks' capital ratios, sudden stops, changes in investment, increases in house prices and fiscal expansions.

Key words: Sectoral balances, flow of funds, macroeconomic modelling.

JEL classification: E21, E22, E25, E37.

(1) Bank of England. Email: stephen.burgess@bankofengland.co.uk
(2) Bank of England. Email: oliver.burrows@bankofengland.co.uk
(3) Kingston University. Email: a.godin@kingston.ac.uk
(4) University of Limerick. Email: stephen.kinsella@ul.ie
(5) Bank of England, Durham University Business School and Centre for Macroeconomics.
Email: stephen.millard@bankofengland.co.uk

The views expressed in this paper are those of the authors, and not necessarily those of the Bank of England. The authors wish to thank Sean Ryan for excellent research assistance and seminar participants at the Centre d'Economie de Paris Nord, Royal Holloway, University of London, the Hungarian Institute for Economics, the Hungarian National Bank and the Bank of England for useful comments. Any errors and omissions, of course, remain the fault of the authors.

Information on the Bank's working paper series can be found at
www.bankofengland.co.uk/research/Pages/workingpapers/default.aspx

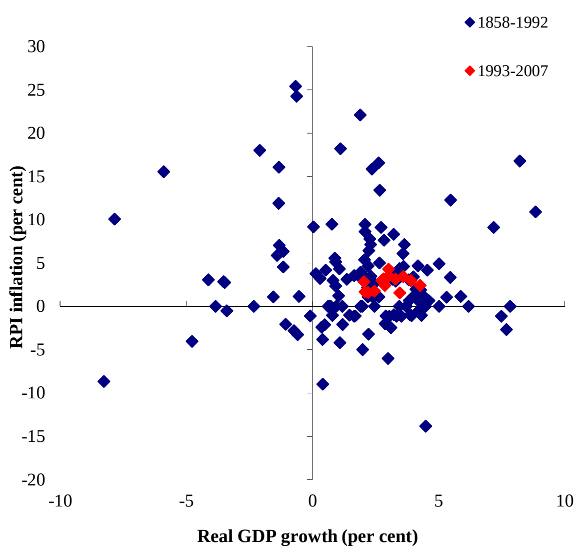
Publications Team, Bank of England, Threadneedle Street, London, EC2R 8AH
Telephone +44 (0)20 7601 4030 Fax +44 (0)20 7601 3298 email publications@bankofengland.co.uk

ISSN 1749-9135 (on-line)

1 Introduction

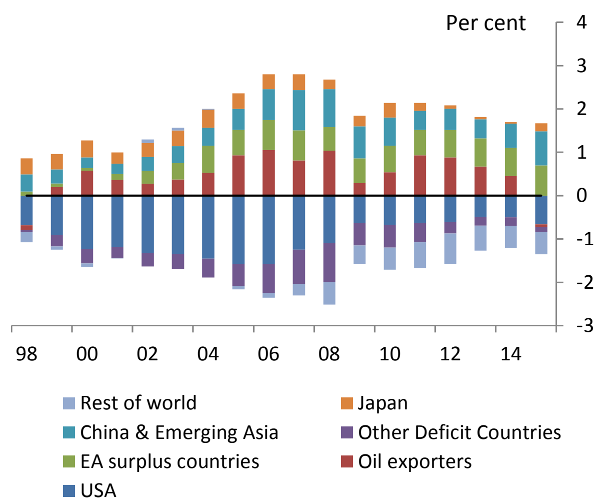
A puzzling feature of the build-up to the Great Recession was the apparent calm observed in the evolution of many key macroeconomic variables – a calm widely referred to as *The Great Moderation.* This *Great Moderation* can be seen in the United Kingdom in the unprecedented stability in GDP growth and inflation outcomes in the 1993-2007 period shown in Chart 1.[1] While it was a period of remarkable stability in aggregate output and price growth, there were concerns about the composition of growth, with sectoral financial balances, both within and across countries, attracting attention. Alongside debates about the causes of *The Great Moderation* ran the puzzle of 'global imbalances'. At a global level, this was apparent in the widening deficits and surpluses across countries shown in Chart 2. For nations like the United Kingdom and the United States, the domestic counterparts to widening current account deficits included unusually low and falling household savings rates and associated financial balances as shown in Chart 3. While these imbalances attracted attention and suggested that there was more to *The Great Moderation* than immediately met the eye, much of the retrospective work on the period has focused on the rapid build-up of gross financial positions underlying the (net) balances and in particular, the rapid growth of debt shown in Chart 4.[2]

Chart 1 UK annual growth and inflation outcomes over the past 150 years



Source: Bank of England

Chart 2 Global current accounts as a percentage of global GDP



Source: IMF

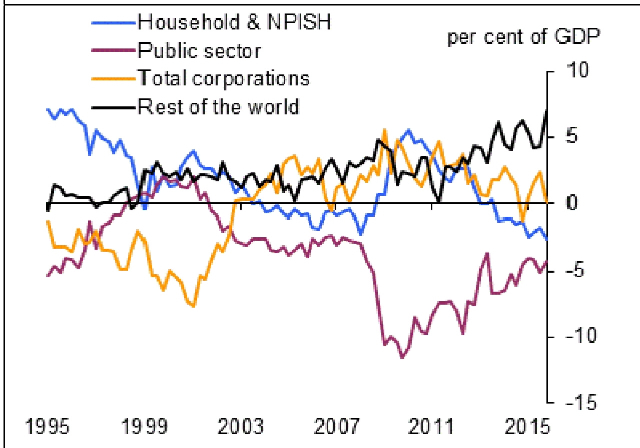
As has been pointed out many times since the crisis, the macroeconomic policy consensus at the time did not provide clear answers as to how policymakers should respond to either financial imbalances or the rapid growth of potentially unsustainable debt burdens, at a time when the real economy appeared

[1] Blanchard and Simon (2001) outline the key stylised facts for the Great Recession. Benati (2006) provides more formal evidence that the period experienced lower volatility in inflation and GDP growth than any previous period in 150 years of data.

[2] The literature on global imbalances has emerged rapidly since 2007. In particular, the papers of Mendoza *et al* (2007), Caballero and Krishnamurthy (2009), Obstfeld (2012) and Chinn *et al.* (2014) explore the nature and provenance of global imbalances, while Bussière *et al.* (2013) and Borio (2014) highlight the need to model financial imbalances within macroeconomic models and summarise the attempts to do so by the profession.

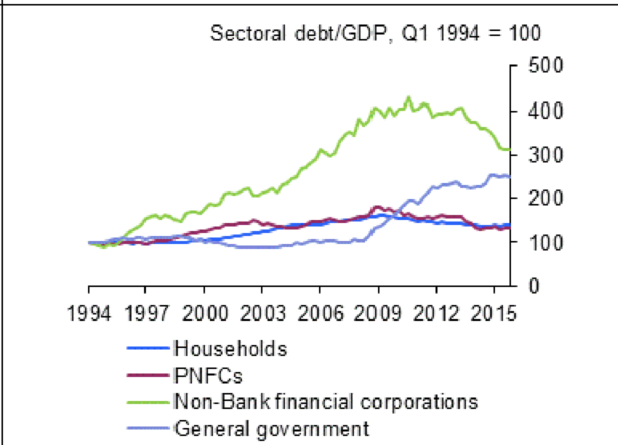
to be stable. The ‘standard’ Dynamic Stochastic General Equilibrium (DSGE) models, on which many policy makers relied, typically had little or no role for financial flows. When the financial crisis struck, these models had little to say about how financial flows had contributed to the crisis and how they might evolve post crisis.

Chart 3: UK sectoral financial balances



Source: ONS. NPISH = non-profit institutions serving households

Chart 4: UK sectoral debt



Source: ONS. PNFC = private non-financial corporations. Debt securities and loans are both included.

This paper aims to make a contribution towards filling in this gap in modelling imbalances, by developing a model with which we can assess how economic and financial imbalances are likely to evolve over longer periods, and whether such an evolution is likely to be sustainable for the UK economy. In addition, we can use the model to examine the evolution of financial balances under different scenarios and observe what the implications might be for monetary and macro-prudential policy over the medium term. We argue that such a model would form a useful addition to the set (‘suite’) of models called upon by policy makers to help them in their decision making.[3]

Our paper makes two contributions to the literature. First, we develop, estimate, and calibrate the model itself from first principles as well as describing the stock-flow consistent database we construct to validate the model; as far as we know, we are the first to develop such a sophisticated SFC model of the UK economy in recent years.[4] And second, we impose several scenarios on the model to test its usefulness as a medium-term scenario analysis tool.

The approach we propose to use links decisions about real variables to credit creation in the financial sector and decisions about asset allocation among investors. It was developed in the 1980s and 1990s by James Tobin on the one hand, and Wynne Godley and co-authors on the other, and is known as the ‘stock-flow consistent’ (SFC) approach. The approach is best described in Godley and Lavoie (2012) and Caverzasi and Godin (2015) and underpins the models of Barwell and Burrows (2011), Greiff *et al*. (2011), and Caiani *et al.* (2014a,b). Dos Santos (2006) describes how SFC models incorporate detailed accounting constraints typically found in systems of national accounts. SFC models allow us

[3] For a discussion of how the Bank of England uses a suite of models in its economic analysis, see Burgess *et al.* (2013).
[4] Such models were popular in the past; for example Davis (1987a, 1987b) developed a rudimentary stock flow consistent model of the UK economy.

to build a framework for the model where every flow comes from somewhere in the economy and goes somewhere, and sectoral savings/borrowings and capital gains/losses add or subtract from stocks of wealth/debt, following Copeland (1949). Accounting constraints allow us to identify relationships between sectoral transactions in the short and long run. The addition of accounting constraints is crucial, as one aspect of the economy we would like to model is the way it might react differently when policies such as fiscal consolidations are imposed slowly or quickly.

Compared with standard DSGE Models such as COMPASS (see Section 4 of Burgess *et al.* (2013)), these models have several advantages: they can be used to analyse the evolution of gross positions of financial assets and liabilities and gross and net financial flows under different assumptions; they allow for feedbacks from financial asset positions to real economic decisions; variables within the models react differently to policies imposed slowly or quickly thus finding different steady states; they allow for an important, and realistic, role for money, credit and banks; they typically (though not necessarily) impose more realistic specifications for expectations and are more realistic than typical DSGE models in terms of the behaviour, and heterogeneity, of agents within the model.

Table A: Pros and cons of using the SFC approach rather than the DSGE approach

Pros	**Cons**
Typically use national accounting constraints to provide a framework.	The model equations are not explicitly linked to the optimisation problems of particular agents.
Allow modelling of gross flow and balance sheet positions by sector.	The framework is not well-established, which makes it harder to take on board insights from other work.
Can be used to model feedback from financial asset and liability positions to the paths for production and spending.	The models are complicated, which makes it hard to explain the main economic mechanisms at work.
Can include an important role for money, credit and the financial system.	They are hard to take to the data: the data requirements are large relative to those in more standard DSGE models.
Can offer a framework for exploring different specifications for agents' expectations.	The model parameters suffer from the Lucas critique: they can be affected by changes in policy regime or time series properties of the driving processes.
Arguably SFC models have more realistic behavioural assumptions than many models which are micro-founded.	The models are not so clearly linked to economic theory.

Against the benefits of SFC models, DSGE models have the advantage that the equations underpinning them are based more directly on the underlying problems facing individual economic agents and are more clearly linked to economic theory; the parameters of each DSGE model are 'structural' in the sense of being invariant to changes in policy or the time-series properties of the driving processes (ie, are 'Lucas-critique proof'); they are simple enough that the mechanisms at work can be explained easily; they produce (at least when linearised) a VAR representation of the endogenous variables that should, in theory, be straightforward to take to the data; and techniques for estimating these models are well developed and understood. In addition, there has been an explosion of work trying to incorporate financial frictions into these models in such a way as they can generate financial crises. (See, eg, Benes *et al*. (2014).) Table A lists the pros and cons of using the SFC approach rather than a more standard DSGE approach. We view these modelling approaches as complements, rather than substitutes, and develop our model accordingly.

The remainder of the paper is structured as follows. Section 2 describes the model. Section 3 describes how we construct the data we use from UK sectoral accounts and flow-of-funds data, and how we calibrate the model using these data. We then discuss a 'clean' forecast produced by the model in section 4, before using it to examine several scenarios for how the UK economy may evolve in the next few years in section 5. Section 6 concludes.

2 Model

Our SFC model of the United Kingdom contains six sectors. Each sectoral variable is indicated by a subscript in brackets. We model households (H); non-financial companies (NFCs); the government (G); banks (B); insurance companies and pension funds (ICPFs); and a simplified rest of the world sector (ROW).

