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MODELLING AND SIMULATING THE BANKING SECTORS OF THE US, GERMANY AND THE UK[1]

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Abstract: The need to understand the dynamics and after-effects of the recent financial crisis, the evolution of macroprudential surveillance and the introduction of macroprudential regulation all require appropriate macroeconomic models of financial institutions and markets. We present models of the banking systems of the UK, US and Germany integrated into the NiGEM global macroeconomic model. These estimated models permit an evaluation both of the effectiveness of macro-prudential policies and their interaction with monetary and fiscal policy. A key policy implication is to remind us that tightening of regulation is not a "free good" but does impact on the economy via the cost of credit. Meanwhile, the impact of macroprudential policies is quite small on the overall economy, suggesting their use in overall macroeconomic stabilisation as a counterpart to monetary policy may be limited although the effect on lending growth and hence potentially in restraining credit booms is more marked. We contend that increasingly active macroprudential policies will make such models as those presented here essential to a correct ongoing calibration and evaluation of policy.

Keywords: Macroprudential policy, macroeconomic models, banking system, capital adequacy, bank lending spreads.

JEL Classification: E27, G18, G21

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1 Introduction

The need to understand the dynamics and after-effects of the recent financial crisis, the evolution of macroprudential surveillance and the introduction of macroprudential regulation all require appropriate macroeconomic models of financial institutions and markets. This paper makes a contribution to that effort via econometric modelling of the key components of the banking sectors of the UK, US and Germany, and their incorporation into the NIESR global macromodel, NiGEM. NiGEM in turn allows comparative simulations to be undertaken on the impact of regulatory changes, for example, higher capital requirements for banks, as well as the response of the banking system to standard fiscal and monetary shocks.

Our modelling of the banking sectors is developed from earlier work on the UK banking sector at NIESR reported in Barrell et al (2009), and updated in Barrell, Davis and Kirby (2010). That work was in turn a cornerstone of the UK contribution to the debate on the macroeconomic impact of tighter regulation (Basel Committee 2010). In effect, a banking model is needed in order to assess the cost to the economy of tighter regulation, imposing as it does a tax on financial activity. To evaluate optimal tightening of regulation, this cost can then be compared with the benefits of tighter regulation in terms of reductions in the probability of a financial crisis.

As noted in Barrell, Davis and Kirby (2010), the traditional form of Dynamic Stochastic General Equilibrium (DSGE) models cannot readily incorporate periods of disequilibrium such as occur after a banking crisis on the real economy, since they are based on equilibrium or at least return to equilibrium faster than is reasonable. NiGEM as a non-DSGE model with a banking sector incorporated is much better able to explain such periods, although it remains linear and thus may underestimate the frequent non-linear impact of shocks. It can also better capture the impact of regulatory tightening, which if imposed suddenly can also entail disequilibrium effects. The rational expectations features of NiGEM increase realism further and reduce the impact of the Lucas critique. The core of the banking model is equations for spreads between borrowing and lending rates for households and corporates, setting of which we consider, in line with Goodhart (2010) and Tobin (1963) to be the best description of how banks operate - setting deposit and lending rates at levels sufficient to cover losses and generate profits and then accepting the resulting quantities of deposits and loans.

In this paper, we outline features of the UK banking model from Barrell, Davis and Kirby (2010) along with similar newly-estimated models for the US and Germany, allowing comparison at both an individual-equation and whole-model level. The paper is structured as follows. In Section 2, we briefly introduce the modelling framework. In Section 3, we discuss and compare the individual equations for the three countries concerned. Then in Section 4 we provide comparative simulation results for the three countries. The conclusion assesses policy implications, progress in our modelling work to date and further research needed.

2 Modelling framework

The NiGEM model which provides the framework of the current modelling exercise contains elements of demand, including consumption and investment, and a supply side (the supply of labour, the level of technical progress and the stock of capital) that is driven by technology, demographics and the user cost of capital. Financial markets are forward looking, as are factor markets (see Appendix 1 for more detail on NiGEM's structure and use).

All of these may be affected by financial regulation or other developments which change bank behaviour. Suppose we tighten regulation for example by raising capital adequacy requirements. By raising banks' costs, this induces a rise in the spread between borrowing and lending rates, so that the rise in banks' net interest income offsets their rise in costs. Increasing the spread between borrowing and lending rates for individuals changes their incomes, and can also change their decision making on the timing of consumption, with the possibility of inducing sharp short term reductions in aggregate demand. Changing the spread between borrowing and lending rates for firms changes the user cost of capital and hence the equilibrium level of output and capital in the economy in a sustained way.

We model banking activity as a set of supply (or price) and demand curves. Demand depends on levels of income or activity, and on relative prices, whilst supply, or price, depends upon the costs of providing assets and on the risks associated with those assets. The banking sectors in our models have four main assets, secured loans to individuals for mortgages, (*morth*) with a borrowing cost (*rmorth*) affected in part by the mark up applied to household loans by banks (*lendw*), unsecured loans to individuals for consumer credit (*cc*) with a higher borrowing cost or rate of return (*ccrate*) again affected by the household margin. Then there are loans to corporates (*corpl*) with a rate of return or cost of borrowing (*lrr+corpw*) where *lrr* is the risk free long rate and *corpw* is the mark up applied by banks, There are liquid assets (*lar*) which are modelled as a residual at a fixed percentage of the balance sheet and other assets (*boa*) modelled as a residual. These categories subsume, along with deposits, other liabilities[2] and risk weighted capital adequacy itself (*levrr*), on-balance sheet bank activity within the UK, US and Germany.

We note that there are periods where nonbank financing activity increases, with loans being made by shadow banks or finance for the non financial sectors being raised by bonds issued by securities markets. This is particularly the case in the UK and US, whereas in Germany most financing is still within the banking system as broadly defined. However, such disintermediation would only matter if we were relying in our modelling on a significant role for quantities of loans rather than the cost of loans. A change in regulation will induce an increase in costs and an increase in off balance sheet and securities activity, all else equal, but the cost of different forms of borrowing will settle to be equal at the margin, and hence it is likely that our approach to modelling the impacts of regulation on prices is not vitiated by the problem of the shadow market and securities issues.

We now go on to describe the framework market by market, noting that banks also issue equities and bonds and take deposits and charge for loans as a mark up over costs. The size and net return on the portfolio generates capital endogenously via retained earnings. Each part of the loans portfolio includes standard determinants to avoid omitted variables bias. We may write them as follows

Secured consumer loans market

The volume of mortgages demanded depends upon real disposable incomes (*rpdi*), real house prices (*rph*) and the real cost of borrowing (*rmort*)

$$\text{morth} = f(\text{rpdi}, \text{rph}, \text{rmort}) \qquad (1)$$

The cost of mortgages depends on the central bank rate (*int*) and the bank markup on household lending (*lendw*)

$$\text{rmort} = \text{int} + \text{lendw} \qquad (2)$$

[2] Apart from capital our modeling of the liabilities side is less behavioural than assets. In general, retail deposits grow in line with the money supply M1 and other liabilities in line with nominal GDP, leaving wholesale deposits as a residual. In the UK we also separately model foreign assets and liabilities, which grow in line with the sterling balance sheet.

The mark up of the mortgage rate over the Central bank intervention rate depends on regulation and risk, and these are captured by the risk adjusted capital adequacy ratio (*levrr*), real net personal sector financial wealth as a ratio of personal incomes (*rnwpi*) and mortgage arrears (*arr*) as risk factors. In the US we model *lendw* as excluding the risk free term structure, leaving the element of the spread that banks can influence (see Section 3.1).

lendw = g(levrr, rnwpi, arr) (3)

Unsecured consumer loans market

The volume of unsecured loans (*cc*) demanded depends on real personal disposable income and on the cost of consumer credit borrowing, (*ccrate*), which in turn depends on the Central Bank intervention rate (*int*) and the normal margin between borrowing and lending rates (*lendw)* and on any specific risk factors for consumer credit (*rpcc*)

cc = f(rpdi, ccrate) (4)

ccrate = g(int, lendw, rpcc) (5)

Corporate loans

The volume of corporate borrowing demanded depends on the profits of the corporate sector (*gprc*), which we proxy through real GDP (*y*) for the US and Germany, and on the cost of borrowing, which is the mark up above the risk free long rate (*lrr*) that banks charge corporates (*corpw*). In the US and Germany, the model fits better when just the corporate lending wedge is included, excluding *lrr* itself.

corpl = h(gprc or y (lrr+corpw) or corpw) (6)

The spread between corporate borrowing and lending rates, *corpw*, depends on the policy environment, and especially on the risk adjusted capital adequacy ratio, *levrr*. It also displays a non linear effect from the difference between actual and target risk weighted capital, with the latter being given in the UK by trigger ratios aggregated across banks, and elsewhere the gap of current capital adequacy over 8%. We calculate the difference, which we might call the headroom available to banks for normal operating purposes, and we use the inverse of this (*invhead*) to pick up non-linear effects of shortages of capital on the lending behaviour of banks. We also include a measure of the output gap, which is the ratio of actual output (*y*) to capacity output (*ycap*) to pick up cyclical elements, and we include the corporate insolvency rate (*insolr*) as a measure of the risks involved in corporate lending, corresponding to arrears for households.

corpw = (levrr, invhead, y/ycap, insolr) (7)

The banking model in the wider economy

The markets for secured and unsecured household lending are part of the consumption and saving decisions in the economy. If consumer borrowing costs change this affects net interest income of the personal sector, and also house prices and housing wealth. These factors in turn feed into consumption decisions, and the shift in the wealth to income ratio changes the savings rate as well. In a small open economy such as the UK with perfect capital mobility, after an adjustment period, this is reflected in the current account and in foreign assets and incomes from abroad, as the saving rate does not affect the production potential of the economy and so rising margins have a short run effect on the economy via this route. For Germany and the US this is also broadly the case although saving there may have an effect on the global long rate and hence a small effect on medium- to long-run productive potential via that route.