2.1 Households

We first lay out the main behavioural equations for the households. (The housing market will be described on its own later.) Households consume out of their disposable income, *YD*, composed of wages *WB* plus government transfers T_H, interest received on deposits $i_{D,-1}.D_{-1}$, as well as any income from annuities *Ann*, less taxes τ_H, pension contributions, *Pens*, and payments related to their mortgages, namely interest paid on mortgages $i_{Mort,-1}.Mort_{-1}$. Taxes are levied in a fixed proportion θ_H to the wage bill, pension contributions are a fixed proportion ρ of expected household disposable income.

$$YD = WB - \tau_H - i_{Mort,-1}Mort_{-1} - Pens + i_{D,-1}D_{H,-1} + T_H + Ann \quad \textbf{(1)}$$

$$\tau_H = \theta_H WB \quad \textbf{(2)}$$

$$Pens = \rho.E(YD) \quad \textbf{(3)}$$

We implement a Haig-Simons consumption function which relates consumption, *C*, to expected disposable income and net wealth accrued in the past $NW_{H,-1}$. The marginal propensities to consume out of both expected disposable income and current net wealth are assumed to be fixed.

$$C = \alpha_1.E(YD) + \alpha_2.NW_{H,-1} \quad \textbf{(4)}$$

Net wealth will be given by the sum of deposits *D*, housing wealth, P_hH, net of mortgage debt, *Mort*, and pension wealth, *ITR*. Household pension wealth will be equal to the liabilities of the ICPF sector, which we discuss in section 2.4 below.

$$NW_H = D_H + ITR + P_hH - Mort \quad \textbf{(5)}$$

The change in aggregate deposit stock is given by household-sector net lending, NL_H, (adjusted for pension contributions) less the net uptake of new mortgages (ie, new mortgages taken out, $Mort_{new}$, less old mortgages repaid, $Mort_{rep}$). In turn, household-sector net lending will be given by disposable income less consumption and investment in housing, I_h. Hence:

$$\Delta D_H = NL_H + Mort_{new} - Mort_{rep} - Pens \quad \textbf{(6)}$$
$$NL_H = YD + Pens - C - I_h \quad \textbf{(7)}$$

We next discuss the housing market specifically. We assume that the stock of housing grows at an exogenous rate and that housing transactions (H_{sold}) depend on house price inflation:

$$H_t = H_{t-1} + g_H \quad \textbf{(8)}$$
$$H_{sold} = \varphi_1 + \varphi_2 \Delta P_h \quad \textbf{(9)}$$

The price of a house is proportional to the household debt to income ratio times expected disposable income, divided by the total stock of housing. And we assume that the debt to income ratio grows at a constant rate. Putting this together we have:

$$p_H = \frac{r_S \cdot DTI \cdot E(YD)}{H} \quad \textbf{(10)}$$
$$DTI = DTI_{-1} + \zeta_1 \quad \textbf{(11)}$$

New mortgages are a function of the loan to value ratio, *LTV*, itself the exogenous ratio of new mortgages $Mort_{new}$ to the value of Mortgage repayments, $Mort_{rep}$, which grow in line with the (lagged) growth in new mortgages, and the relation shown in equation **(9)**.

$$Mort_{new} = LTV . p_H . H_{sold} \quad \textbf{(12)}$$
$$\Delta Mort = Mort_{new} - Mort_{rep} \quad \textbf{(13)}$$
$$\frac{Mort_{rep,t}}{Mort_{rep,t-1}} = e^{\varepsilon_1} \left(\frac{Mort_{new,t-1}}{Mort_{new,t-2}} \right)^{\varepsilon_2} \quad \textbf{(14)}$$

Finally, nominal investment in housing is assumed to be a simple linear function of (lagged) new mortgages and (lagged) house prices:

$$I_{H,t} = \vartheta_1 + \vartheta_2 Mort_{new,t-1} + \vartheta_3 P_{h,t-1} \quad \textbf{(15)}$$

2.2 Firms

Firms have to make a set of interrelated decisions about how much to produce, investment, employment and finance.[5] Their output will be demand driven but we ensure that, in the long run, demand grows at the same rate as productive potential.

We assume a flexible labour market and a Cobb-Douglas production function. In this case, the labour share is constant:

[5] Our description of firms draws strongly on Chapter 11 of Godley and Lavoie (2012).

$$WB = (1-\gamma)GDP \tag{16}$$

Where GDP is defined as gross output, *Y*, less imports, *M*:

$$GDP = Y - M \tag{17}$$

We allow firms to accumulate productive capital by investing and that this investment, *I*, will depend upon capital utilisation and the cost of financing investment by bank loans. Hence:

$$k_t = (1-\delta)k_{t-1} + I_t \tag{18}$$

$$g_{k,t} = \left(\frac{k_t - k_{t-1}}{k_{t-1}}\right) = \gamma_Y + \gamma_u \frac{GDP_{t-1}}{k_{t-1}} - \gamma_r\left(i_{L,t-1} - i_{R,t-1}\right) \tag{19}$$

The ratio of GDP to the capital stock, *k*, proxies capital utilisation, and i_L is the interest rate on bank loans, while i_R is the risk-free interest rate (that paid by the central bank on reserves held with it).

Firms are also assumed to hold deposits, D_F, these are assumed to grow in line with nominal GDP according to:

$$D_{F,t} = D_{F,t-1}\frac{GDP_t}{GDP_{t-1}} \tag{20}$$

Demand comes from consumption, investment in physical capital and housing, I_H, government spending, *G*, and exports, *X*, and will equal gross output:

$$Y = C + I + I_H + G + X \tag{21}$$

Since firms use imports as intermediates in production, we assume that demand for imports depends on output and the exchange rate, *e*:

$$M_t = M_{t-1}\exp\left(\mu_1 + \mu_2 \ln\left(\frac{Y_{t-1}}{Y_{t-2}}\right) + \mu_3\left(e_{t-1} - e_{t-2}\right)\right) \tag{22}$$

Firms are assumed to retain a constant proportion of their (post-tax) profits, Π_F, as retained earnings, $\Pi_{F,U}$, and distribute the rest as dividends, Div_F. Hence,

$$\Pi_{F,t} = Y_t - M_t - WB_t - \left(\tau_{F,t} - T_{F,t}\right) - i_{L,t-1}L_{t-1} + i_{D,t-1}D_{F,t-1} \tag{23}$$

$$\Pi_{F,U} = s_F \Pi_F \tag{24}$$

$$Div_F = (1 - s_F)\Pi_F \tag{25}$$

Where τ_F are taxes paid by firms, T_F are government transfers to firms and *L* is the (end-of-period) stock of outstanding bank loans to firms. Taxes are levied as a fixed percentage of pre-tax profits:

$$\tau_F = \theta_F \left(Y_t - M_t - WB_t - i_{L,t-1} L_{t-1} + i_{D,t-1} D_{t-1} \right) \quad \textbf{(26)}$$

Dividends are distributed to the holders of firm equity – ICPFs and the rest of the world – in proportion to the value of their equity holdings, $V_{F,\ ICPF}$ and $V_{F,RoW}$, respectively:

$$Div_{F,ICPF} = Div_F \frac{V_{F,ICPF}}{V_F} \quad \textbf{(27)}$$

$$Div_{F,RoW} = Div_F \frac{V_{F,RoW}}{V_F} \quad \textbf{(28)}$$

Firms issue equities, v_F, at a price $P_{V,F}$,– again to ICPFs and the rest of the world – in order to finance a relatively small proportion of their investment spending. (The lower case *v* denotes a volume measure.) The price at which they issue the equities equates the nominal demand for them with the supply:

$$v_{F,t} = v_{F,t-1} + \frac{\psi_V I_{t-1}}{E\left(P_{V,F,t}\right)} \quad \textbf{(29)}$$

$$P_{V,F,t} v_{F,t} = V_{F,t} = V_{F,ICPF,t} + V_{F,RoW,t} \quad \textbf{(30)}$$

Any remaining investment spending that cannot be financed out of retained earnings is then financed by bank borrowing:

$$L_t = L_{t-1} - NPL_t - NL_{Ft} - P_{V,F,t} \Delta v_{F,t} + \Delta D_{F,t} \quad \textbf{(31)}$$

Notice that, in the first instance, new loans to firms (as well as loan write-offs, *NPL*) will be matched by a rise in firms' bank deposits. As the money is spent, it will move out of firm bank deposits into changes in firms' net lending and equity, such that equation **(23)** will continue to hold. This means that our model is compatible with the 'banks as creators of money through lending' way of thinking about banks stressed by Jakab and Kumhof (2015).

By definition net lending of the corporate sector will be given by:

$$NL_F = \Pi_F - Div_F - I_t \quad \textbf{(32)}$$

And write-offs, *NPL*, are given by:

$$NPL_t = \xi_1 L_{t-1} \quad \textbf{(33)}$$

2.3 Government

We assume government expenditures G are exogenously determined, in order to examine the effects of different paths for future government spending. Given its expectation of the price at which it will be able to sell them, the government issues enough bonds, b_G to cover its deficit. These bonds are held by the rest of the world, the ICPF sector, and, for monetary policy purposes, by the Bank of England. So nominal demand for government bonds will be given by:

$$B_G = B_{G,ICPF} + B_{G,RoW} + B_{G,CB} \quad \textbf{(34)}$$

Once the price of these bonds is revealed, the government finances any further borrowing by issuing short-term bills, *Gbills*, which we assume to be non-interest-bearing. Net lending by the government, NL_G, will be given by the difference between government revenue, including profits remitted from the central bank, and expenditure, including interest payments on its debt:

$$NL_G = \tau_H + \tau_F - G - T_H - T_F - i_{B,G,-1} B_{G,-1} + \Pi_{CB} \quad \textbf{(35)}$$

Hence, the real supply of government bonds will be given by:

$$b_{G,t} = b_{G,t-1} - \frac{NL_{G,t}}{E(P_{B,G,t})} + \frac{GBills_{t-1}}{E(P_{B,G,t})} \quad \textbf{(36)}$$

Their price will be given by:

$$P_{B,G,t} = \frac{B_G}{b_G} \quad \textbf{(37)}$$

And the supply of bills will be given by:

$$GBills_t = E(P_{B,G,t}) \Delta b_{G,t} - \left(B_{G,t} - B_{G,t-1} \frac{P_{B,G,t}}{P_{B,G,t-1}} \right) \quad \textbf{(38)}$$

Transfers to households and firms are assumed to grow in line with nominal GDP. And, finally, the interest rate paid on government bonds is related to their price according to:

$$i_{G,t} = \iota_1 + \iota_2 * P_{B,G,t} \quad \textbf{(39)}$$

2.4 ICPF sector

We assume that the agents have defined contribution pensions. At retirement, they take their pot of savings and spend it on an annuity. We assume that annuity payments depend on accumulated pension wealth:

$$Ann = \zeta_1 + \zeta_2 ITR \quad \textbf{(40)}$$

The ICPF sector faces market risk on its balance sheet. Its assets, A_{ICPF}, consist of bonds issued by the government, the banks, $B_{\mathrm{B,ICPF}}$, and the rest of the world, B_{ROW}, as well as domestic and foreign equities, V_{ROW}:

$$A_{ICPF} = B_{G,ICPF} + B_{B,ICPF} + B_{ROW} + V_{F,ICPF} + V_{ROW} \quad \textbf{(41)}$$

Where we can note that B_{ROW} and V_{ROW} are denoted in domestic currency.

ICPFs' profits, Π_{ICPF}, consist of returns on their investments less the annuity payments they make to households. We assume that, when deciding on dividends, Div_{ICPF}, which are paid out to investors in the rest of the world, ICPFs target a share of their expected net worth.

$$\Pi_{ICPF,t} = i_{B,G,t-1}B_{G,ICPF,t-1} + i_{B,B,t-1}B_{B,ICPF,t-1} + i_{B,ROW,t-1}B_{ROW,t-1} + Div_{F,ICPF,t} + Div_{ROW,t} - Ann_t \quad (42)$$

$$Div_{ICPF,t} = (1 - s_{ICPF})(E(A_{ICPF,t}) - ITR_{t-1}) \quad (43)$$

$$E(A_{ICPF,t}) = A_{ICPF,t-1} + E(NL_{ICPF,t}) + Pens_t \quad (44)$$

$$NL_{ICPF,t} = \Pi_{ICPF,t} - Div_{ICPF,t} \quad (45)$$

Where NL_{ICPF} denotes net lending of the ICPF sector and we can note that Div_{ROW} is denoted in domestic currency. The change in household pension wealth will then be given by:

$$\Delta ITR = \Delta A_{ICPF} - NL_{ICPF} \quad (46)$$

The ICPF sector faces a portfolio allocation problem in that it needs to allocate its funds across domestic and foreign bonds and domestic and foreign equity. We assume that the change in the proportion of its assets held in a particular asset class depends on the relative rates of return on each asset class. This approach is similar, in spirit, to the method used by Brainard and Tobin (1968) except that we allow for the presence of trends in investor sentiment towards particular asset classes, reflecting what we observe in our data.[6] As with Brainard and Tobin, we impose the condition that these shares must sum to unity in every period by definition.

$$\begin{pmatrix} B_{G,ICPF,t} \\ B_{B,ICPF,t} \\ B_{RoW,t} \\ V_{F,ICPF,t} \\ V_{RoW,t} \end{pmatrix} = \left(\begin{pmatrix} \frac{B_{G,ICPF,t-1}}{A_{ICPF,t-1}} \\ \frac{B_{B,ICPF,t-1}}{A_{ICPF,t-1}} \\ \frac{B_{RoW,t-1}}{A_{ICPF,t-1}} \\ \frac{V_{F,ICPF,t-1}}{A_{ICPF,t-1}} \\ \frac{V_{RoW,t-1-1}}{A_{ICPF,t-1}} \end{pmatrix} + \begin{pmatrix} \lambda_{ICPF,1,0} \\ \lambda_{ICPF,2,0} \\ \lambda_{ICPF,3,0} \\ \lambda_{ICPF,4,0} \\ \lambda_{ICPF,5,0} \end{pmatrix} + \begin{pmatrix} \lambda_{ICPF,1,1} & \lambda_{ICPF,1,2} & \lambda_{ICPF,1,3} & \lambda_{ICPF,1,4} & \lambda_{ICPF,1,5} \\ \lambda_{ICPF,2,1} & \lambda_{ICPF,2,2} & \lambda_{ICPF,2,3} & \lambda_{ICPF,2,4} & \lambda_{ICPF,2,5} \\ \lambda_{ICPF,3,1} & \lambda_{ICPF,3,2} & \lambda_{ICPF,3,3} & \lambda_{ICPF,3,4} & \lambda_{ICPF,3,5} \\ \lambda_{ICPF,4,1} & \lambda_{ICPF,4,2} & \lambda_{ICPF,4,3} & \lambda_{ICPF,4,4} & \lambda_{ICPF,4,5} \\ \lambda_{ICPF,5,1} & \lambda_{ICPF,5,2} & \lambda_{ICPF,5,3} & \lambda_{ICPF,5,4} & \lambda_{ICPF,5,5} \end{pmatrix} E \begin{pmatrix} r_{B,G,t} \\ r_{B,B,t} \\ r_{B,RoW,t} \\ r_{V,F,t} \\ r_{V,RoW,t} \end{pmatrix} \right) E(A_{ICPF,t}) \quad (47)$$

Where the actual and expected returns on the ICPFs assets are defined by:

[6] By implication, we expect these time trends to continue over the horizon of the scenarios we consider, though we can always aim off them when actually using the model for scenario analysis. Clearly, for the model to have a well-defined steady state, then the constants must all equal zero, i.e., these trends must stop at some point and the asset shares within the portfolio remain constant from that point onwards.

$$1+E\left(r_{B,G}\right)=E\left(i_{B,G}\right)+\frac{E\left(P_{B,G}\right)}{P_{B,G,-1}} \quad \textbf{(48)}$$

$$1+r_{B,G}=i_{B,G}+\frac{P_{B,G}}{P_{B,G,-1}} \quad \textbf{(49)}$$

$$1+E\left(r_{B,B}\right)=E\left(i_{B,B}\right)+\frac{E\left(P_{B,B}\right)}{P_{B,B,-1}} \quad \textbf{(50)}$$

$$1+r_{B,B}=i_{B,B}+\frac{P_{B,B}}{P_{B,B,-1}} \quad \textbf{(51)}$$

$$1+E\left(r_{B,ROW}\right)=E\left(i_{B,ROW}\right)+\frac{E\left(P_{B,RoW}\right)}{P_{B,RoW,-1}}+\frac{e_{-1}}{e} \quad \textbf{(52)}$$

$$1+r_{B,RoW}=i_{B,ROW}+\frac{P_{B,RoW}}{P_{B,RoW,-1}}+\frac{e_{-1}}{e} \quad \textbf{(53)}$$

$$1+E\left(r_{V,F,t}\right)=\frac{E\left(Div_{F,t}\right)}{V_{F,t-1}}+\frac{E\left(P_{V,F}\right)}{P_{V,F,-1}} \quad \textbf{(54)}$$

$$1+r_{V,F,t}=\frac{Div_{F,t}}{V_{F,t-1}}+\frac{P_{V,F}}{P_{V,F,-1}} \quad \textbf{(55)}$$

$$1+E\left(r_{V,ROW,t}\right)=\frac{E\left(Div_{ROW,t}\right)}{V_{ROW,t-1}}+\frac{E\left(P_{V,RoW}\right)}{P_{V,RoW,-1}}+\frac{e_{-1}}{e} \quad \textbf{(56)}$$

$$1+r_{V,ROW,t}=\frac{Div_{ROW,t}}{V_{ROW,t-1}}+\frac{P_{V,RoW}}{P_{V,RoW,-1}}+\frac{e_{-1}}{e} \quad \textbf{(57)}$$

2.5 Banks

Banks set their bond issuance, B_B at the beginning of each period in order to make their balance sheets balance at the end of the period, given the price at which they expect to be able to sell them. Demand for bank bonds comes from the ICPF sector and from the rest of the world. In nominal terms, we have simply that:

$$B_B=B_{B,ICPF}+B_{B,ROW} \quad \textbf{(58)}$$

Once the price of these bonds is revealed, the banks finance any further borrowing by issuing short-term non-interest-bearing bills, *BBills*. Net lending by the banking sector, NL_B, will be given by:

$$NL_{B,t}=i_{Mort,t-1}Mort_{t-1}+i_{L,t-1}L_{t-1}-i_{D,t-1}\left(D_{H,t-1}+D_{F,t-1}\right)-i_{B,B,t-1}B_{B,t-1}-Div_{B,t} \quad \textbf{(59)}$$

The supply of bank bonds will be given by:

$$b_{B,t}=b_{B,t-1}+\frac{\Delta Mort_t+\Delta L_t-\Delta D_{H,t}-\Delta D_{F,t}-\Delta V_{B,t}-NL_{B,t}+NPL_t+BBills_t}{E\left(P_{B,B,t}\right)} \quad \textbf{(60)}$$

Where V_B denotes bank equity, assumed to be privately-held and not traded by investors in the rest of the world, and the supply of bills will be given by:

$$BBills_t = E(P_{B,B,t})\Delta b_{B,t} - \left(B_{B,t} - B_{B,t-1} \frac{P_{B,B,t}}{P_{B,B,t-1}} \right) \quad \textbf{(61)}$$

The price of bank bonds matches up demand and supply:

$$P_{B,B,t} = \frac{B_{B,t}}{b_{B,t}} \quad \textbf{(62)}$$

The interest rate paid on bank bonds will be given by:

$$i_{B,B,t} = o_1 + i_{B,G,t} + o_2 P_{B,B,t} \quad \textbf{(63)}$$

Turning to bank equity, we fix its price, implying that its return will be given by:

$$r_{V,B,t} = \frac{Div_{B,t}}{V_{B,t}} \quad \textbf{(64)}$$

where Div_B denotes dividends paid out by the banks to their foreign shareholders. Banks' equity will evolve as:

$$\Delta V_B = NL_B - NPL \quad \textbf{(65)}$$

Banks will set their equity, V_B, so as to target a risk-weighted capital ratio greater than the regulatory minimum, υ_{min}, which depends on risk-weighted assets:

$$V^T{}_{B,t} = (\nu_{\min} + \nu_0)(\nu_1 Mort_t + \nu_2 L_t) \quad \textbf{(66)}$$

Where ν_1 and ν_2 denote the risk weights on mortgages and loans, respectively.

We assume that the banks distribute dividends to ensure a constant return on their equity:

$$Div_{B,t} = \xi_1 V_{B,t-1} \quad \textbf{(67)}$$

We can define the banks' aggregate regulatory capital ratio, ν_B and their leverage ratio, *lev*, by

$\nu_{B,t} = \frac{V_{B,t}}{\nu_1 Mort_t + \nu_2 L_t}$ and $lev_t = \frac{V_{B,t}}{Mort_t + L_t}$, respectively.

We assume that banks in aggregate adjust to deviations of capital from its target level by adjusting the mark-up they charge on loans. Specifically, banks set the interest rate on loans as a mark-up over average funding costs and on deposits as a mark down on the rate of interest the central bank pays them on their holdings of reserves, i_R. By setting the interest rate, they are making a supply decision and giving us some leverage over supply, without having to let price clear the market. The mark-up on loans depends on the deviation of actual capital from its target level.

$$i_{Mort} = \chi_{0,Mort} + \chi_{1,-1}.E(i_D) + \chi_{2,-1}.E(i_{B,B}) + \chi_{3,-1}.E(r_{V,B}) - \xi_2.\nu_1.(V_{B,t-1} - V^T{}_{B,t-1}) \quad \textbf{(68)}$$

$$i_L = \chi_{0,L} + \chi_{1,-1}.E(i_D) + \chi_{2,-1}.E(i_{B,B}) + \chi_{3,-1}.E(r_{V,B}) - \xi_2.\nu_2.(V_{B,t-1} - V^T{}_{B,t-1}) \quad \textbf{(69)}$$

$$i_D = \chi_{0,D} i_R - \chi_{1,D} \quad \textbf{(70)}$$

where $\chi_1 = \frac{D_H}{D_H+B_B+V_B}$, $\chi_2 = \frac{B_B}{D_H+B_B+V_B}$, $\chi_3 = \frac{V_B}{D_H+B_B+V_B}$ and the $\chi_{0,i}$ incorporate a measure of the riskiness of the various assets, and $E(r_{V,B})$ is the expected return on bank equity.

2.6 Rest of the world

The trade balance is determined by the demand for imports from firms and the exogenous demand for UK exports emanating from the rest of the world, X. The current account, which will be the negative of net lending by the rest of the world denominated in sterling, NL_{ROW}, is then composed of the trade balance and dividends and interests payments by domestic firms and banks as well as exogenous flows of dividends and bonds payments from the rest of the world to the ICPF sector:

$$\begin{aligned} NL_{ROW} &= M - X - Div_{ROW} - i_{B,ROW,-1}B_{ROW,-1} + Div_{F,ROW} \\ &\quad + Div_B + Div_{ICPF} + i_{B,G,-1}B_{G,ROW,-1} + i_{B,B,-1}B_{B,ROW,-1} \end{aligned} \quad \textbf{(71)}$$

We assume that the growth in rest of the world dividend payments to the United Kingdom is equal to the growth in the value of rest of the world equity, that is, dividend yields are constant. And we assume that the interest rate on rest of the world debt is given by:

$$i_{B,ROW,t} = i_{B,ROW,t-1} + \varsigma_1 \left(i_{B,ROW,t-1} - \varsigma_2 - \varsigma_3 P_{B,ROW,t-2} \right) \quad \textbf{(72)}$$

By definition, domestic assets (in sterling terms) held by the rest of the world will be given by:

$$A_{ROW} = V_{F,ROW} + V_B + B_{G,ROW} + B_{B,ROW} + Bbills + GBills \quad \textbf{(73)}$$

Foreign investments are distributed over the assets in the model via a portfolio demand equation:

$$\begin{pmatrix} B_{G,ROW,t} \\ B_{B,ROW,t} \\ V_{F,ROW,t} \end{pmatrix} = \left(\begin{pmatrix} \frac{B_{G,ROW,t-1}}{A_{ROW,t-1}} \\ \frac{B_{B,ROW,t-1}}{A_{ROW,t-1}} \\ \frac{V_{F,ROW,t-1}}{A_{ROW,t-1}} \end{pmatrix} + \begin{pmatrix} \lambda_{ROW,10} \\ \lambda_{ROW,20} \\ \lambda_{ROW,30} \end{pmatrix} + \begin{pmatrix} \lambda_{ROW,11} & \lambda_{ROW,12} & \lambda_{ROW,13} \\ \lambda_{ROW,21} & \lambda_{ROW,22} & \lambda_{ROW,23} \\ \lambda_{ROW,31} & \lambda_{ROW,32} & \lambda_{ROW,33} \end{pmatrix} E \begin{pmatrix} r_{B,G,t} \\ r_{B,B,t} \\ r_{V,F,t} \end{pmatrix} \right) E(A_{ROW,t}) \quad \textbf{(74)}$$

where, again, we assume that the change in the proportion of its assets held in a particular asset class depends on the relative rates of return on each asset class and where we again allow for the presence of trends in investor sentiment towards particular asset classes, reflecting what we observe in our data.

Sterling-denominated liabilities of the rest of the world to domestic investors (specifically the ICPF sector) consist of bonds and equity:

$$Liab_{ROW} = V_{ROW} + B_{ROW} \quad \textbf{(75)}$$

The supply of these liabilities is assumed exogenous. And so the UK Net International Investment Position as a percentage of GDP will be given by $\frac{Liab_{ROW} - A_{ROW}}{GDP}$.

We use a flexible exchange rate closure of the model where the movement in the exchange rate moves to equalise the returns on domestic vis-à-vis foreign bonds:

$$\frac{e_t}{e_{t-1}} = 1 + r_{B,ROW,t-1} - \frac{r_{B,B,t-1}B_{B,RoW,t-1} + r_{B,G,t-1}B_{G,RoW,t-1}}{B_{B,RoW,t-1} + B_{G,RoW,t-1}} \quad \textbf{(76)}$$

2.7 Central bank

The central bank's assets are government bonds and its liabilities are the reserves of the banking sector. Its demand for government bonds is assumed to be exogenous. It doesn't pay interest on reserves so its profits will equal the interest it earns on government bonds. Monetary policy is assumed to set this rate of interest according to a nominal GDP growth targeting rule, where we assume the rule has a form that ensures the interest rate never falls below zero (its lower bound).

$$B_{G,CB} = R \quad \textbf{(77)}$$

$$\Pi_{CB,t} = i_{B,G,t-1}B_{G,CB,t-1} \quad \textbf{(78)}$$

$$\ln(i_{R,t}) = \pi_1 + \pi_2 \ln(i_{R,t-1}) + (1-\pi_2)\pi_3 \Delta \ln(GDP_t) \quad \textbf{(79)}$$

2.8 Expectations

Finally, we assume adaptive expectations throughout the model:

$$E(X) = X_{-1} + \upsilon.(\mathrm{E(X)}_{-1} - \mathrm{X}_{-1}) \quad \textbf{(80)}$$

3 Data and calibration

In this section we explain how we have used UK data to calibrate and operate the model. The model is a 'non-linear backward-looking' model, of the type explained in section 6.2.7 of Burgess *et al.* (2013). A data annex explains more about how we have sourced the data for the model. The following sections describe two specific challenges we had to overcome in matching the model to the data.

3.1 Challenge 1: matching the model's transaction flow matrix to the UK national accounts

Table B shows the model's transaction flow matrix (TFM). Although our behavioural model is large and complicated (probably at the upper limit of tractability), it is significantly simpler than the full set of national accounts published by the ONS. This is true in two particularly important respects. First, the number of rows in both the income and financial accounts is significantly lower in our model than in the published national accounts. The ONS Blue Book, for example, contains around 6500 series for the seven sectors in our model. The equivalent number in our TFM is around 100. Second, the behavioural equations impose a number of zero restrictions on the behaviour of particular sectors. For example, because we assume that all business investment is carried out by NFCs, and do not have equations for investment in other sectors, we are implicitly assuming that investment by banks, ICPFs and OFIs is zero, whereas in practice they account for about 5% of business investment.

Table B: Transactions flow matrix

		Households	PNFCs	Government	Banks	ICPFs	Bank of England	Rest of the world
Consumption		-ccp	ccp					
Investment			-ikcp + ikcp					
Housing investment		-ihcp	ihcp					
Govt expenditure			gonscp	-gonscp				
Exports			xcp					-xcp
Imports			-mcp					mcp
Wages		wages	-wages					
Annuity payments		annpay				-annpay		
Pension contributions		-penscont				penscont		
Taxes		-taxhh	-taxnfc	tax				
Transfers		transhh	transnfc	-trans				
Dividend flows	Banks				-divbank			divbank
	NFC		-divnfc			divnfc_icpf		divnfc_row
	ROW					divrow		-divrow
	ICPF					-divicpf		divicpf
Interest flows	Deposits	i_dephh* dephh			-i_dephh* dephh			
	Mortgages	-i_mort*mort			i_mort*mort			
	Govt bonds			-i_dgovt *dgovt		i_dgovt* dgovt_icpf	i_dgovt* dgovt_cb	i_dgovt* dgovt_row
	Bank bonds				-i_dbank* dbank	i_dbank* dbank_icpf		i_dbank* dbank_row
	ROW bonds					i_drow*drow		-i_drow*drow
	NFC loans		-i_loannfc* loannfc		i_loannfc* loannfc			
Net lending		-nlp	-nlnfc	-nlgg	-nlbank	-nlicpf		-nlrow

See Table E in Annex 1 for more information on variable mnemonics.