The market for corporate borrowing is more closely involved in the determination of the level of output in the long term, via the supply side, which depends upon the supply of labour, the level of technical progress, demographics and the stock of capital. The stock of capital depends in turn on the user cost of capital, and firms' ability to borrow from banks (or from shadow banks), in the equity market and through issuing bonds. At the margin, the cost of each form of borrowing will be the same. Hence a rise in the cost of borrowing from banks will induce a substitution away from that form of borrowing, and this will drive up the marginal cost of borrowing elsewhere. A higher cost of capital will result, and equilibrium output will be affected.

If regulation is tightened, for example via higher capital adequacy requirements as in Basel III, then increasing margins and reducing lending will both move banks back toward their desired capital ratio. If the capital adequacy target ratio (*levrrt*) rises then risk weighted capital adequacy (*levrr)* will increase and so will the cost of corporate and personal sector borrowing. In the UK there has been a normal excess above the required minimum level of capital adequacy which has averaged 3 percentage points in this sample with corresponding historic differences in the US and Germany. As the difference between the actual and the target ratio, or headroom (*head*), available to the banking system shrinks we might expect banks to push up their borrowing charges. As headroom goes to zero we would expect there to be significant non-linear increases in borrowing costs. In order to capture this we included both headroom and its inverse (*invhead*) in all our margin equations, and we retain either variable when they are significant.

In order to evaluate the impacts of regulation we have to have a complete banking sector balance sheet for assets and we have to model the adjustment of bank capital adequacy either through the adjustment of lending or through the accumulation of additional capital. The unweighted balance sheet (*bbal*) includes our three categories of lending along with liquid assets (*brla*) a given percent of the balance sheet and other assets (bboa) which rise in line with the rest of the balance sheet, and it may be written as

$$\text{bbal} = \text{corpl} + \text{morth} + \text{cc} + \text{brla} + \text{bboa} \tag{8}$$

The equilibrium of the balance sheet structure depends upon the impact of factors on the price charged and on the factors that affect the demand equations that in turn depend on prices. If all impacts of, say *levrr* were the same in all price equations and all elasticities of demand in our quantity equations were the same then a change in *levrr* would leave the proportionate structure of the portfolio unchanged. These price and cost effects are not equal. In order to analyse the portfolio adjustment process in response to a shock we also have to take the risk weighted balance sheet, *bbalwa*, where coefficients are in line with the risk weights from Basel 1, which prevailed for the estimation sample, and can be seen as broadly in line with Basel 2 weights for simulations.

$$\text{bbalwa} = \text{corpl} + 0.5*\text{morth} + \text{cc} + 0.2*\text{brla} + 0.3*\text{bboa} \tag{9}$$

If the authorities were to increase the amount of regulatory capital required to be held by banks then it would raise costs and change the scale and structure of the balance sheet.

We note for completeness that the liabilities side, as noted above, is not modelled in detail other than the derivation of capital itself which is described in Section 3.6 below. In general, retail deposits (*rd*) grow in line with the money supply M1 and other liabilities (*bol*) grow in line with nominal GDP, leaving wholesale deposits (*wsd*) as a residual which ensure assets and liabilities are equal. This is in line with the practice of banks to use the wholesale markets as a residual source of funds. In the UK we also separately model foreign currency assets and liabilities, including foreign currency capital which grow in line with the sterling balance sheet.

3 Empirical results for individual equations

3.1 Modelling Spreads for Households and Companies

The equation we have estimated for the household sector margin (mortgage rate less savings rate, *lendw*) is estimated over the last two decades in each country. It is in error correction form for the UK and Germany because all variables included in it are I(1), This pattern distinguishes a short run and long run effect. In the US the wedge is I(0) so we estimate it as a levels equation. Reflecting the predominance of fixed rate lending in the US, we have defined *lendw* in that country as excluding the risk free term structure (long less short rate) which should isolate the profit and risk related component under the control of banks.

The wedge between borrowing and lending rates faced by consumers approaches equilibrium relatively quickly in the UK with a feedback coefficient of 0.45 and somewhat more slowly in Germany with a coefficient of 0.33. The consumer spread depends upon personal sector mortgage arrears (*arr*) in the UK and US, the ratio of net personal wealth to personal income (*nwpi*) in the UK and Germany and the (risk adjusted) capital adequacy ratio of the banking system (*levrr*) in all three countries. Both the level of arrears and the net financial wealth of the personal sector relative to its income may be seen as indicators of risk, with the former increasing it and the latter reducing it, much as is suggested by the signs of their coefficients in the equation.

The levels coefficients are comparable in these equations as they are the actual long run coefficients for the UK and Germany (i.e. the equation is estimated nonlinearly for the UK and by Granger-Engel 2-step for Germany). The major contrast is in the capital ratio effect, which is three times larger in the US and Germany than the UK. The arrears effect in the UK and US is in contrast comparable with a coefficient of around 0.65. The net financial wealth effect is much larger in Germany than the UK, and the German equation also features a negative impact of interest rates. This last may reflect “relationship banking” in that country where banks historically sought to absorb risks for borrowers in times of economic difficulty.

Except in the US, no separate role for headroom or its inverse was found in this equation. For the UK, this may reflect the fact that the average mortgage rate (which we use here as this is the rate that also feeds into personal net interest incomes) does not change very rapidly when interest rates change. The personal sector markup, *lendw* feeds into both the mortgage borrowing rate and a credit card borrowing rate

Table 1: Modelling the spread for households

		UK	US	Germany
Dependent		D Lendw	Lendwx (lendw-lr-r3m)	D Lendw
Constant		-0.0001 (-0.87)	-0.587 (-0.4)	0.007 (0.3)
Lendw(-1)		-0.446 (-4.4)		-0.308 (-3.2)
Constant inside long run (-1)		0.024 (-5.8)		9.7 (15.8)
Levrr	(-3)	0.064 (2.8)		
	(-2)		0.177 (1.92)	
	(-1)			0.248 (2.2)
Arr	(-4)	0.604 (8.8)		
	(-3)		0.666 (7.02)	
Nwpi (-1)		-0.316 (-7.3)		
Nwpi (-3)				-1.5 (11.2)
Invhead (-1)			1.856 (2.38)	
Int(-3)				-0.496 (22.6)
Dlendw (-1)				0.653 (6.5)
Sample		1990q3-2008q2	1992q1 - 2008q4	1992Q1 2010Q1
R-Bar-2		0.39	0.513	0.376

Note : t-statistics in parenthesis, German equation is estimated by Granger-Engel 2 step procedure

The equation for the corporate borrowing wedge (*corpw*) is estimated in level terms for all three countries, as the dependant variable appears to be stationary.

The corporate sector margin (corporate lending rate less deposit rate, *corpw*) again depends upon a number of risk-based factors, with a strong role for the output gap (*y/ycap*) and a business sector insolvency rate (*insolr*), as well as the inverse of headroom (*invhead*) and the risk adjusted capital adequacy ratio (*levrr*). Looking comparatively, the UK and German equations have much larger impacts of the output gap than in the US, implying the corporate margin may be more cyclically volatile. Insolvency is present in levels for all countries, with a much larger coefficient in Germany and to a lesser extent the UK than the US. Inverse headroom is significant for the US and UK, with comparable coefficients, implying an extra boost to margins when capital falls close to its desired (or required) level.

The most important coefficients for evaluating the impact of regulation and other influences on capital are those on risk adjusted capital adequacy (*levrr*), which implies a similar impact for capital requirements on corporate spreads in all three countries.

We note that the impact of a rise in capital adequacy in the UK is greater on corporate than for household spreads, which implies that tighter regulation induces banks to seek to shift to less risky activity, an effect that can be realised since as discussed below, the impact of interest rates on mortgage lending is also less than for riskier corporate and unsecured consumer borrowing. In contrast, the impact of a rise in capital adequacy on spreads in the US and Germany is more comparable between household and corporate spreads. Hence the impact on portfolios may be more balanced, depending on other factors. We assess this further in the simulations below.