These are both potential obstacles to our goal of modelling the financial balances for each sector of the UK economy. The financial balance ('net lending') of each sector is a balancing item which is ultimately a function of every other series in that sector's income or financial account. If we leave out some rows of the accounts, or attribute spending to one sector that is actually being carried out by another, we will inevitably only be able to model the net lending of each sector with some residual error.

For the model to be a useful lens to look at the economy, it is not important that this residual be zero.

Many entries in the national accounts are small and would be extremely challenging to model using behavioural equations derived from economic theory. However, for practical applications it is important that we ensure that our behavioural equations are explaining the majority of the interesting variation in the sectoral financial balances over the 1998-2014 period for which we take data (ie, that the remainder is just noise, or a fairly constant wedge that we can explain) and that, when we use the model to forecast, we treat these residual components rigorously. Because these small residual components are not modelled explicitly in the TFM, and there is not an automatic offset in another sector, there is a risk that they could lead to a violation of important accounting identities when using the model for simulations. What we do is to treat the residual for each sector as an AR(1) process when simulating the model. Since the residuals must sum to zero in the last period of back data, holding them all flat when simulating will ensure that that relationship is maintained in forecasts. The residuals must all sum to zero over the past because the sum of the net lending balances in any set of national accounts is zero, and because the variables which are accounted for explicitly in our TFM all lead to double entries by construction.[7]

Chart 5 shows the extent to which our behavioural equations successfully model net lending for each sector. In each case the blue line shows net lending as published in the latest vintage of the *UK Economic Accounts*, published by the ONS, and the red line shows the series implied by the TFM we are using. This is therefore not a measure of 'fit' in an econometric sense: what it really shows is the detail that we lose by discarding the roughly 6500 series in the relevant part of the national accounts and using instead the 100 or so series that are needed to run our behavioural equations. To take the government sector as an example, if one took data for government consumption and investment, interest payments, and taxes from and transfers to households and NFCs, one would expect to get close to the government's net lending position, but not to match precisely, because of the much greater detail in the national accounts. This is indeed what we find.

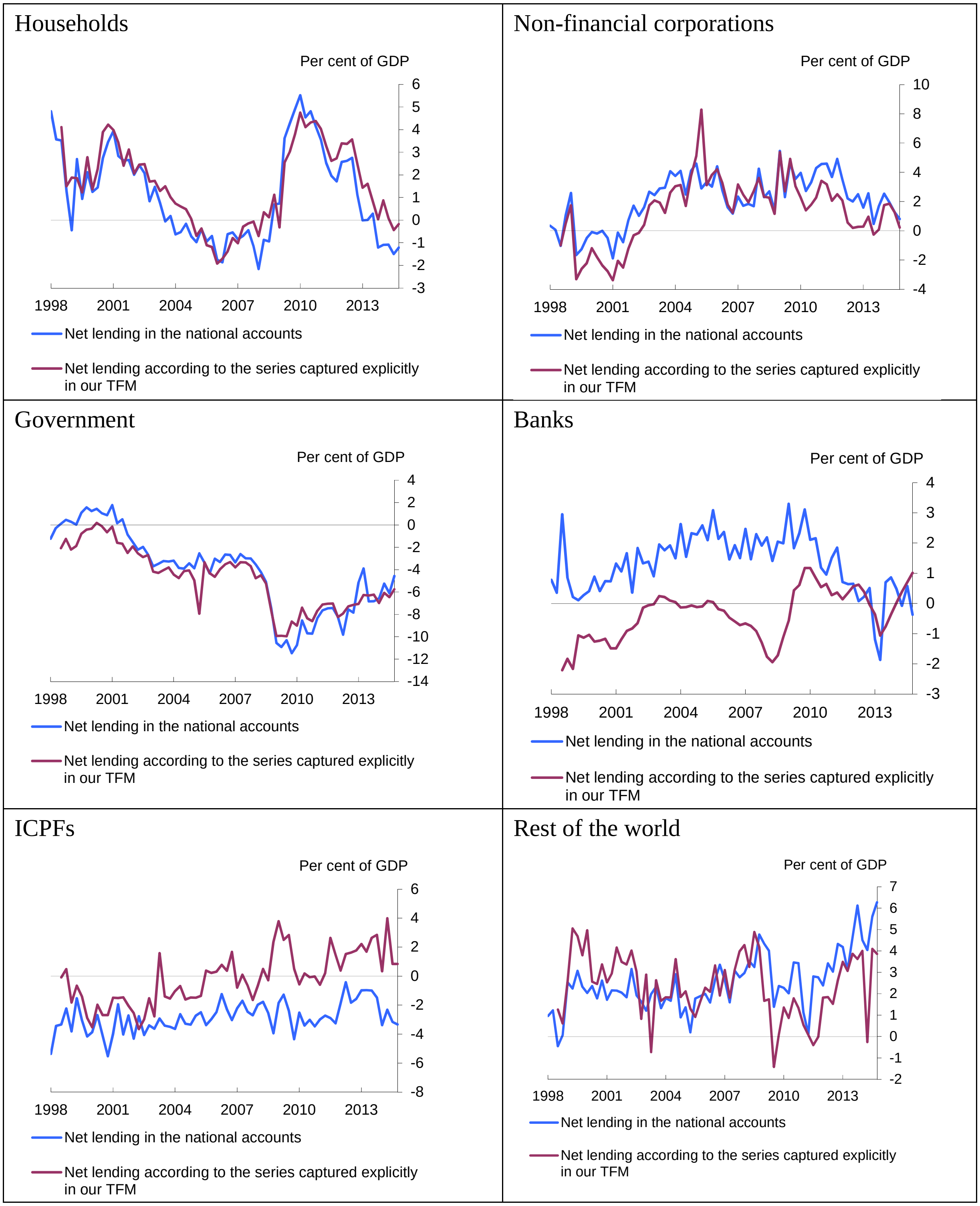
Given the relative parsimony of our TFM, we regard the closeness of fit for four of the sectors (households, NFCs, government and rest of the world) as being extremely good. The fit is less good for banks and ICPFs. That may be due partly to data limitations: the financial flows associated with these sectors are extremely large and we know that even the published statistical discrepancies between the estimates of net lending from the income and financial accounts for these sectors can be very large.[8] But another reason is likely to be that our model is imposing strong restrictions on these sectors. For example, ICPFs are assumed to hold all of the UK's equity claims on the rest of the world in our TFM, whereas in practice we know many of those are held by NFCs, through foreign direct investment (FDI), so earnings on FDI are mostly being wrongly attributed to ICPFs in our model. Note that there is a corresponding bias in most time periods in the NFCs chart. For future work, we will consider extending the model to address this, perhaps by including behavioural equations for FDI. However, one would need to be very wary of the need to keep the model tractable: this model is

[7] This is true once the statistical discrepancy between income and expenditure has been accounted for. In our model we add this to the net lending balance for OFIs for convenience. We do not model the OFI sector explicitly but we do keep track of its financial balance for accounting reasons.

[8] When aligning measures of net lending from the income and financial accounts, the ONS allow there to be a deviation between the two and they publish a statistical discrepancy. But those are to some extent engineered: the published net lending balances are themselves adjusted judgementally, so the statistical discrepancies implied by raw data could be much larger.

already, as far as we aware, the largest model of its type built for the UK, and there is a danger that further significant extensions would risk making the model too complex to use.

Chart 5: The extent to which our model's behavioural equations allow us to replicate sectoral financial balances over 1998-2014



3.2 Challenge 2: ensuring that stock-flow consistency is maintained in simulations

As described in the introduction, one of the key strengths of our approach is that the model is 'stock-flow-consistent', as defined originally by Godley and Cripps (1983). We can simulate the evolution of balance sheets for each sector in a way which is completely consistent with their real economy activity and the transactions taking place between economic agents.

One necessary condition for stock-flow-consistency is that real economic transactions are associated with two entries in the corresponding financial accounts, one for the payee sector and one for the sector receiving the funds. To a large extent, this is ensured by the structure of our model. For example, if households purchase goods from NFCs for consumption purposes, that will be reflected in lower net lending of households and higher net lending for firms, all else equal. The way our model is specified, this will automatically feed through to a reduction in household deposits and a reduction in firms' borrowing, because the changes in those financial stocks depend explicitly on the sectors' net lending. The only additional check that is needed relates to the 'residual' terms for each sector that are not explicitly modelled in our TFM (see previous section). In the model, we add an 'accounting check' variable which sums the net lending balances across all sectors, and there is a flag if this ever becomes non-zero during simulations.

Another necessary condition is that the stock of each financial instrument evolves in a way that can be accounted for using the transactions in that stock and any revaluation effects. Specifically (and using government bonds as an example):

Stock (end of period t) = Stock (end of period t-1) + Net issue of new government bonds in period t + Revaluation effect due to change in bond prices[9] **(84)**

where, ignoring complications to do with intra-period transactions, we have

*Revaluation effect = Stock (end of period t-1) * (Price(t) / price(t-1))* **(85)**

In our model, revaluation effects only arise for three main instruments: government bonds, bank bonds and NFC equities.

For most financial instruments, this necessary condition will hold automatically, because the updating equations for the stocks are defined in terms of previous periods' stocks and the net lending balances for the current period. However, there is a complication with government bonds and bank bonds which needs careful attention. For those two sectors, the problem is that they use bond liabilities as their 'buffer' instrument, to ensure that they are sufficiently funded to meet all their payment obligations in the current period. However, the prices of those instruments are assumed to depend on the current period's supply, as well as nominal demand. Banks and the government therefore base their bond issuance on *expected* prices, and they can subsequently be surprised when asset markets clear. If prices are out of line with their expectations, then equation **(84)** above will be violated. (Note that the same issue does not arise for NFCs, because in their case loans, rather than equities, is the

[9] This can also include write-offs and other volume changes. In our model we only attempt to consider write-offs on NFC loans.

‘buffer’ stock; so it is not a problem for stock-flow-consistency if their expectation for equity prices turns out to be incorrect.)

To avoid this, we introduce the plausible assumption that banks and government also have access to one-period sources of funding to meet such unexpected short-term shifts in cashflow. We introduce two unobservable variables, bank bills and government bills, which mop up the difference between expected and actual financing needs, and are added to the new financing requirement in the next period. For simplicity, we treat these bills as non-interest-bearing. They are also identities in the model, so it is not necessary to supply data for them. These adjustments to the model are documented fully in Section 2. As Chart 6 shows, when we run the model with these additional variables, the funding that these two sectors are assumed to meet with bills, rather than bonds, is very small in almost all time periods.

Chart 6: Estimated stocks of government and bank bills relative to bonds

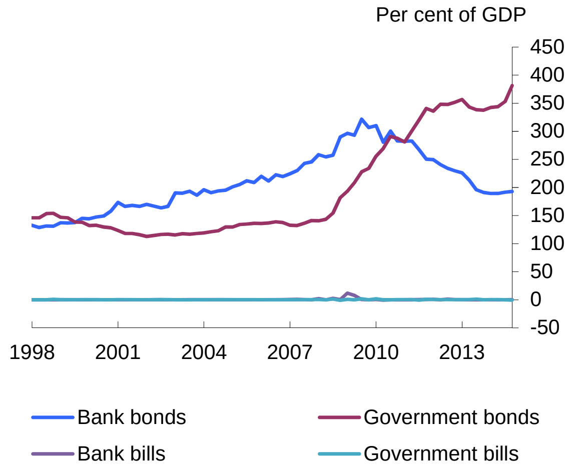


Chart 7: Illustration that the model is stock-flow-consistent over the forecast for the government sector

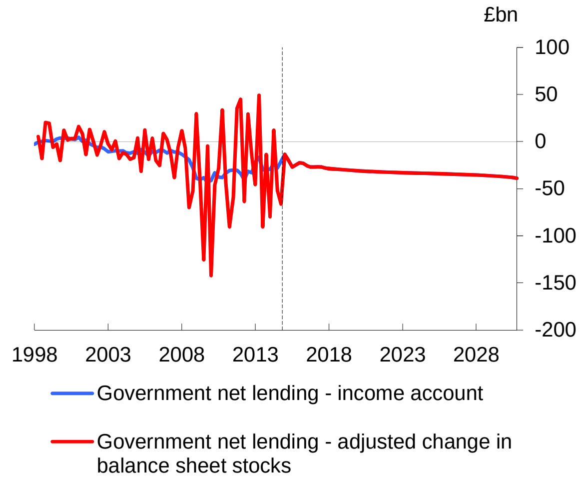


Chart 7 shows the government financial balance (red line) over the past and the forecast. The blue line then shows the change in the stock of government liabilities, adjusted for explicit revaluation effects. Over the past, the data are not perfectly stock-flow-consistent, because there are effects in the national accounts data other than explicit revaluations which can cause the flows to deviate from the changes in stocks. Over the forecast, however, our model imposes this automatically, meaning that the two lines are the same. The equations determining these stocks of bills are laid out in Section 2.

To ensure that stock-flow-consistency holds for all sectors in simulations of the model, we have introduced six further ‘check’ variables, which evaluate equation **(84)** for each sector. Once we have added these short-term bills for government and banks, we find that stock-flow-consistency does indeed hold when we forecast using the model.[10] An example is shown in Chart 7 for the government sector.

[10] As an aside, it is worth noting that these identities do not always hold over the past. This is because of other volume changes (like reclassifications) in the national accounts data, and because our asset price indices – which are indicative series taken from non-ONS sources – will not be a perfect proxy for the revaluation effects that are implied by the stocks and flows in the national accounts. This is clear from the historical comparison in Chart 7.