There are interest rate effects in the equations for the US, with the short real rate providing an additional risk indicator with a positive sign, while again in Germany there is a negative effect, this time of the short nominal rate. That may again reflect “credit insurance” related to relationship banking.

Table 2: Modelling the spread for companies

	UK	US	Germany
Dependent	Corpw	Corpw	Corpw
Constant	-0.197 (-0.5)		-1.35 (-3.2)
Log(y)-log(ycap)	13.1 (4.7)	1.371 (2.27)	
(-4)			21.5 (8.0)
Invhead (-1)	0.842 (5.3)	0.741 (2.75)	
Insolr	0.522 (5.7)	0.108 (2.95)	
Insolr (-3)			2.02 (5.5)
Levrr	0.195 (5.6)	0.204 (25.93)	0.199 (3.2)
Rr		0.021 (2.45)	
R3m			-0.097 (-3.3)
Sample	1989q2-2007q4	1991q4-2008q2	1980q4-2009q4
R-bar-2	0.64	0.467	0.676

Note : t-statistics in parenthesis

We found no role for liquidity in this mark-up equation, reflecting its absence from the regulatory regime over this period. Apart from German short rates, all levels variables in the equation have a positive sign, i.e. an increase in any of them raises the cost of borrowing for companies and affects their borrowing ability and level.

A decrease in headroom and a consequent tightening in bank finance may lead to firms seeking alternative sources of finance, such as an increase in their bond issuance and reliance on equity markets. Companies may also turn to the shadow market. But in each case we would expect the cost of borrowing in terms of debt to be the same at the margin as bank borrowing *corpw*.

In order to test and model this proposition we need to link the corporate bond markup (*iprem*) to the corporate borrowing margin in the banking sector. The user cost of capital is the tax adjusted, market weighted average of the cost of equity finance and the cost of borrowing from banks or by issuing bonds. It therefore depends upon a mark up over the risk free borrowing rate facing the public sector, and this mark up will be similar in bank and bond markets if firms can easily move between the two. A simple regression of the credit risk premium on BAA bonds *iprem* on the corporate spread within banks *corpw* supports our suggestion and indicates a one-to-one relationship between the BAA spread and the bank borrowing rate, as we can see below. We have included the equation below directly for the UK[3] and imposed a unitary coefficient on *corpw* in the US and Germany.

Table 3: Modelling the bond spread

	UK	US	Germany
Dependent	Iprem	iprem	iprem
Constant	1.218458 (7.4)		
Corpw	1.001903 (18.9)	0.876 (28.7)	0.783 (14.1)
Sample	1999M01 2007M09	1981Q4-2011Q1	1980Q1-2011Q1

Note : t-statistics in parenthesis

3.2 Modelling secured lending to consumers

The margin on household lending has to feed into the secured lending equation through its impact on the mortgage rate (*rmort*). In the UK and Germany we have imposed that in the long run the mortgage rate rises with the spread and responds one for one to intervention rates[4]. In the US a similar outcome is obtained via estimation.

In the short-term, mortgage rates rise more or less one to one with the spread. However, in all three countries there is some noticeable lag in the effects of intervention rates. In the UK this may reflect that some of the stock of debt is at fixed rates, but generally only for a short period, while in Germany and especially the US, more of the stock is at fixed rate so a lag would be expected from the term structure relationship. In the UK and US the equation is dynamically homogenous to changes in the intervention rate (coefficients on change terms add to one) and hence only the level of the rate affects the long run costs of mortgages, whereas in Germany only 70% of a short term rise in intervention rates is passed on. The equation is estimated in error correction form as the variables in it are all I(1). No specific risk factors entered this equation when they were investigated, and hence risk has its impact through the arrears and wealth variables in *lendw*.

[3] For the UK, the underlying data for both investment premium and corporate wedge variables is taken in monthly terms to maximise the number of observations. As the monthly data reveals a break in both series in the first month of 2004, which in turn affects stationary test results, we ran unit root tests with break dummies included.

[4] There may also since 2007 have been a separate role for the three month inter bank rate as credit markets became disrupted, but this is difficult to pick up in this context.

Table 4: Modelling the real mortgage rate

	UK	US	Germany
Dependent	D Rmort	D Rmort	D Rmort
Constant	-0.031 (-1.3)	-0.047 (-0.51)	-0.038 (-1.52)
(rmort(-1) - (int(-1)+lendw(-1)))	-0.130 (-2.2)		-0.066 (-1.84)
Rmort(-1)		-0.092 (-3.15)	
R3m(-1)		0.087* (2.81)	
Lendw(-1)		0.068* (2.33)	
Dint	0.826 (35.9)		0.71 (15.89)
DInt (-4)	(1-0.826449)		
Dr3m		1.038 (30.69)	
D lendw	1	0.962 (23.3)	1.149 (28.04)
Sample	1999q1-2008q3	1982q1-2011q1	1994q2-2008q1
R-bar-2	0.854	0.903	0.935

Note : t-statistics in parenthesis, * long run effects are 0.946 for R3M(-1) and 0.74 for Lendw(-1)

The market for the quantity of mortgage lending (*morth*) must include a demand relationship as well as a price equation. The impact of bank capital on this market depends both on the coefficients on *levrr* and *lendw* in the price equation and also on the coefficient on price in the demand equation. All the variables in the equation for *morth* are I(1) so we estimate with an error correction structure. Hence the real stock of mortgages (*morth)*, which is deflated by consumer prices (*ced*) slowly adjusts to an equilibrium relationship with real post tax incomes (*rpdi*) with a long run demand elasticity marginally above one in the UK, 0.4 in the US and 2.6 in Germany. The large coefficient in Germany may reflect a more recent change from a culture of saving before house purchase to borrowing, than in the UK and US, hence the term may be affected by stock adjustment.

In the US and UK, the level of borrowing and its dynamics are influenced by both the level and rate of change of real house prices (*ph/ced*). There is, in contrast, no identifiable levels term in Germany, where house prices have been historically quite static. The real mortgage rate (*rrmort*) has a significant and negative impact on mortgage borrowing in the UK and US, while in Germany there is only a difference effect. Nevertheless the outcome for all three is that a rise in capital adequacy, or other form of regulatory tightening, will raise mortgage rates and negatively affect borrowing.

Table 5: Modelling mortgage lending

	UK	US	Germany
Dependent	DLog (morth/ced)	DLog (morth/ced)	DLog (morth/ced)
Constant	-0.518 (-2.6)	-0.096 (-0.44)	-0.326 (-2.06)
Log (morth/ced) (-1)	-0.128 (-5.7)	-0.182 (-5.14)	-0.026 (-2.73)
Log (rpdi) (-2)	1.058 (13.1)	0.44 (-3.27)	2.602 (5.89)
Log (ph/ced) (-1)		1.19 (-7.82)	
Log (ph/ced) (-4)	0.256 (6.1)		
D log (ph/ced) (-2)	0.175 (3.0)		
D log (ph/ced) (-1)		0.517 (3.47)	
D log (ph/ced)			0.424 (2.38)
Rmort(-2)-((Ced(-2) /Ced(-3))^4 -1)*100	-0.007 (-2.8)	-0.02 (-2.84)	
D Log Rmorth (-2)			0.297 (4.7)
D Rmort (-3)			-0.012 (-3.86)
Sample	1986q1-2008q2	1990q2-2010q4	1987q1-2007q1
R-bar-2	0.51	0.527	0.704

Note : t-statistics in parenthesis

3.3 Modelling unsecured lending to consumers

Total personal sector borrowing includes consumer credit (*cc*), and this in turn depends upon the rate of interest on consumer credit (*ccrate*). In our modelling the consumer credit interest rate rises in line with the intervention rate (*int*) and the lending margin for consumers *lendw*, although it is, as might be expected, noticeably higher than the mortgage spread would suggest. The variables are all I(1) so there is an error correction equation structure. The relationship of the consumer credit rate to the intervention rate and the spread is imposed in the UK but is broadly consistent with estimation in the US. In Germany there is a long run link to capital adequacy as well as the intervention rate, with the spread being insignificant. There is a significant inertia in this relationship, notably in the UK while adjustment is quickest in Germany.

In the UK there are short run dynamic terms in the intervention rate and the dependent variable, and the latter also appear for Germany. There appears to be no separate role for risk factors in this equation, perhaps because they are all correlated with mortgage arrears and/or the net wealth/income ratio, which does influence the credit card borrowing rate through *lendw*.

Table 6: Modelling the consumer credit rate

		UK	US	Germany
Dependent		D Ccrate	D Ccrate	D Ccrate
Constant		0.457 (1.7)	0.611 (2.66)	0.195 (0.72)
(ccrate(-1) - (int(-1) +lendw(-1)))		-0.045 (2.0)		
Ccrate (-1)			-0.083 (-3.23)	-0.249 (-5.59)
Int (-1)				0.249 (5.59)
R3m (-1)			0.071 (3.35)	
Lendw(-1)			0.054 (1.73)	
Levrr (-1)				0.661 (6.66)
D Int (-1)		0.302 (2.5)		
D Ccrate	(-1)	0.349 (3.1)		
	(-2)			0.287 (3.28)
Sample		1995q3-2008q3	1982Q1 2011Q1	1991q1-2011q1
R-bar-2		0.394	0.088	0.614

Note : t-statistics in parenthesis

For the demand equation, consumer credit lending, the variables are I(1) implying again an error correction approach. The volume of consumer credit lending, *cc* is very inertial in relation to income (*rpdi*) with a feedback from the equilibrium of 0.035 in the UK and 0.023 in Germany suggesting it takes six years or more to adjust to a new stock equilibrium. In contrast in the US the error correction term is over 0.1 implying a much more rapid adjustment. The UK and Germany have an imposed long run homogeneity with respect to

RPDI while in the US the long run income elasticity is around 2. The stock is quite sensitive to the real cost of consumer credit borrowing (*rccrate*) with a long run semi-elasticity of -0.2 (i.e. - 0.0075/ 0.035) in the UK, -0.25 in the US but only -0.04 in Germany.

Table 7: Modelling consumer credit lending

	UK	US	Germany
Dependent	D Log (rcc)	D Log (rcc)	D Log (rcc)
Constant	0.0006 (0.2)	0.016 (0.1)	-0.11 (-1.74)
Log (rcc) (-1) (Error correction)	-0.035 (2.7)	-0.114 (-4.04)	
Log Rcc (-4)-Log Rpdi (-4)			-0.023 (-1.86)
Log Rpdi (-1)	0.035 (2.7)	0.244 (1.75)	
Rccrate (-1)	-0.008 (-5.0)	-0.028 (-2.2)	
(-2)			-0.001 (-1.67)
D Log Rcc(-1)			0.372 (3.99)
Sample	1994q1-2008q2	1983Q4-2009Q4	1986q4-2011q1
R-bar-2	0.625	0.287	0.475

Note : t-statistics in parenthesis

3.4 Modelling corporate sector borrowing

We have modelled the demand for corporate borrowing in a similar way to consumer borrowing, treating it as a demand curve for firms. In the UK, real corporate borrowing (*corpl/ced*) error-corrects on real corporate profits from the non-oil sector (*gprc*), while in the US and Germany we proxy corporate profits through real GDP (*y*). Homogeneity is imposed in the UK and Germany, and a figure close to homogeneity emerges in the US also. Corporate lending is influenced by corporate borrowing costs which in the UK are a mark up over the risk free interest rate (*lrr+corpw*) while in the US and Germany we use *corpw* alone. The long run semi-elasticity of demand with respect to real borrowing costs in the UK is -0.2, much as in our consumer credit demand equations, while in the US it is lower at –0.16. In the UK both corporate sector borrowing and unsecured credit are more sensitive to these costs than is secured consumer borrowing, whereas in the US the interest rate elasticity for corporate borrowing is comparable to that for mortgage borrowing. For Germany we only have a difference effect of corpw, implying that cost effects are less important than demand effects in the long run in that country, perhaps because unlike the UK and US, the alternatives of bond and equity financing are less available for most of the corporate sector. The equations have dynamics of adjustment to the equilibrium that are relatively slow, correcting only 5 per cent of any discrepancy between actual and equilibrium within any quarter in the UK, 2% in Germany and 8% in the US.

Table 8: Modelling corporate sector borrowing

		UK	US	Germany
Dependent		D Log (corpl/ced)	D Log (corpl/ced)	D Log (corpl/ced)
Constant		0.204 (5.0)	-0.567 (-5.93)	-0.082 (-1.8)
Log (corpl/ced) (-1)		-0.048 (-4.2)	-0.082 (-6.34)	-0.021 (-1.88)
Log (gprc/ced) (-1)		0.048 (4.2)		
Lrr+Corpw		-0.01 (-4.6)		
Corpw (-1)			-0.013 (-4.65)	
Log (Y) (-1)			0.091 (6.17)	0.021 (1.88)
D log(corpl/ced)	(-4)	0.394 (4.8)		
	(-2)		0.676 (12.65)	0.239 (3.55)
D Corpw (-4)				-0.007 (-1.7)
Sample		1988q2-2008q2	1982q1-2011q2	1981q3-2011q1
R-bar-2		0.464	0.683	0.479

Note : t-statistics in parenthesis

3.5 Modelling arrears and insolvencies

Of course it is desirable to endogenise risk in the economy, so that macroeconomic factors may have an additional way to feed back onto banks loan pricing behaviour. Our work on arrears and insolvencies is at a preliminary stage.

There are no data for the rate of mortgage arrears in Germany, instead we use personal bankruptcies, itself a problematic series since a reform in the early 2000s led to a stock adjustment in the level of the series. Hence we only estimate up to 1999, whereas for the US and UK estimation can be to date. Arrears are determined by debt-to-income ratios, unemployment, output gaps, house prices and interest rates, in an error correction framework. The impact of debt is larger (by a factor of 2.5) in the US than in the UK, perhaps reflecting the greater ease of default in that country (non-recourse mortgages allow the keys to be handed back to the bank with no subsequent liability). Debt is the only long run effect in the

UK, in the US there is also an impact of monetary rigour on arrears while in Germany personal bankruptcies are linked to unemployment and excess capacity in the economy. There are a number of cyclical terms as well, with the acceleration of house prices and rise in unemployment having a negative effect on arrears in the UK, rises in house prices and interest rates in the US and growing excess capacity in Germany.

Table 9: Modelling arrears rate (personal insolvencies rate for Germany)

	UK	US	Germany
Dependent	D ARR	D ARR	D ARR
Constant	0.31 (2.61)	3.199 (6.11)	0.001 (3.43)
Arr (-1)	-0.02 (-3.04)	-0.051 (-5.19)	-0.04 (-4.63)
Log((liabs/ced)/ rpdi) (-1)	0.119 (2.73)	0.666* (-3.94)	
Log(ycap)-log(y) (-1)			0.004 (3.03)
U/100 (-1)			0.0003 (1.9)
DD log(ph/ced) (-2)	-0.552 (-2.05)		
D arr (-1)	0.538 (8.03)		0.667 (10.51)
D u (-1)	0.094 (3.23)		
Int (-2)		0.033* (-2.36)	
D log(ph/ced) (-1)		-10.599 (-6.58)	
D log(ycap)-log(y)			0.005 (2.26)
D Log(y)		-10.293 (-3.45)	
Sample	1985q1-2011q2	1991q2 2011q1	1975q2-1999q1
R-bar-2	0.785	0.843	0.779

* Equation was estimated nonlinearly, coefficients recalculated to aid comparability.
Note : t-statistics in parenthesis

The rate of corporate insolvencies is I(0) in the US and I(1) in the UK and Germany. It is driven by excess capacity, interest rates and economic growth. In the UK, levels effects arise from excess capacity, with a long run elasticity of around 8, which is around a quarter of the impact in the US. There is also an interest rate levels effect, again smaller than the US but comparable with that in Germany. The US also features an impact of the risk premium on corporate bonds, that reflects risk and hence also credit rationing that may lead to insolvency. The UK and Germany have short run income growth terms (acceleration in the UK and growth in Germany) implying increasing insolvency rates in recessions, and in Germany also when excess capacity rises.

Table 10: Modelling corporate insolvencies

		UK	US	Germany
Dependent		D INSOLR	INSOLR	D INSOLR
Constant		-0.007 (-0.74)	-0.614 (-0.97)	0.015 (1.93)
Insolr	(-1)	-0.034 (-4.35)		
	(-2)			-0.016 (-2.22)
Log(ycap)-log(y) (-1)		0.271 (2.05)	28.635 (6.8)	
R3m (-2)		0.006 (4.95)	0.204 (3.1)	
R3m(-3)				0.003 (2.7)
Iprem (-1)			79.794 (4.34)	
D insolr (-1)		0.756 (15.49)		
D log(y)				-0.472 (-2.3)
	(-2)			-0.44 (-2.01)
	(-3)			-0.698 (-3.09)
D D log(y) (-2)		-1.157 (-2.33)		
D D log(y) (-4)		-1.531 (-2.99)		
D log(ycap)-log(y) (-4)				0.449 (1.81)
Sample		1985q1-	1987q1-2010q4	1976q2-2009q2

	2010q3		
R-bar-2	0.834	0.479	0.206

Note : t-statistics in parenthesis

3.6 Modelling Capital Adequacy

Following the discussion above, we set up a simple algebraic framework for capital adequacy. If there is a shock to any of the assets of the banking system then *levrr* will change, and banks will be obliged to adjust either their capital or their asset structure. Capital can either be raised by rights issues or by absorbing some of the gross operating surplus of the system. Giving the example of the UK, the first line in equation (10) gives the speed of adjustment for bank capital. As *levrr* is the risk weighted ratio of capital to assets, or *bcap* divided by risk weighted assets, *brwa*, we can calibrate the adjustment of *bcap* in line with the speeds of adjustment discussed in Osborne (2008). We multiply the shortfall indicator in the first line by 1.5 to achieve this. If *levrr* is below its normal level,[5] given the desired level of headroom, 3, some of it will be used to rebuild bank capital and increase headroom, and operating margins on consumer lending will be increased. The gross operating surplus of the banking system is the gross margin on the three types of lending multiplied by the total value of the stock of the particular category of lending, and this is the second line in the expression below. Division of each term by 400 reflects that we are working in percentages with quarterly data.