3.3 Calibration and estimation

We derived our parameter values via a twin approach of calibration and estimation. In all cases we used UK data over the period 1998 Q1 to 2014 Q4. An annex contains detailed descriptions of all the variables used.

Starting with those parameters we calibrated, we set κ, the parameter determining the weight on past errors when agents are forming their adaptive expectations, to 0.1, in line with Hommes (2013) and Evans and Ramey (2006). We set the tax rate on household income, θ_H, to 18.5% and the average rate of pension contributions, ρ, to 9%, their average values in our dataset. We set δ, the quarterly nominal depreciation rate of capital, to 1.3%. This is done so that the derived estimate of the capital stock roughly matches the estimates for the United Kingdom in Oulton and Wallis (2015). The growth rate of the debt-to-income ratio, ζ, is set equal to 0.03, and the ratio of housing wealth to mortgage debt, r_s, equal to 2.9, their average values in our dataset.

The steady-state share of capital, γ, is set to 0.35, implying a labour share of 0.65, equal to its average in our dataset. The share of retained earnings, s_F, is set to 74%, and the tax rate on corporate profits, θ_F, is set to 62%, their average values in our dataset. The parameter ψ, the proportion of new investment financed by issuing equity, should be equal to the steady-state proportion of total firm liabilities that consist of equity. In our dataset, which excludes corporate debt, this proportion is 84%. But given this value seemed unrealistically high to us, we used a value of 10%. We set the proportion of non-performing loans, ξ_1, to 0.2%, its average value in our dataset. Finally, for the imports equation, we calibrate the coefficient on the exchange rate in such a way that the response of the current account to an exchange rate change is roughly in line with that used in IMF estimates of current account adjustment. The implied values are 0.004, 1 and 0.005 for μ_1, μ_2 and μ_3, respectively.

For the block of the model determining banks' dividends and equity, we assume a target level of equity of ten percentage points above the bare regulatory minimum, which is likely to be a reasonable approximation for the system as a whole once all additional loss-absorbing buffers are taken into consideration. That is, we set ν_0 to 10% and ν_{min} to 8%. The relevant risk weights on mortgages, ν_1, and loans, ν_2, respectively, are set to 0.35 and 1. When the banks' equity level is on target, we assume a return on equity of around 8%, its average value in our dataset. For the ICPFs, the only parameter we need to set – other than the coefficients in the portfolio equations – is the share of total assets that are retained, s_{ICPF}. We set this parameter to 0.9991, its average value in our dataset.

For the monetary policy rule, we used a quarterly inertia coefficient, π_2, of 0.9, roughly in line with that in COMPASS (Burgess *et al.* (2013)), and we set the other coefficients in such a way that nominal Bank rate is around 5% when nominal GDP growth is around 5%. The implied values of π_1 and π_3 are -0.01 and 136.5, respectively.

The portfolio equations are estimated in differences rather than levels. Specifically, we regress the change in the portfolio weight on all the rates of return and a constant, in order to be able to account for long-term trends in portfolio weights. Where OLS emits a coefficient which appears to be the 'wrong' sign, we set that coefficient to zero. This is mainly an issue with the off-diagonal entries in equation **(47)**, where it is hard to estimate a specification in which they are all negative. The resulting portfolio equations are as follows:

$$\begin{pmatrix} B_{G,ICPF} \\ B_{B,ICPF} \\ B_{RoW} \\ V_{F,ICPF} \\ V_{RoW} \end{pmatrix} = \left(\begin{pmatrix} 0.0032 \\ 0 \\ - \\ -0.006 \\ 0 \end{pmatrix} + \begin{pmatrix} 0.003 & 0 & -0.2 & -0.12 & -0.03 \\ 0 & 0.003 & 0 & 0 & 0 \\ - & - & - & - & - \\ 0 & 0 & 0 & 0.23 & 0 \\ 0 & -0.01 & 0 & 0 & 0.12 \end{pmatrix} E \begin{pmatrix} r_{B,G} \\ r_{B,B} \\ r_{B,RoW} \\ r_{V,F} \\ r_{V,RoW} \end{pmatrix} \right) E(A_{ICPF}) \tag{86}$$

and

$$\begin{pmatrix} B_{G,ROW} \\ B_{B,ROW} \\ V_{F,ROW} \end{pmatrix} = \left(\begin{pmatrix} 0 \\ 0.002 \\ - \end{pmatrix} + \begin{pmatrix} 0.13 & -0.06 & 0 \\ 0 & 0.03 & -0.1 \\ - & - & - \end{pmatrix} E \begin{pmatrix} r_{B,G} \\ r_{B,B} \\ r_{V,F} \end{pmatrix} \right) E(A_{ROW}) \tag{87}$$

In each case, one equation was not estimated, rather we imposed the budget 'adding-up' constraints:

$$B_{ROW} = E(A_{ICPF}) - B_{G,ICPF} - B_{B,ICPF} - V_{F,ICPF} - V_{ROW} \tag{88}$$

$$V_{F,ROW} = E(A_{RoW}) - B_{G,RoW} - B_{B,RoW} - V_B \tag{89}$$

We estimated the remaining parameters of our model, using ONS data over a sample period of 1998-2014. Specifically, we use OLS estimation of the behavioural equations of our model to estimate the model parameters. In this version of the model, the equations are estimated one at a time. The resulting parameter values are shown in Table C.

Table C: Parameter values estimated by OLS

Equation number	Dependent variable	Parameter values
4	Consumption	$\alpha_1 = 0.793, \alpha_2 = 0.008$
9	Housing transactions	$\varphi_1 = 283, \varphi_2 = 8.6$
14	Mortgage repayments	$\varepsilon_1 = 0.011, \varepsilon_2 = 0.51$
15	Housing investment	$\vartheta_1 = 4200, \vartheta_2 = 0.11, \vartheta_3 = 37.2$
19	Growth rate of capital	$\gamma_y = -0.07, \gamma_u = 0.08, \gamma_r = -0.3$
39	Government bond yield	$\iota_1 = 0.055, \iota_2 = -0.027$
40	Annuity payments	$\zeta_1 = 23064, \zeta_2 = 0.003$
63	Mortgage interest rate	$\chi_{0,mort} = 0.0056$
64	Loan interest rate	$\chi_{0,L} = 0.0025$
65	Deposit interest rate	$\chi_{0,D} = 0.0052, \chi_{0,D} = 0.0033$
66	Bank bond yield	$o_1 = 0.023, o_2 = -0.02$
72	Rest of the world bond yield	$\varsigma_1 = -0.079, \varsigma_2 = 0.077, \varsigma_3 = -0.064$

4 Using the model to forecast

In this section, we use the model to produce a simple forecast for the next ten years. We take in a full dataset up to 2014 Q4, and then allow the model to project the entire set of variables out to 2025 Q4. Clearly we do not expect the forecasts to be accurate at such long horizons, but using a long horizon allows us to assess whether or not the solution is explosive, and the manner in which imbalances might unwind.[11]

In order to produce such a forecast, we need to take a stand on the future paths of our two exogenous variables, which are government spending and exports. As the purpose is to show how the model can be used to produce a forecast – rather than produce our best forecast for the next ten years – we adopt the simple assumptions of growing government spending and exports at constant rates in line with their long run average growth rates.

Forecasting also involves making a judgement about how variables will evolve when they deviate from their behavioural equations in the last period of back data. Typically, forecasters either 'lock in' any deviation (perhaps because they are aware of a structural break) or 'unwind' it, perhaps because it is thought to be due to noise in the data. In our hands-free forecast, we adopt the simplest possible approach: we let all variables revert to their model-implied paths in the first quarter of the forecast ('setting all the residuals to zero'). The only exception we make is for the income flows for each sector which are not explicitly modelled (see discussion around Chart 5), where these need to be set to non-zero values. We set these equal to their values over the 2013-14 period, in order to avoid putting too much weight on their values in the final period of data (2014 Q4).

This is a simple and transparent approach to forecasting which has two advantages. First, it allows easy interrogation of the long run properties of the model. Second, it provides a transparent baseline against which we can run simulations (see next section). However, it is likely that in policy applications forecasters would want to take a more sophisticated approach to managing these residuals. In many cases variables may have deviated from their model predictions for a long time, and for good reason, and a more sensible approach might be to unwind the differences slowly, over a timespan of years.

4.1 Short-term forecast

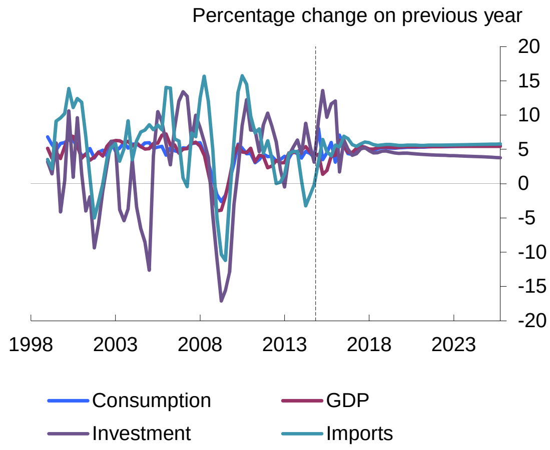
Our forecast is shown in Chart 8. In the first year of the forecast the economy slows down. House prices and housing investment are currently above the levels implied by their equations in the model and, so, when their residuals are unwound, they fall. This leads to negative wealth effects on consumption and a direct fall in GDP growth (from housing investment). However, the model is set up with positive trend productivity growth and we are inputting profiles for the exogenous exports and government spending paths which have growth rates in line with their historical averages. The real economy therefore recovers once the forecast reaches 2016 and reverts to more normal growth rates.

[11] Within our model, there is no self-equilibrating mechanism that would necessarily bring balance sheets back into equilibrium if they were subject to shocks; ie, it is quite possible that debt stocks will start to grow in an unstable way. We think this is useful since, if a scenario suggests debt stocks would start to grow unsustainably, then that suggests that the central bank might want to take macroprudential steps to deal with this.

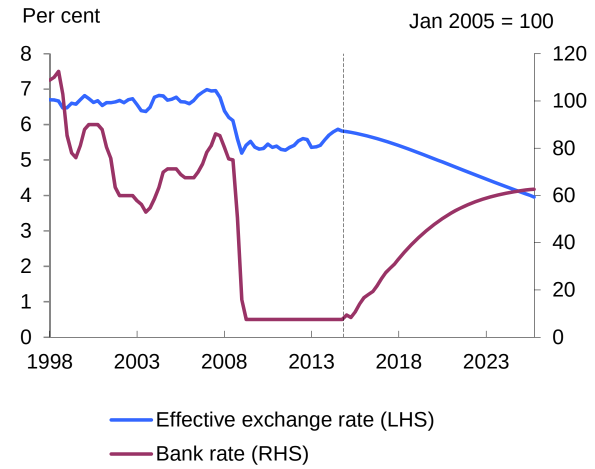
In financial balances space, the short term is characterised by a rise in household saving. The fiscal deficit widens but the current account deficit narrows.

Chart 8: Features of a hands-off forecast using the model

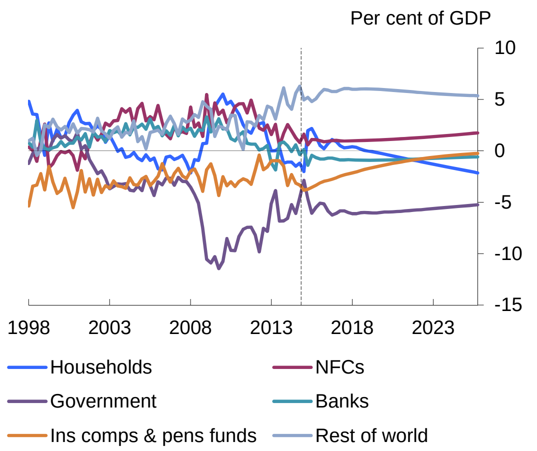
GDP, consumption, business investment and imports



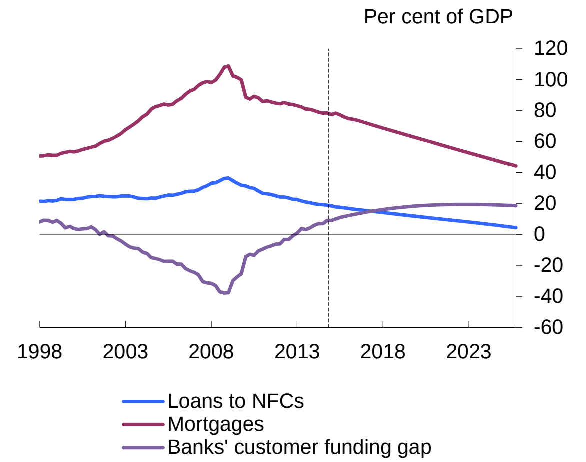
Bank rate and effective exchange rate



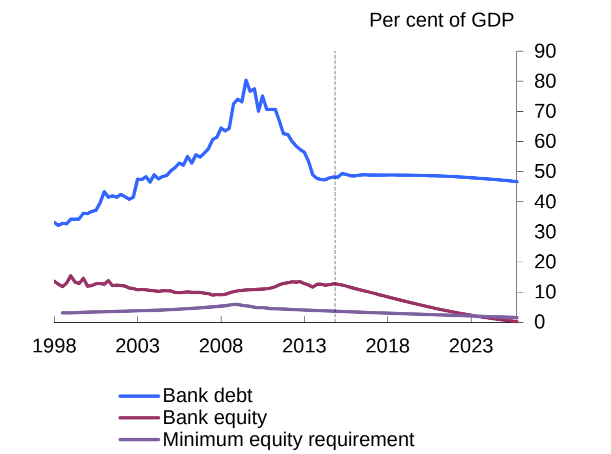
Sectoral financial balances



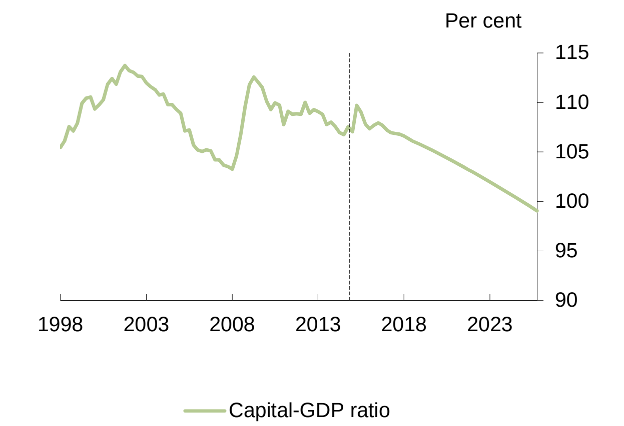
Mortgages, NFC loans and banks' customer funding gap