bcap = bcap(-1) + ((1-(levrr(-1)/(levrrt(-1)+3)))*1.5*10*

((lendw(-1)/400.)*(morth(-1)+cc(-1))+(corpw(-1)/400.)*corpl(-1))

-0.6*((arr(-1)-0.9)/400)*(morth(-1)+cc(-1))

-0.522*((insolr(-1)-1.24)/400)*corpl(-1) (10)

Changes in the speed of adjustment in this equation change the short run, but not the long run effects of changes in capital adequacy targets. Equation (10) is extended by endogenous arrears and insolvencies to reflect the losses imposed on bank capital by corresponding defaults. The equation seeks to capture the fact that margins are set to offset average levels of defaults so capital is depleted when defaults are above this level (in the case of the UK, 0.9% for arrears and 1.24% for insolvencies. The coefficients on arrears and insolvencies (-0.6 and –0.522 for the UK) then reflect the estimated impact of defaults on spreads. The *bcap* equation varies between countries to capture differences in these various effects.

4 Model simulations

We sought to test the models by three NiGEM simulations, firstly showing the impact of raising capital adequacy requirements by one percentage point, which assesses the impact of regulatory tightening on the banking sector directly and thus indirectly on the wider economy. Then, we undertook two standard macroeconomic simulations in order to test how the banking sector behaves under normal economic circumstances. These are respectively a monetary easing and a fiscal easing. The monetary easing is a permanent 1% increase in the nominal target for the country concerned, while the fiscal easing is a permanent 1% of GDP rise in real government consumption.

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[5] Normally uklevrr/(uklevrrt+b) would be approximately 1.0, and over our sample period in the UK b has averaged around 3.0. If banks hold their desired headroom capital then none of the operating surplus will be used to augment it.

We present the results for key banking and macroeconomic variables for each of the three countries alongside one another, which helps assess the differences in response as well as pointing to any shortcomings of the models as estimated – bearing in mind that the banking models are still "work in progress" and are at present available in NiGEM as options. Of course, although we are focused on the results for the country in question, we are running the entire global system with corresponding (smaller) impacts worldwide and consequent feedbacks to the home economy.

4.1 Capital adequacy

Looking first at the results for a 1 percentage point increase in required bank capital adequacy (Chart Series 1 appended), the impact in each country is to reduce GDP, in line with other work presented by the Basel Committee (2010). The smallest decline is in the UK and the largest initially is in the US, although after 2 years the German effect is the most sizeable. Looking at a three year time horizon, the average impact on GDP of a one percentage point rise in capital adequacy requirements is around –0.07% close to the average of –0.09% in Basel Committee (2010).

The transmission mechanism for lower GDP is, as suggested by the model structure, mainly via the changes in banking sector spreads which are impacted directly by higher capital adequacy requirements. The rise in the household sector spread is lowest in the UK at around 7 basis points, while in line with the equations, that in Germany and the US is larger at around 20 basis points. The corporate sector spread rises comparably in the three countries in the first two years, showing an increase of around 20 basis points. Accordingly, rises in spreads are comparable across both sectors and all three countries with the UK household spread being the exception. Endogenous rises in insolvencies and arrears (not illustrated) occur mostly in the US and help explain a higher initial level of *corpw* in that country.

Investment is the main channel of transmission for capital adequacy since the corporate sector spread raises the user cost of capital and hence the volume of investment. For the first two years the decline in private investment is comparable at 0.5-1%, thereafter the decline eases in the US and UK, while in Germany, investment remains lower at -1.1%. Consumption, which is not illustrated, falls as a consequence of lower "other personal income" (since spreads are wider, consumers have less savings income and pay more on loans), lower house prices (affecting personal wealth) and a weaker economy affecting RPDI via employment and wages.

The interest rates on mortgage lending and consumer credit borrowing form intermediate steps to the demand equations. We can see that the sign is the same for each country, namely that the rise in capital adequacy boosts the real mortgage rate and the consumer credit rate. The mortgage rate changes are comparable in the long run converging at around 10 basis points, although German rates initially "spike" at a high level. For consumer credit rates the rise is larger both short and long term in the German model than for the UK and US, reflecting the direct impact of capital adequacy in that equation.

We can trace the impact of the rise in margins on borrowing by households and companies, as demand for loans falls back in the light of higher costs of credit. In terms of corporate lending, the UK and US show similar falls of around 3-4% over the medium term, as costs of credit rise and profitability or respectively GDP decline. The impact on corporate lending in Germany is much less, reflecting the fact that we could not identify a levels effect of the spread in our estimate shown above, only a difference. Accordingly the decline responds mainly to the weakness of the economy. The pattern for mortgage lending has German and US lending falling by 0.6-1.0% while UK lending declines by a maximum of 0.1%. Consumer credit declines further in Germany than in the UK and US, with the effect being around four times larger, although the coefficient on consumer credit is quite small.

The rise in bank capital itself is largely a consequence of the rise in requirements, but also reflects the impact of changes in lending volumes, risks and interest rates. Despite the differences in banking sector responses, as well as to a lesser extent in macroeconomic responses, the change in capital per se is broadly similar, as should be expected. A one percentage point rise in the target for capital adequacy – which in turn raises capital adequacy itself by the same amount, raises capital itself by around 9% in the UK and Germany and 7% in the US. The latter is perhaps largely a consequence of the higher level of capital adequacy in the US according to our dataset.

As discussed above, concerning the outcomes for balance sheets, for the UK, if *levrrt* (and hence *levrr*) were to be raised by one percentage point as in this simulation then our modelling of costs and of the demand for loans etc embedded in the simulation show that the size of the bank's balance sheet (*bbal*) falls by 1.1 per cent. However, the elasticities differ across risk categories, and hence the scale of risk weighted assets falls by 1.4 per cent as banks shift into less risky assets as a result of the increase in costs that follows on from the rise in regulatory capital requirements. This is consistent with the differences observed in Francis and Osborne (2009). The corresponding results for the US are similar in that the balance sheet falls by 1.6% after a one percentage point rise in capital adequacy, while risk weighted assets fall by 2%. Hence in that country too, banks switch to less risky assets. In Germany however, there is less of a clear difference between risk weighted and unweighted assets, with both falling by around 0.6% in our model as it stands. Note that the comparative changes in lending differ markedly from the comparative changes in spreads, being much more comparable, reflecting inter alia different elasticities in the lending equations.

Finally we see the endogenous changes in interest rates that occur in the simulation. The initial rise in each country is linked to a technical fall in the exchange rate, which raises inflation. Afterwards, monetary policy is eased as the economy weakens and inflation falls back. We see a larger easing in the US than in Germany (which reflects the fact it is in the eurozone) and the UK (where the fall in GDP and inflation is rather less).

4.2 Monetary and fiscal easing

These standard NiGEM simulations are intended to test the behaviour of the banking sector models in the context of the wider macroeconomy. We report them at lesser length.

In the monetary policy simulation (Chart Series 2), a rise in the nominal target raises GDP for a number of years, by around 0.15%. This is a consequence of lower initial interest rates, which also imply a depreciation of the exchange rate. The easing is reduced over time as interest rates respond to inflation. Investment is boosted initially but falls in both the UK and Germany after 2-3 years, helping to explain the less sustained boost to GDP than in the US.

Changes in corporate lending margins are fairly negligible at around 2-3 basis points, although it is notable that they rise in the first 2 years of the simulation in all countries. This probably reflects the common impact of excess capacity and also headroom as the capital adequacy rate declines initially but later the change returns to zero as retentions build up to cover the increased lending. The household lending wedge is virtually unchanged in the UK and US, while in Germany it initially falls, reflecting a rise in personal wealth, which is later unwound.

The patterns of lending are very similar across the three countries, suggesting commonalities in the banking sector models themselves in response to lower interest rates and a sustained boost to the economy. Corporate lending and mortgage lending each rise by around 1%, while the more volatile consumer credit rises by 1-2.5%, with the greater rise being in the UK.

Mortgage rates and consumer credit rates are both initially reduced by the monetary easing, as would be expected, although except in the US this becomes a positive shift in due course as the economy grows and the easing in interest rates diminishes. Bank capital rises in all three simulations in comparable ways, with balance sheets growing and despite lower interest rates. Also there are fewer defaults to erode capital.

Looking now at Chart Series 3, easing fiscal policy raises GDP by 0.4-0.8% initially but this is in due course eliminated as monetary policy is tightened to offset inflation, also raising the exchange rate. Corporate investment, for example, is boosted only marginally and then falls sharply. The degree of crowding out in Germany is less than in the UK and US due to a lesser response of monetary policy, again because Germany is a component of the euro area rather than a single monetary area itself.