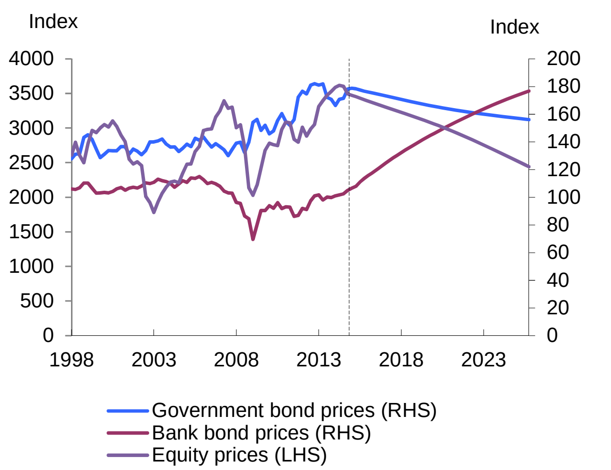
Banks' equity and debt relative to GDP



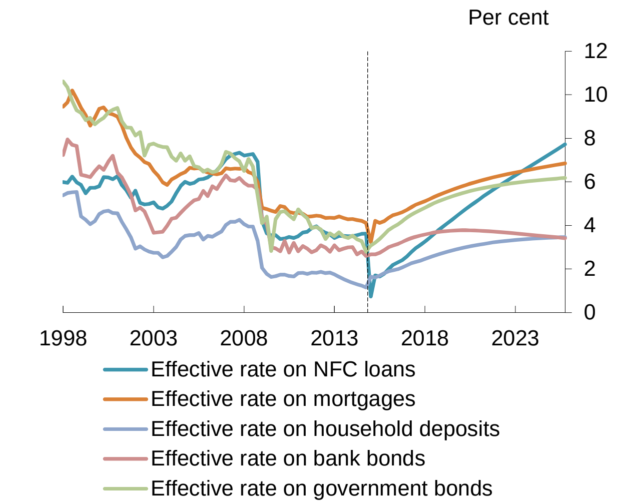
Capital-output ratio



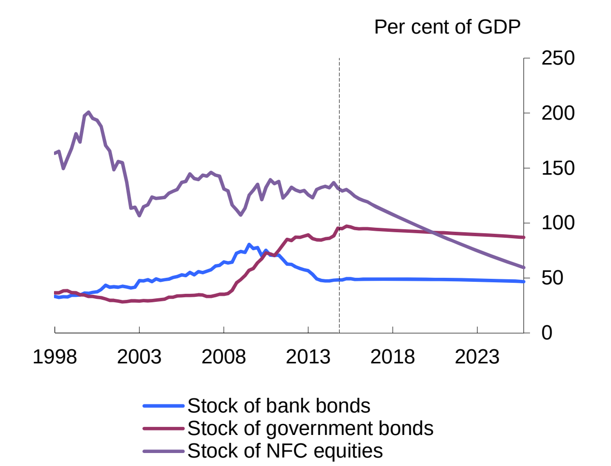
Prices of bank bonds, government bonds and equity prices



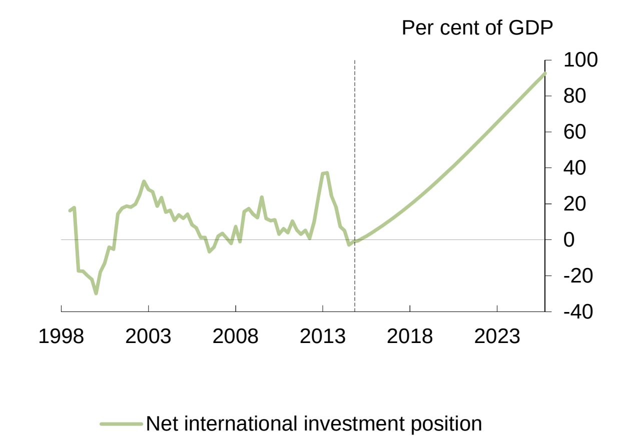
Effective interest rates



Stocks of equities and bonds relative to GDP



Net international investment position



4.2 Long-term forecast

Further out, the financial balances evolve in ways which are similar to their recent behaviour in the United Kingdom, reflecting the fact that the model is calibrated on recent data. Thus the government remains in deficit, as does the current account, and saving by NFCs is partly offset by household dissaving. ICPFs remain big dissavers, relying on investment income returns to offset their negative net lending position.

What happens to financial variables in the extended forecast? The private sector deleverages, with corporate savings being used to pay off loans, and the fall in house prices and slower housing market turnover than in the past leads to mortgages falling as a share of GDP. Banks' deposit funding is more than sufficient to fund loans and mortgages and banks are obliged to hold less capital. Bank debt generates higher returns than other assets (see below) and the price of bank debt rises, driving its yield down. This means that the interest rate on bank bonds does not rise even as Bank rate is raised during the recovery. The higher bank rate is passed through into lending rates, however.

The forecast also shows a fall in the prices of NFC equities and government bonds. For equities, this occurs because ICPFs sell their holdings of equities progressively over the forecast. That is partly based on an extrapolation of trends from the past, where ICPFs have switched from equities into bonds, captured in the portfolio equations in the model. Although the demand for government bonds remains solid, the persistent government deficits over the forecast imply a rising supply of bonds, which drives down the price and drives up the yield.. Investors therefore hold more bonds and fewer equities. (Our portfolio equations do not have any adjustment to expected returns to take account of the risk associated with the different asset classes.)

With domestic bond yields high, the exchange rate depreciates gradually to equalise returns. This leads to a rise in the UK's net international investment position, reflecting its high share of foreign currency denominated overseas assets.

5 Some simulations

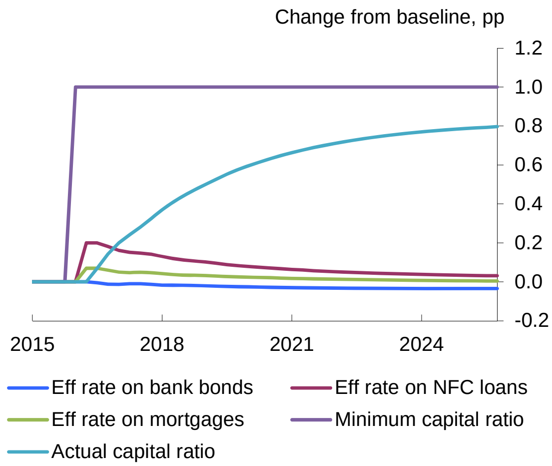
In this section we produce specific simulations relative to this baseline. In each case we apply judgements to a suitably chosen endogenous variable and then invert the model on a given residual (shock) to allow the judgement to feed through to all the other endogenous variables. The idea is to show how the model can be used to examine the possible effects of such scenarios on financial flows rather than to provide precise forecasts of how the economy will actually respond to these changes.

5.1 A rise in banks' capital requirements

An interesting question for macroprudential policy is the impact of a system wide one percentage point increase in banks' capital requirements. We can simulate this in our model, and also have the ability to impose other judgements simultaneously, for example to specify what happens to banks' distributions.[12] In this simulation we choose to hold the dividend payout rate of banks fixed as they raise more capital.

Chart 9: The effect of a one percentage point rise in system-wide capital requirements

Bank capital ratio, bank bond yields and loan rates



Loan volumes and GDP

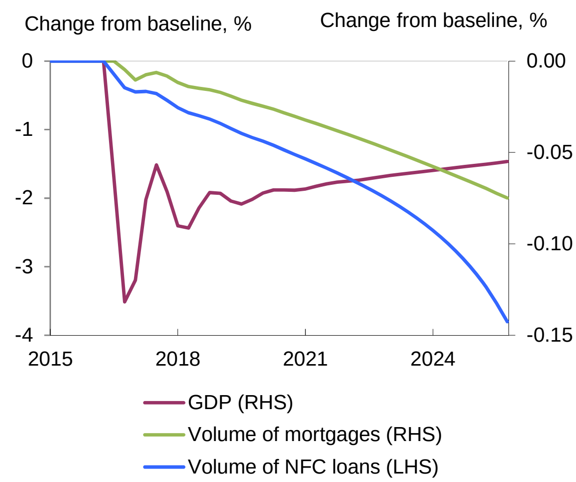


Chart 9 shows the effect of this change. Since the dividend payout rate is fixed, the cost of equity finance is the same. But the weight of equity in banks' overall average funding costs rises, pushing up their average funding costs. This, however, is offset by a fall in bank bond yields, as they do not need to issue so much debt. Banks also raise the margin on their loans to try to boost their profitability. The net effect of these is relatively small: loan rates are 15 basis points higher at their peak. This feeds back through to the real economy through weaker investment demand and leads to lower GDP and lower loan volumes. The effect on mortgage rates is lower due to the lower risk weight.

Table D: Illustrative estimates of the impact of a one percentage point increase in banks' headline capital requirements (peak impacts)

	Loan rates (bps)	Loan volumes (%)	GDP (%)
Aiyar, Calomiris and Wieladek (2014)		[-5.7,-8.0]	
Bridges et al. (2014)		-3.5	
Elliot (2009)	[4.5,19.0]		
Francis and Osborne (2012)		0	
Macroeconomic Assessment Group (2010)	[5.1,25.0]	[-0.7,-3.6]	
Burgess, Burrows, Godin, Kinsella and Millard (2016)	*+15 (corporate)*	*-4 (corporate)*	*-0.1*

Source: Harimohan and Nelson (2014)

Table D puts our estimates in the context of other recent studies of the effect of higher capital requirements. Those in our model are broadly in line with the existing literature, although we do not include any quantity rationing. That said, as Harimohan and Nelson (2014) note, these effects are

[12] The only assets in our model which are relevant for capital ratios are mortgages and corporate loans. We impose a risk weight of 35% for mortgages and 100% for NFC loans.

unlikely to be linear, or the same at all points in the financial cycle. In the simulation we describe here, the adjustment to capital is small and there is no implication that investors are worried about bank solvency in the base case. The effects might be proportionately larger if banks had a bigger capital shortfall.

5.2 A ‘sudden stop’ on the UK current account

One of the strengths of our approach is that both the income and the financial account components of the balance of payments are monitored simultaneously. In most modern macroeconomic models, such as DSGEs, the balance of payments is determined on the income side and financial flows simply adjust. In our model, it is also possible for shocks to arise on the financial side, and for this to force adjustment in real variables.

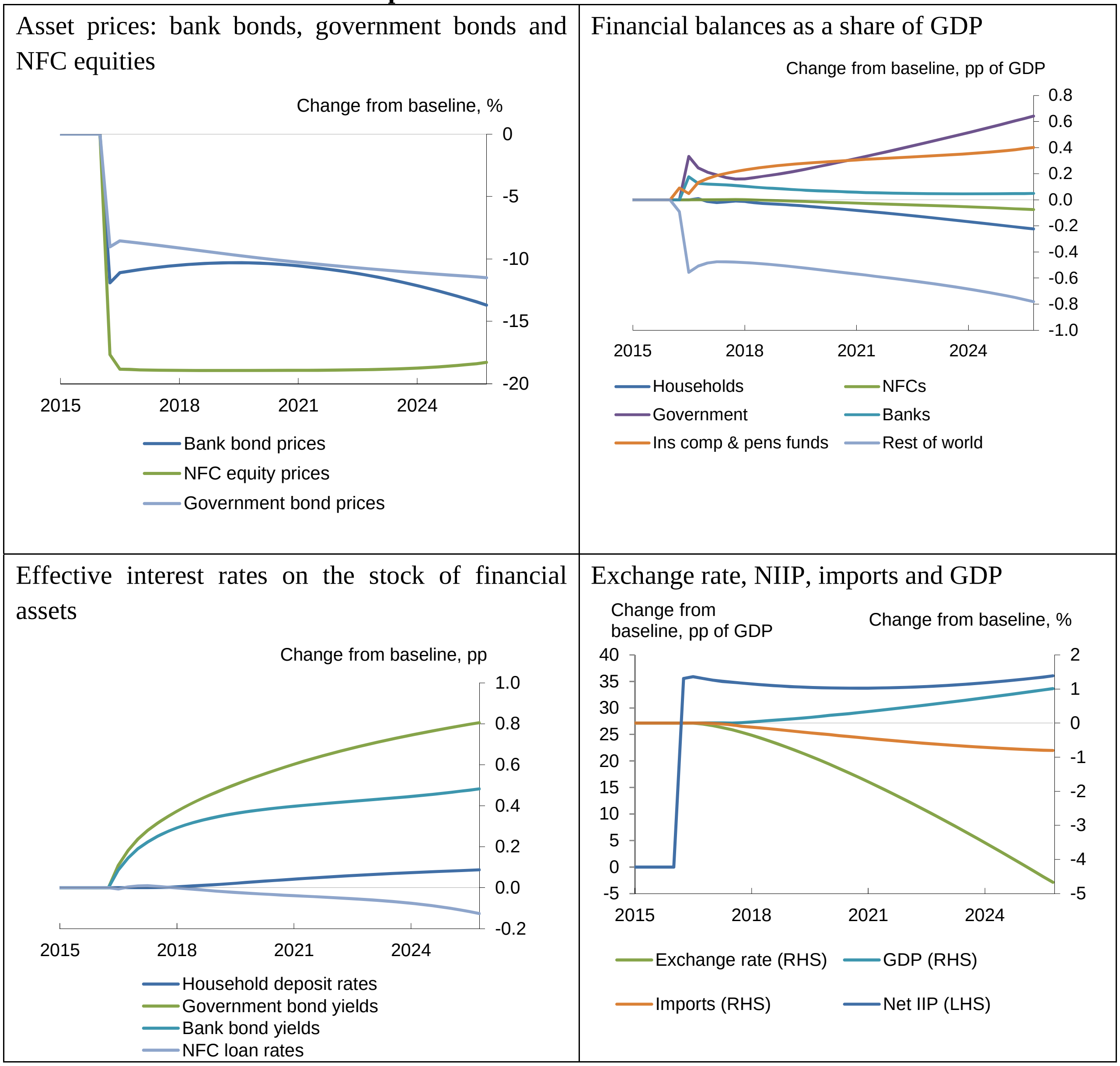
We mimic the effect of a ‘sudden stop’ on the current account as defined by Calvo and Reinhart (2002). We lower the demand for UK bonds and equity by overseas investors by 20% in the first period, and then allow the model to respond. These judgements are introduced as shocks to the portfolio equations, which then feed through to lower prices for those three assets. In our model this leads endogenously to a fall in asset prices, a rise in yields and a fall in the exchange rate.

Our results are shown in Chart 10. The shock has two sets of effects. First, there is a significant tightening of credit conditions in the domestic economy. Bank bond prices fall by 15% and government bond prices by 10%, and these pass through gradually to the stock of outstanding debt, with government bond yields eventually rising by 80 basis points.

However, offsetting those effects, the fall in the exchange rate leads to a fall in imports and a rise in the net international investment position, boosting domestic wealth and hence domestic demand. Overall, this actually leads to a small net positive effect on the level of GDP. We do not regard this as plausible: in practice there would be longer lags through which those international wealth changes would feed through to consumption. Furthermore, such a major event in financial markets would almost certainly be associated with greater uncertainty and increased disruption to financial markets and the real economy, which would introduce negative effects on growth that we do not model here. One option for future work would be to introduce a more direct link in the model between long term interest rates (which rise in this scenario) and GDP.

Turning to financial balances, we can identify two sets of effects. As overseas investors sell UK assets and their returns go up, net lending of ICPFs (who mostly hold their assets) increases at the expense of the rest of the world: in other words, this shock helps the current account deficit to narrow. At the same time, the positive wealth effects from higher GDP and a higher NIIP lead to lower household saving and a smaller government deficit.

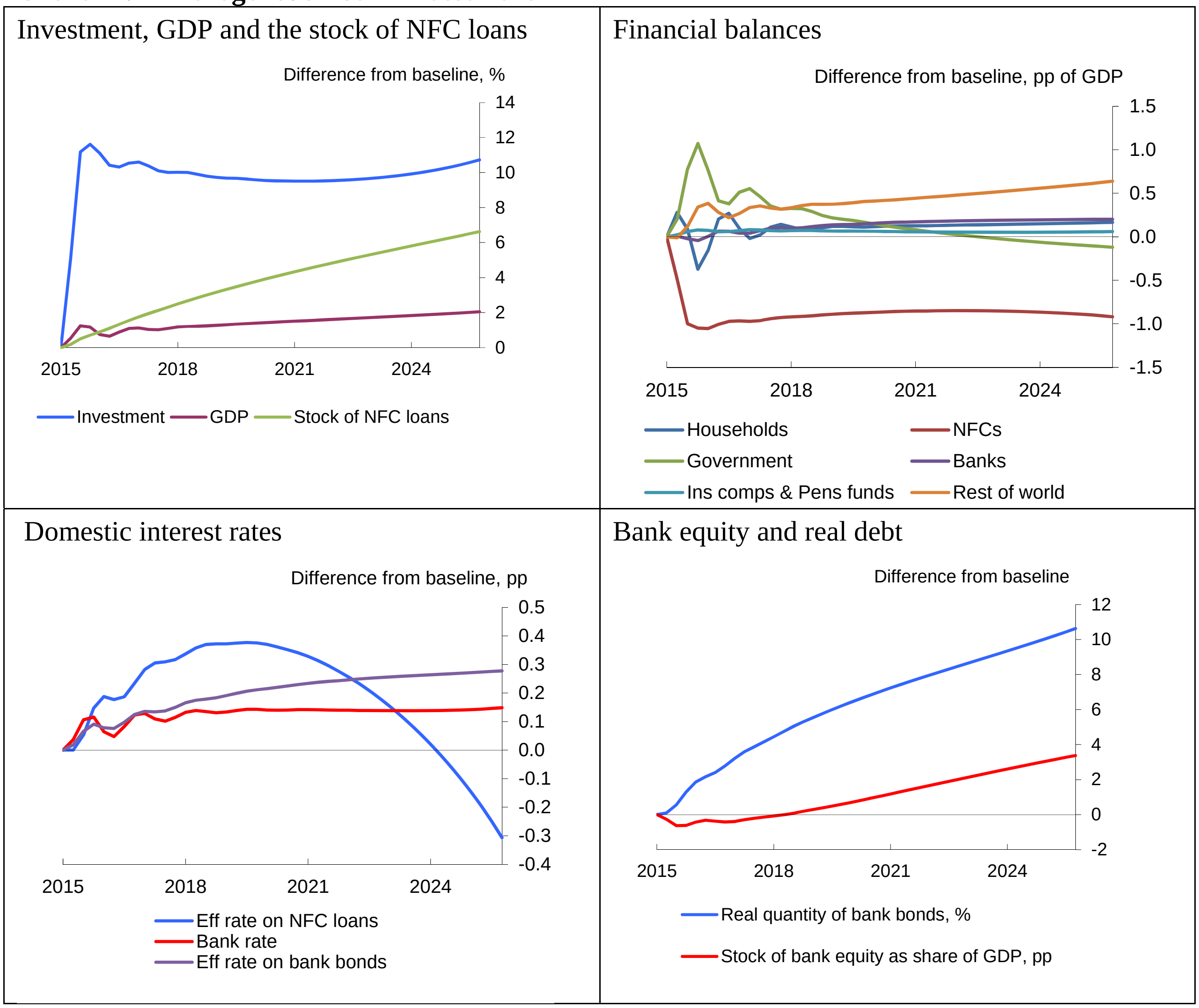
Chart 10: Effect of a 'sudden stop' on the UK current account



5.3 An exogenous rise in investment

We model an exogenous positive shock to NFC's investment by adding a residual to our investment equation and letting it feed through to the rest of the model. This leads NFCs to invest more than their 'desired' level of investment, as specified in our investment equation. The results of the exercise are shown in Chart 11.

Chart 11: An exogenous rise in investment



In our calibration the level of investment is 12% higher at its peak, and GDP more than 1% higher. Corporate profits do rise, by about 1%. However, the net effect of the rise in investment and rise in profits is to leave their net lending much lower, and they need to increase liabilities to fund this extra dissaving. They do this in two ways. First, they issue equity, leading to a rise in net saving by ICPFs and the rest of the world. Second, they borrow more from domestic banks. However, the fiscal position improves substantially as a result of higher taxes from the stronger economy. (Government spending is fixed in the simulation.)

The rise in NFC loans has consequences for the banking system. In order to fund these, banks have to issue more bonds, which drives down their price and drives up yields. Bank rate also rises as the policymaker tightens in the face of a stronger economy, and the combination of these two factors leads to an increase in domestic lending rates. This also increases the debt service costs of the corporate sector and further lowers their net lending. Banks' net lending is higher and they are able to build a higher capital buffer to match the higher stock of loans.

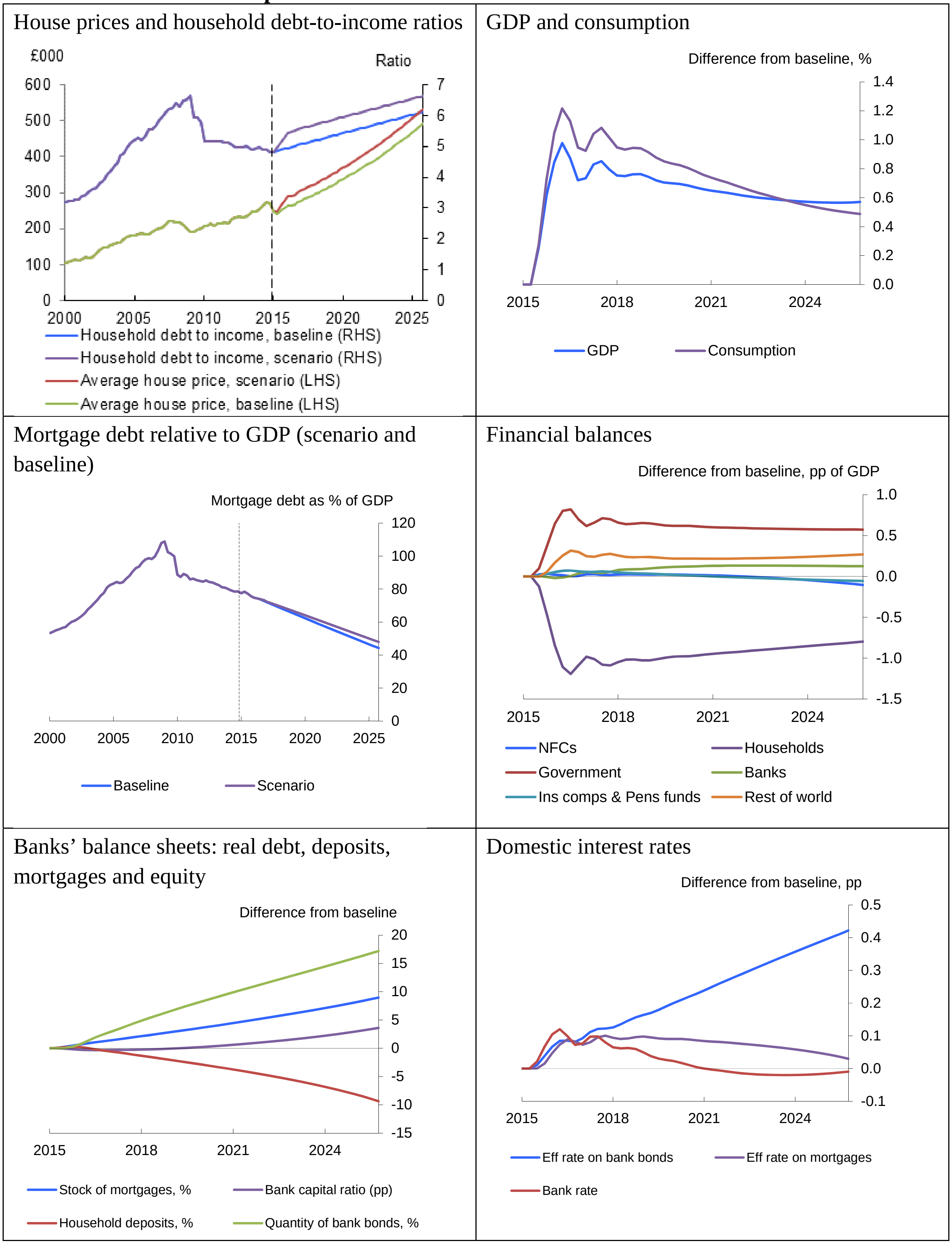
5.4 An increase in house prices

In this scenario we assume house prices rise by 10% over the first year of the forecast. We implement this assumption by allowing households' debt-to-income ratio to rise. This is essentially an exogenous process in the model, though we could interpret this as being an increase in banks' risk appetite, or perhaps a macroprudential policy loosening via a tool specific to the housing market. The results are shown in Chart 12.

Since housing wealth appears in the consumption function, the rise in house prices leads to an increase in consumption and GDP. Another channel which operates is through housing investment, which is assumed to be sensitive to house prices. The house price rise leads to a stronger economy but also a rise in mortgage debt. Since the stock of houses only turns over slowly, this takes time, but after ten years the stock of mortgage debt is 8% higher (four percentage points of annual GDP). Looking at financial balances, household net saving is lower, as one would expect, and part of that is offset by a stronger fiscal position. But the current account is worse. On the income side, imports rise and, on the financial account side, overseas investors help to supply much of the finance to support the domestic credit boom. Banks are unable to meet the higher demand for mortgages through household deposits (as households are dissaving), so they have to issue more bonds, many of which are purchased by overseas investors. Barwell and Burrows (2011) suggested that this overseas funding of the domestic 'Customer Funding Gap' was a feature of the pre-crisis period.

The increased supply of bank bonds also leads to an increase in yields, which occurs alongside a rise in Bank rate. Domestic mortgage rates therefore rise. This increases households' debt service costs (as does the rise in the stock of debt), further worsening their net lending position.