How do the banking models behave in this macroeconomic context? There is a positive shift in the household spread, albeit delayed in the case of the US, of around 2-4 basis points, largely reflecting shifts in excess capacity. The corporate wedge appears volatile in the chart but the amplitude of shifts is quite small.

In terms of borrowing, the volume of mortgage lending and consumer credit react quite similarly, rising with the initial boost to the economy before falling back as monetary policy is tightened. Corporate lending behaves similarly in the US and Germany, rising initially then falling back while in the UK it remains negative.

The interest rates all rise in line with monetary policy tightening, with a greater consequent rise in the UK than in the US and Germany. Finally, bank capital falls after a period of stability in the UK, reflecting lower lending volumes despite higher interest rates and margins, while US and German capital is built up slightly. Capital adequacy rises slightly in this simulation, but not enough to have a marked independent effect on the economy.

5 Conclusions and further research

This exercise is still preliminary, albeit an important part of the ongoing updating and development of NiGEM, so it can capture in particular the growing role of macroprudential policy in coming years. A key policy implication is of course to remind us that tightening of regulation is not a “free good” but does impact on the economy via the cost of credit. Accordingly, rises in capital adequacy may need to be calibrated to the expected benefit in terms of reduced risk of crises. On the other hand, the impact of macroprudential policies is quite small on the overall economy, suggesting their use in overall macroeconomic stabilisation as a counterpart to monetary policy may be limited (Basel Committee 2010) although their effect on lending growth and hence potentially in restraining credit booms is more marked. It may be useful to test whether costs can be reduced and effectiveness increased via policies which are more targeted to specific markets, as for example is discussed for Sweden in Davis et al (2011). One downside is that such policies may be more readily circumvented by disintermediation.

In terms of further research, in the short term we shall incorporate the arrears and insolvencies equations in the model to give a fuller picture of interactions between the banking sector and the real economy. We shall also continue to refine the equations and framework set out in this paper for the US, UK and Germany. In the longer term, we may incorporate other forms of macroprudential policy, especially where there is a rise in specific capital requirements e.g. on mortgages and also LTV limits. We may endogenise the countercyclical buffers for those economies that seek to incorporate the full Basel III menu, using various determinants including those proposed in Borio et al (2009).

Rises in liquidity requirements could be further assessed, although an impact of liquidity on spreads proved elusive in the UK work highlighted in Barrell et al (2009). Further work on the liabilities side could seek to better gauge the development of banks' liability management and the liquidity risks to which it gives rise. Following Davis et al (2011) we could modify house price equations following evidence in that paper that a number of potential macroprudential effects can be captured in freely estimated house price equations. Notably, we can have effects arising via the user cost, which can proxy LTV limits, spreads, which can proxy for changing capital ratios, as well as a mortgage stock effect. And finally there will be estimation of banking models for further countries, initially France and Japan but later perhaps Canada and Italy. These will depend on data availability as well as resources, naturally. The more countries we model, the more accurate the model will be at showing the comparative effects of international regulatory collaboration as opposed to country-by-country policies.

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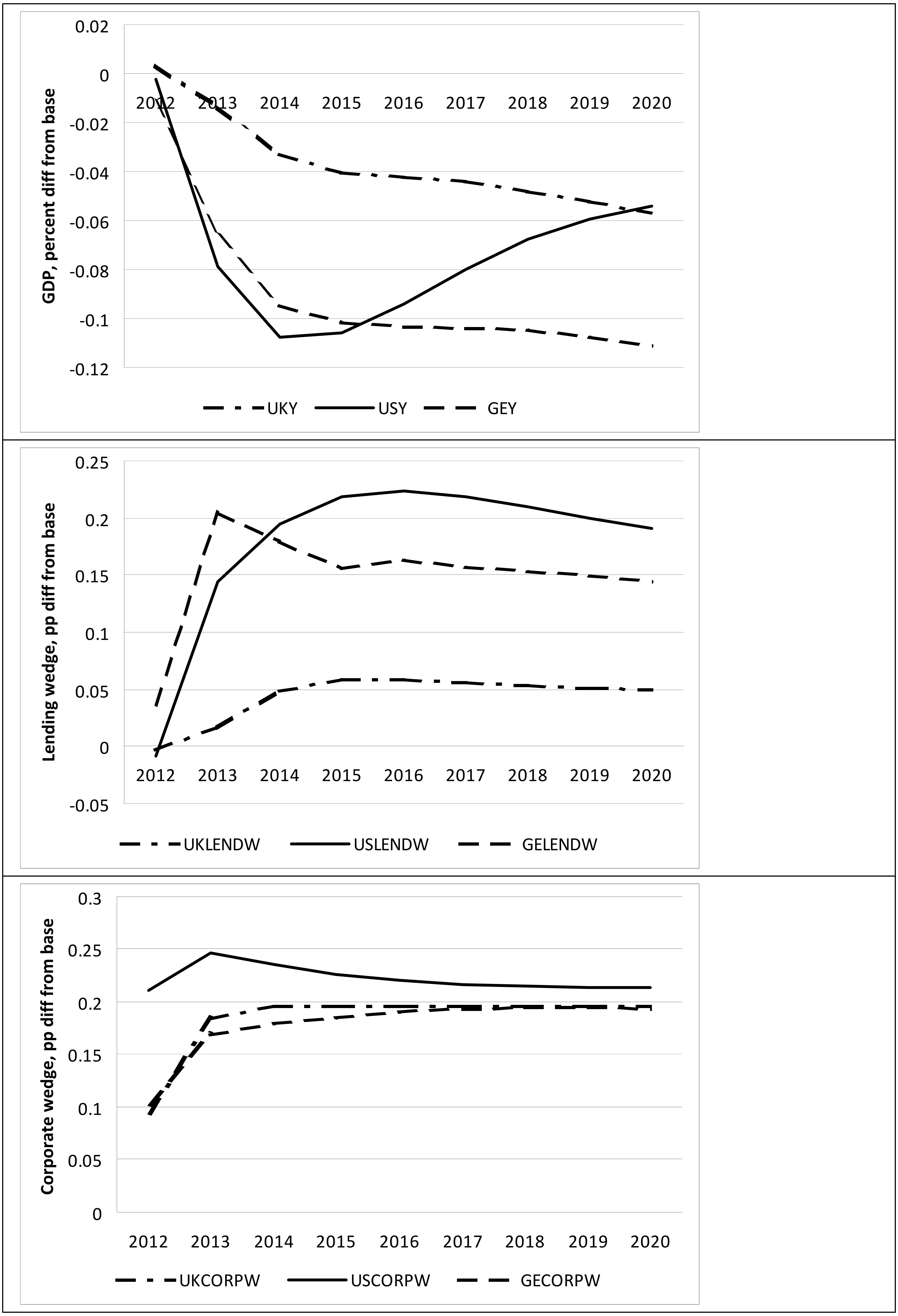
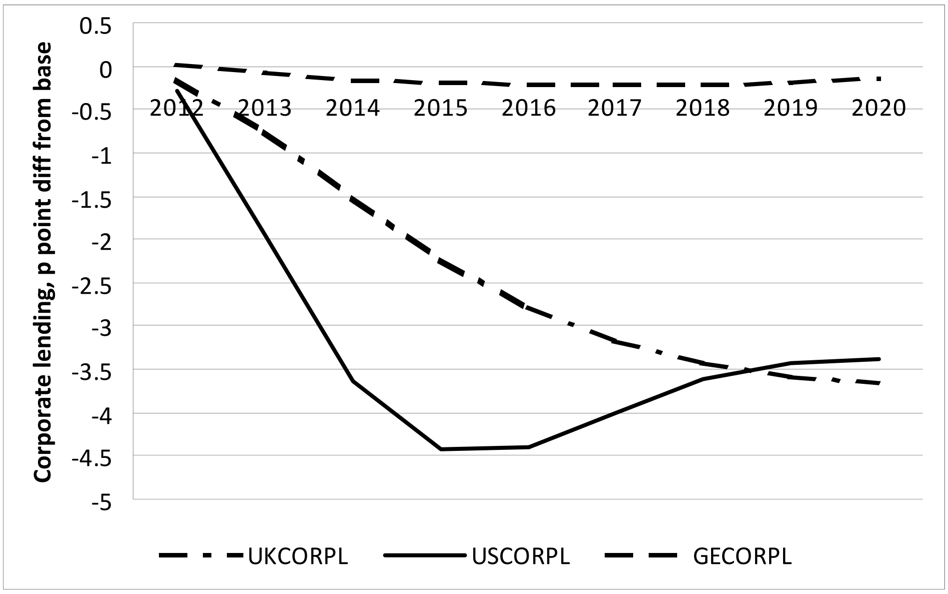
Chart series 1 – One percentage point shock to required capital adequacy (levrrt)

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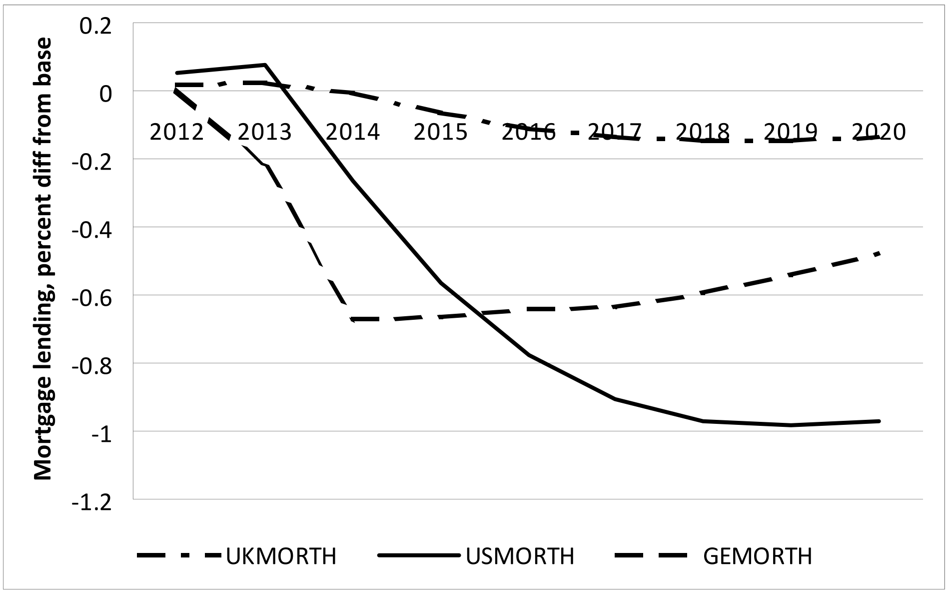
-1
-1.5
-2
-2.5
-3
-3.5
-4
-4.5
-5
2012 2013 2014 2015 2016 2017 2018 2019 2020
Corporate lending, p point diff from base
UKCORPL
USCORPL
GECORPL


0.2
0
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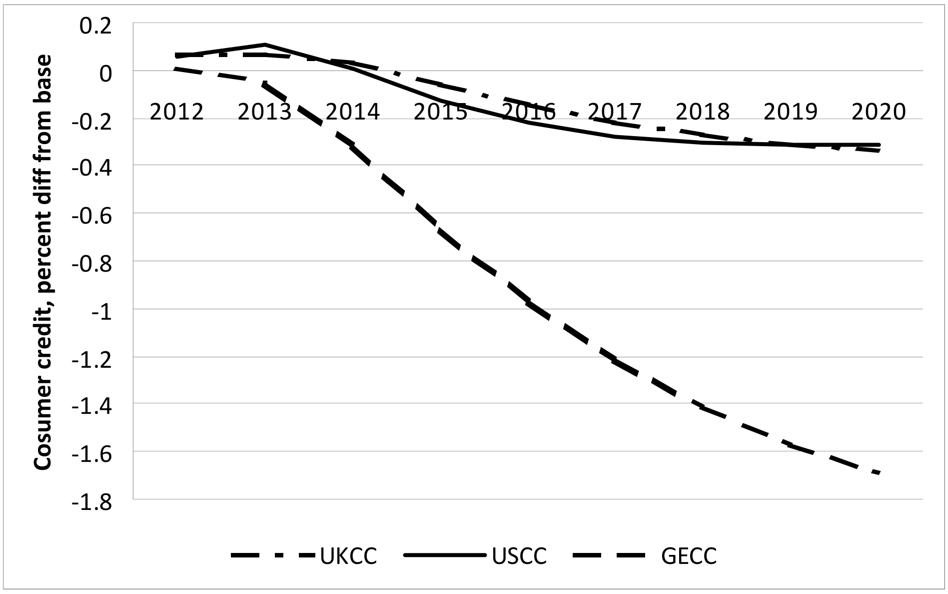
-0.4
-0.6
-0.8
-1
-1.2
2012 2013 2014 2015 2016 2017 2018 2019 2020
Mortgage lending, percent diff from base
UKMORTH
USMORTH
GEMORTH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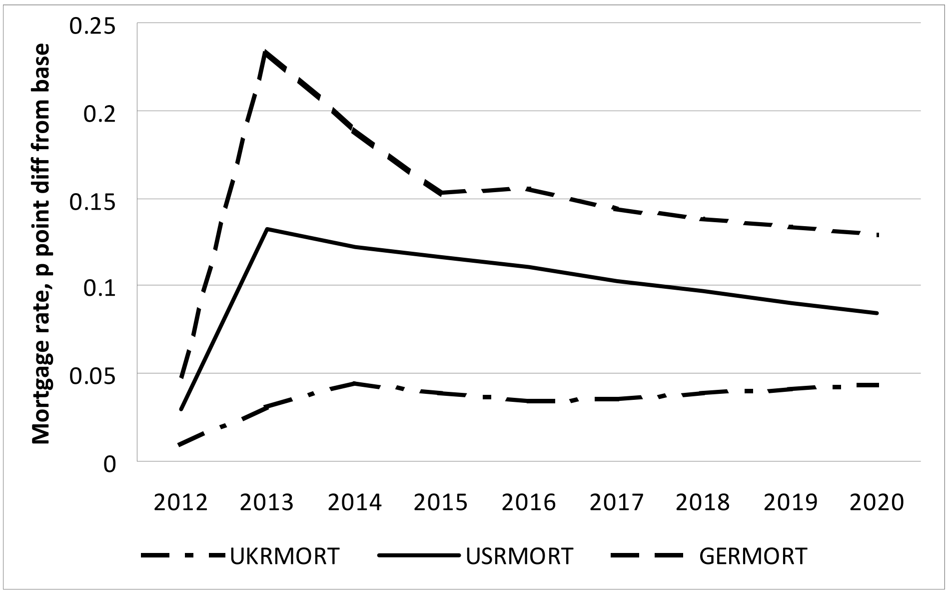
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
-1.8
2012 2013 2014 2015 2016 2017 2018 2019 2020
Cosumer credit, percent diff from base
UKCC
USCC
GECC


Mortgage rate, p point diff from base
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0.15
0.1
0.05
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
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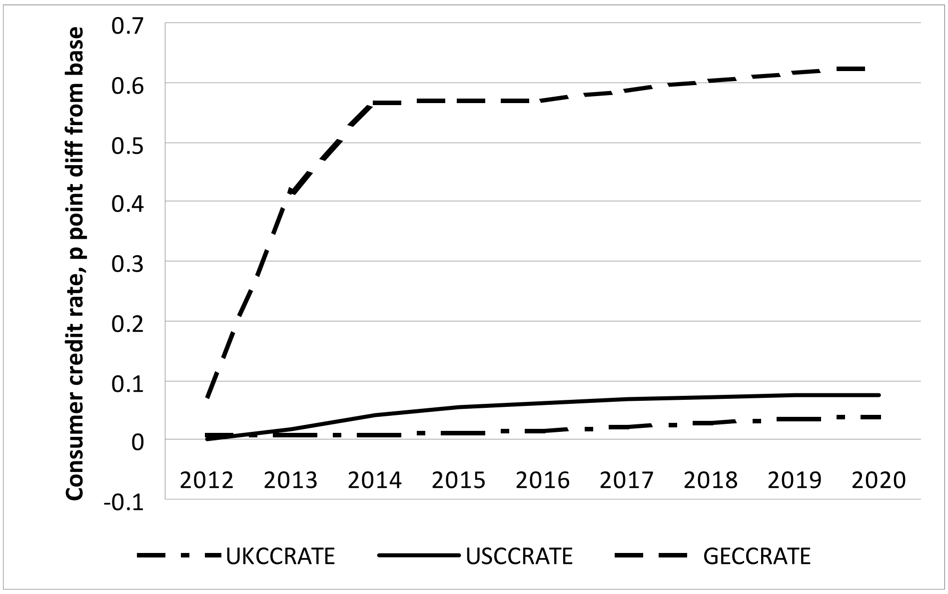
USRMORT
GERMORT