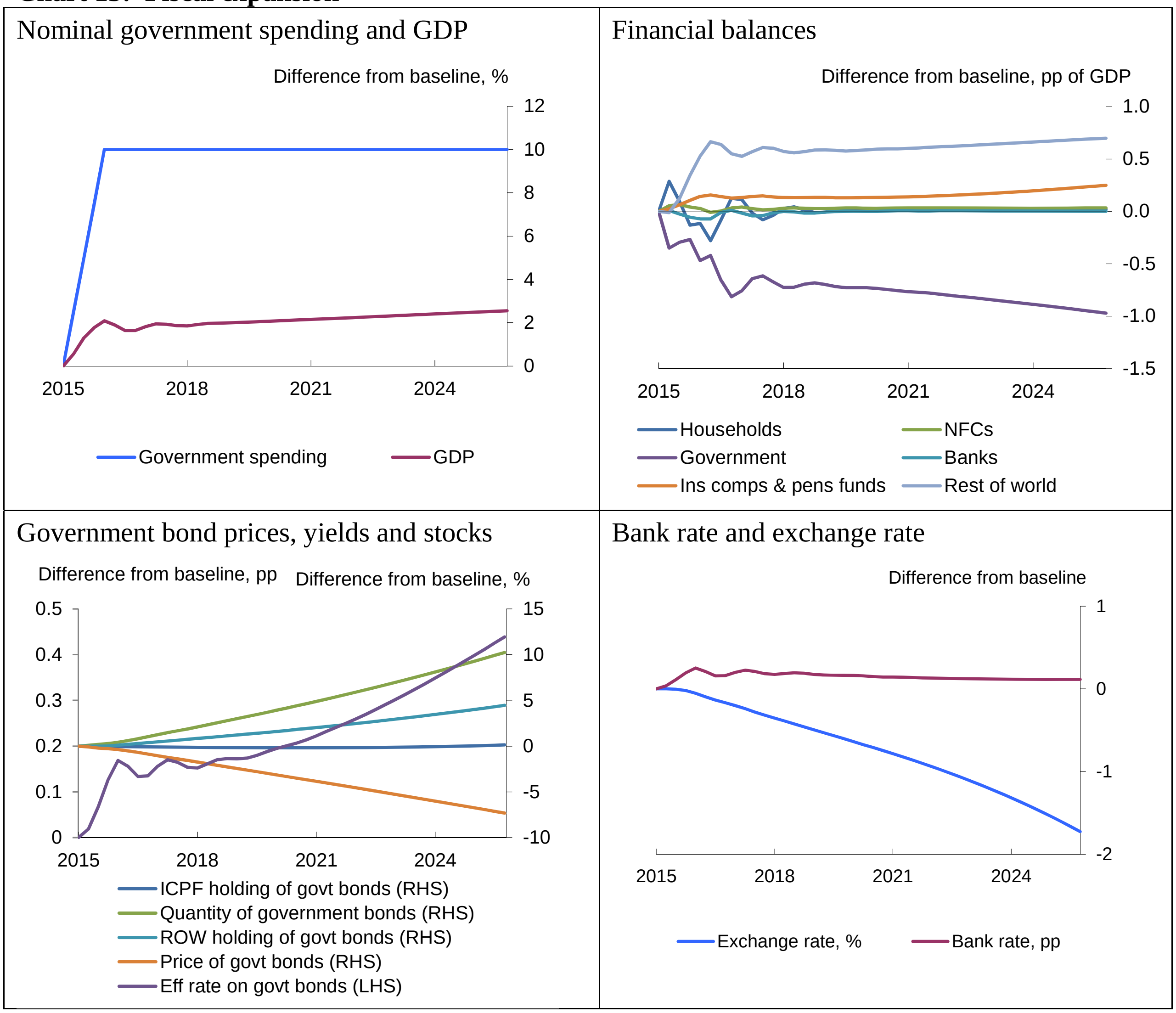
Chart 12: A rise in house prices



5.5 Fiscal expansion through higher spending

We consider an increase of 10% in government spending, phased in over three years. The results are shown in Chart 13. As firms' incomes rise, this feeds through to wages, and consumption and investment also rise. Some of this feeds through to higher imports. Overall, the fiscal multiplier in our model is around 1.

Chart 13: Fiscal expansion



Although the economy is in better shape and taxes pick up, in our model the expansion is not self-financing: the government runs a bigger deficit and its debt rises, though only modestly. Gilt prices fall and yields rise by about 50 basis points, increasing the government's service costs and pushing the deficit up further. Given the parameterisation of our portfolio equations, we find that most of the extra stock of gilts is bought by overseas investors, rather than ICPFs. This helps to fund the higher current account deficit caused by the rise in imports. The expansion in GDP leads the monetary policymaker to raise Bank rate, and the exchange rate falls gradually.

6 Conclusions and further work

This paper introduces a new model to understand the evolution of financial balances over the medium to long term in the United Kingdom. We build and estimate a stock-flow consistent model using a new dataset built from flow of funds data from 1987 to 2014, and design new tests for stock flow consistency within the data. This model is designed to complement existing models available to policymakers, as part of a 'suite of models' approach.

The model is designed to link decisions about real variables to credit creation in the financial sector as well as decisions about asset allocation among investors for a wide array of financial assets. The model is large but analytically tractable.

We show how we can use the model to assess how economic and financial imbalances are likely to evolve over a longer period and whether such an evolution is sustainable given particular scenarios such as fiscal expansions, house price increases, investment increases, sudden stops on the current account and changes to system-wide capital requirements.

Further work will expand the core model to explore the role of demographic processes, a more articulated financial system, modelling foreign direct investment, alternative labour market scenarios, and large scale system wide shocks.

References

Adams, S, Bowers, L and Foster, R (2015), 'The UK Flow of Funds project: Comprehensive review of the UK financial accounts', *mimeo*.

Barwell, R and Burrows, O (2011), 'Growing fragilities? Balance sheets in the Great Moderation', Bank of England *Financial Stability Paper* No. 10.

Benes, J, Kumhof, M and Laxton, D (2014), 'Financial crises in DSGE models: A prototype model', International Monetary Fund *Working Paper* No. 14/57.

Borio, C (2014), 'The financial cycle and macroeconomics: What have we learnt?', *Journal of Banking & Finance*, Vol. 45, pages 182-98.

Blanchard, O and Simon, J (2001), 'The long and large decline in US output volatility', *Brookings Papers on Economic Activity*, Vol. 1, pages 135-64.

Brainard, W C and Tobin, J (1968), 'Pitfalls in financial model building', *American Economic Review*, Vol. 58, pages 99-122.

Burgess, S, Fernandez-Corugedo, E, Groth, C, Harrison, R, Monti, F, Theodoridis, K and Waldron, M (2013), **'**The Bank of England's forecasting platform: COMPASS, MAPS, EASE and the suite of models', Bank of England *Working Paper* No. 471.

Bussière, M, Imbs, J, Kollmann, R and Rancière, R (2013), 'The financial crisis: Lessons for international macroeconomics, *American Economic Journal: Macroeconomics*, Vol. 5, pages 75-84.

Caballero, R J and Krishnamurthy, A (2009), 'Global imbalances and financial fragility', National Bureau of Economic Research *Working Paper* No. 14,688.

Calvo, G A and Reinhart, C M (2002), **'**Fear of floating', *Quarterly Journal of Economics*, Vol. 117, pages 379-408.

Caiani A., Godin, A., Lucarelli, S. (2014a), 'A Stock Flow Consistent Analysis of a Schumpeterian Innovation Economy', *Metroeconomica*, Vol. 65, pages 397-429.

Caiani A., Godin, A., Lucarelli, S. (2014b), 'Innovation and finance: a stock flow consistent analysis of great surges of development', *Journal of Evolutionary Economics*, Vol. 24, pages 421-448.

Caverzasi, E, & Godin, A (2015), **'**Post-Keynesian stock-flow consistent modelling: a survey', *Cambridge Journal of Economics*, Vol. 39, pages 157-187.

Chinn, Menzie D., Barry Eichengreen, and Hiro Ito, (2014) "A forensic analysis of global imbalances." *Oxford Economic Papers* 66, no. 2: 465-490.

Copeland, M A (1949), **'**Social accounting for moneyflows', *The Accounting Review*, Vol. 24, pages 254-64.

Davis, E. P. (1987a), A stock-flow consistent macro-econometric model of the UK economy part 1. *Journal of Applied Econometrics*, 2(1):111–132.

Davis, E. P. (1987b), A stock-flow consistent macro-econometric model of the UK economy part II. *Journal of Applied Econometrics*, 2(1):259–307.

Dos Santos, C H (2006), 'Keynesian theorising during hard times: stock-flow consistent models as an unexplored 'frontier'of Keynesian macroeconomics', *Cambridge Journal of Economics*, Vol. 30, pages 541-65.

Evans, G W and Ramey, G (2006), 'Adaptive expectations, underparameterization and the Lucas critique', *Journal of Monetary Economics*, Vol. 53, pages 249-64.

Godley, W and Cripps, F (1983), Macroeconomics, London: Fontana.

Godley, W and Lavoie, M (2012), Monetary economics: An integrated approach to credit, money, income, production and wealth, Basingstoke: Palgrave Macmillan.

Greiff, M, Kinsella, S and Nell, E J (2011), 'Income distribution in a stock-flow consistent model with education and technological change', *Eastern Economic Journal*, Vol. 37, pages 134-49.

Harimohan, R and Nelson, B (2014), 'How might macroprudential capital policy affect credit conditions?', Bank of England *Quarterly Bulletin*, Vol. 54, pages 287-303.

Hommes, C (2013), Behavioral rationality and heterogeneous expectations in complex economic systems, Cambridge, England: Cambridge University Press.

Jakab, Z and Kumhof, M (2015), 'Banks are not intermediaries of loanable funds – and why this matters', Bank of England *Working Paper* No. 529.

Mendoza, E. G., Quadrini, V., & Rios-Rull, J. V. (2007), Financial integration, financial deepness and global imbalances (No. w12909). National Bureau of Economic Research.

Obstfeld, M. (2012), Financial flows, financial crises, and global imbalances. *Journal of International Money and Finance*, 31(3), 469-480.

Oulton, N, & Wallis, G (2015), 'Integrated estimates of capital stocks and services for the United Kingdom: 1950-2013', Centre for Economic Performance *Discussion Paper* No. 1,342.

Poutineau, J C and Vermandel, G (2015), **'**Cross-border banking flows spillovers in the Eurozone: Evidence from an estimated DSGE model', *Journal of Economic Dynamics and Control*, Vol. 51, pages 378-403.

Annex: Sources of data used in the model

In order to estimate the model and then forecast with it, we need to source data for around 60 variables. Two of these are exogenous variables and the remainder are 'non-identity' endogenous variables: that is, variables which are associated with a behavioural equation where the fit over the past is not exact. The remaining variables are derived from accounting identities and do not need to be sourced explicitly.

Table E shows the model variables that actually require data to be supplied, and where we source the data from. Most series come from the UK Economic Accounts, published by the Office for National Statistics (ONS). However, there are other series we have to source from elsewhere, such as data on financial market prices and the housing market. Where possible we take quarterly data between 1998 and 2014. Daily data such as asset prices are taken as end-quarter values. Where we can, we also choose variable definitions that are consistent with those in the MPC's forecast models, so that it is easier to use our model as a cross-check on the MPC's forecast.

Table E: Data sources for variables used in the model

Variable description	**Mnemonic**	**Source used – ONS UK Economic Accounts unless otherwise specified**
Actual dividend payments by NFCs	divnfc	
Actual stock of NFC equities, real	enfckp	Uses FTSE all share to deflate national accounts series
Annuity payments made by ICPFs to households	annpay	
Average house price, £000	phouse	ONS house price indes
Bank lending to NFCs	loannfc	
Bank rate, annualised	rga	Bank of England
Banks' bond liabilities, real	dbankkp	Uses Merrill Lynch bond price indices to deflate national accounts series
Banks' equity, nominal, held passively by ROW	ebank	
Central bank demand for government bonds	dgovt_cb	Bank of England
Current account from income side (inverse of)	nlrow	
Dividend payments by banks, to RoW	divbank	
Dividend payments by ROW (going to ICPF)	divrow	
Effective interest rate on NFC deposits	i_depnfc	
Household consumption	ccp	
Household mortgage debt to disposable income ratio process	DTI	
Household net lending	nlp	
Housing investment	ihcp	
ICPF dividend payments (to ROW)	divicpf	
ICPF holdings of bank bonds	dbank_icpf	ICPF holdings imputed from ONS data using sector shares of total interest receipts

ICPF holdings of government bonds	dgovt_icpf	ICPF holdings imputed from ONS data using sector shares of total interest receipts
ICPF holdings of NFC equities	enfc_icpf	ICPF holdings imputed from ONS data using sector shares of total dividend receipts
ICPF net lending	nlicpf	
Interest rate on household deposits	i_dephh	
Interest rate on household mortgages	i_mort	
Interest rate on loans to NFCs	i_loannfc	
Net lending of general government	nlgg	
Net lending of NFCs	nlnfc	
Net lending of the banking sector	nlbank	
Net lending of the OFI sector	nlofi	
NFC deposits at banks	depnfc	
Nominal business investment (all attributed to NFCs)	ikcp	
Nominal exports	xcp	
Nominal GDP at market prices	gdpcp	
Nominal government spending	gonscp	
Nominal imports	mcp	
Number of owner occupied houses in the UK, 000s	numhouse	Derived by residual using ONS housing market statistics
Pension contributions made by households to ICPFs	penscont	
Price index for ROW bonds in foreign currency terms	p_drow	Datastream
Price index for ROW equities in foreign currency terms	p_erow	Datastream
Quarterly interest rate on bank bonds	i_dbank	
Quarterly interest rate on government bonds	i_dgovt	
Quarterly interest rate on ROW bonds	i_drow	
Ratio of new mortgage lending (including remortgaging) to total value of housing transactions	LTV	Bank of England, CML, HMRC
Real stock of government bonds	dgovtkp	
ROW holdings of bank bonds	dbank_row	ROW holdings imputed from ONS data using sector shares of total interest receipts
ROW holdings of government bonds	dgovt_row	ROW holdings imputed from ONS data using sector shares of total interest receipts
ROW holdings of NFC equities	enfc_row	ROW holdings imputed from ONS data using sector shares of total dividend receipts
Sterling exchange rate, indexed to Jan 2005	eer	Bank of England
Stock of household deposits	dephh	
Stock of household mortgages	mort	
Stock of ROW bonds (held by ICPF)	drow	

Stock of ROW equities (held by ICPF)	erow	
Taxes paid by households	taxhh	
Taxes paid by NFCs	taxnfc	
Total compensation paid by NFCs to households (includes non wage labour costs and HH GOS)	wages	
Total household claims on pension funds	penswlth	
Total housing transactions, 000s	housetrans	CML, HMRC
Total mortgage repayments	mortrep	Bank of England
Transfers from government to households	transhh	
Transfers from government to NFCs	transnfc	
Write offs on NFC lending	woffnfc	Bank of England