Consumer credit rate, p point diff from base
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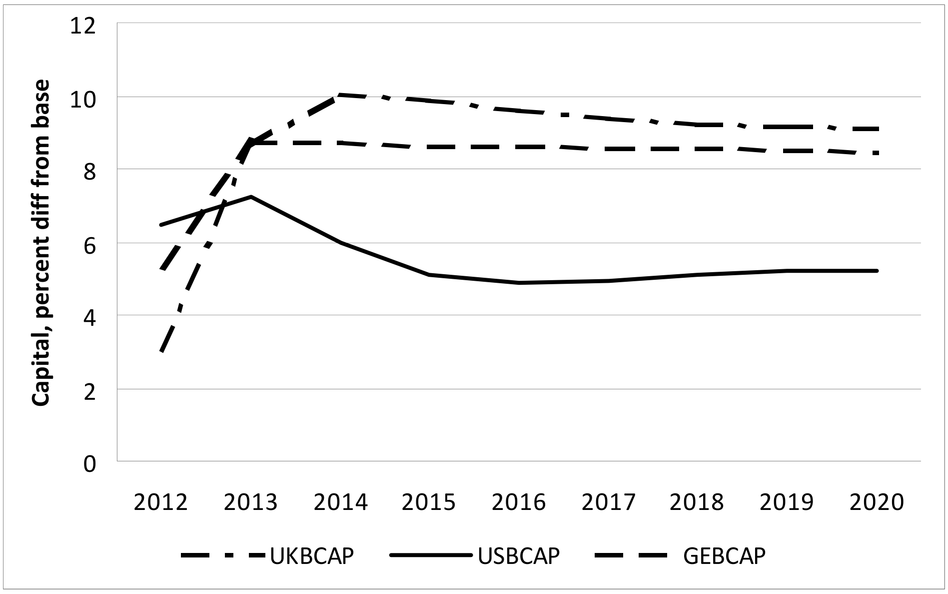
0.6
0.5
0.4
0.3
0.2
0.1
0
-0.1
2012 2013 2014 2015 2016 2017 2018 2019 2020
UKCCRATE
USCCRATE
GECCRATE


Capital, percent diff from base
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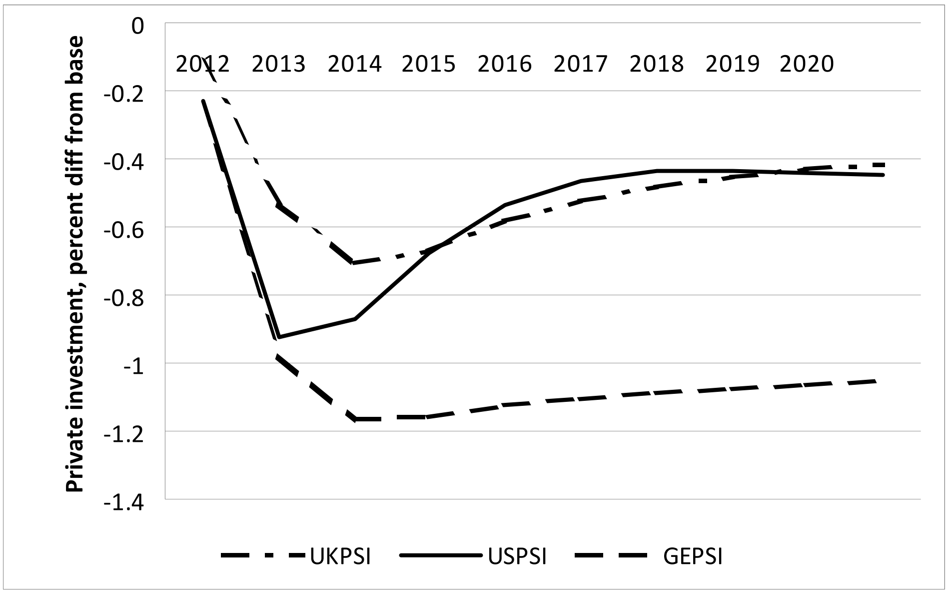
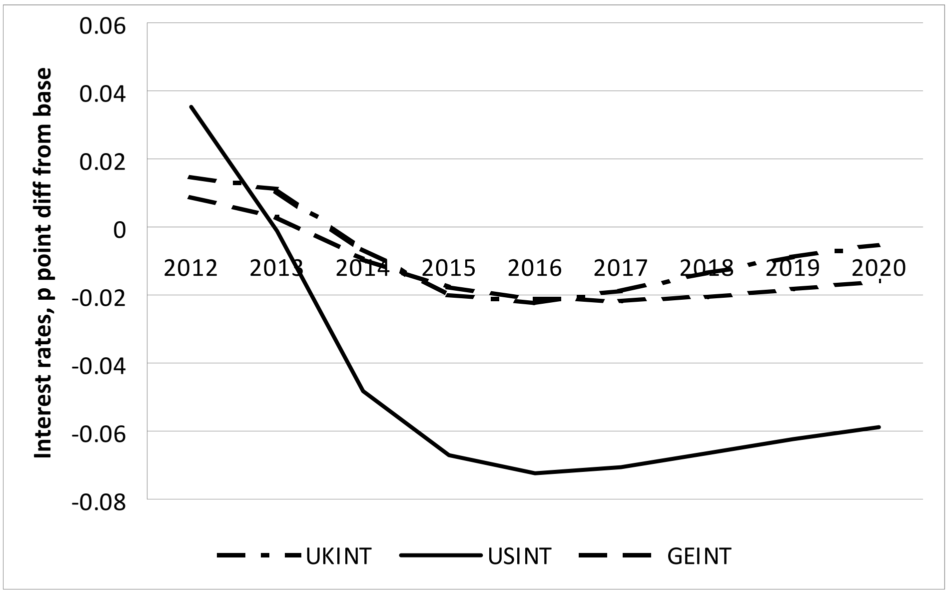
10
8
6
4
2
0
2012 2013 2014 2015 2016 2017 2018 2019 2020
UKBCAP
USBCAP
GEBCAP

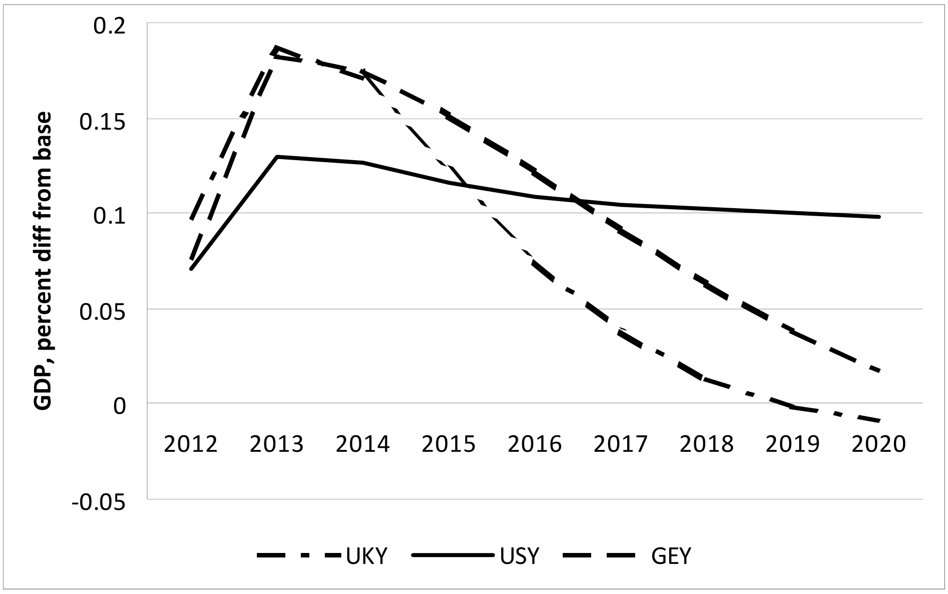


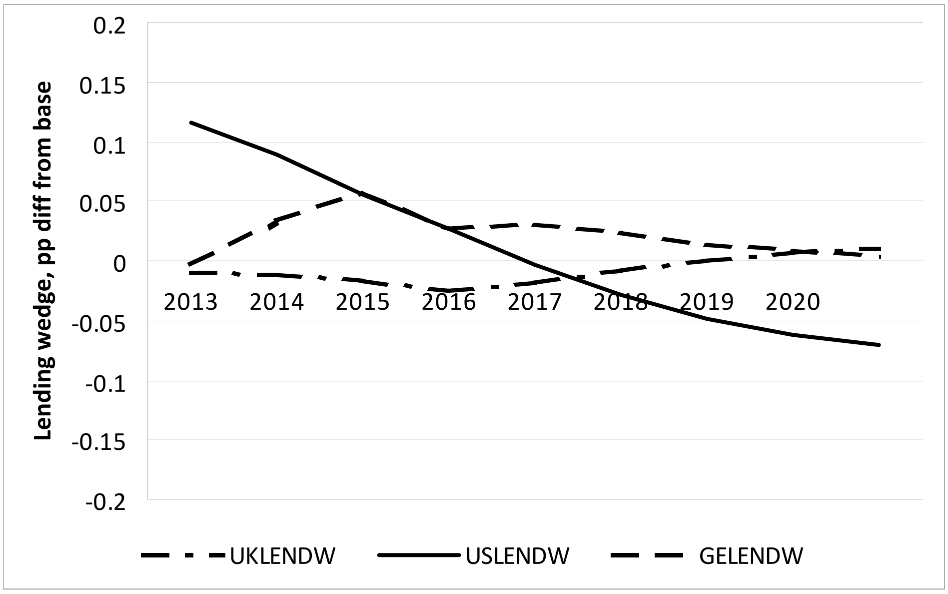
Private investment, percent diff from base
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKPSI
USPSI
GEPSI

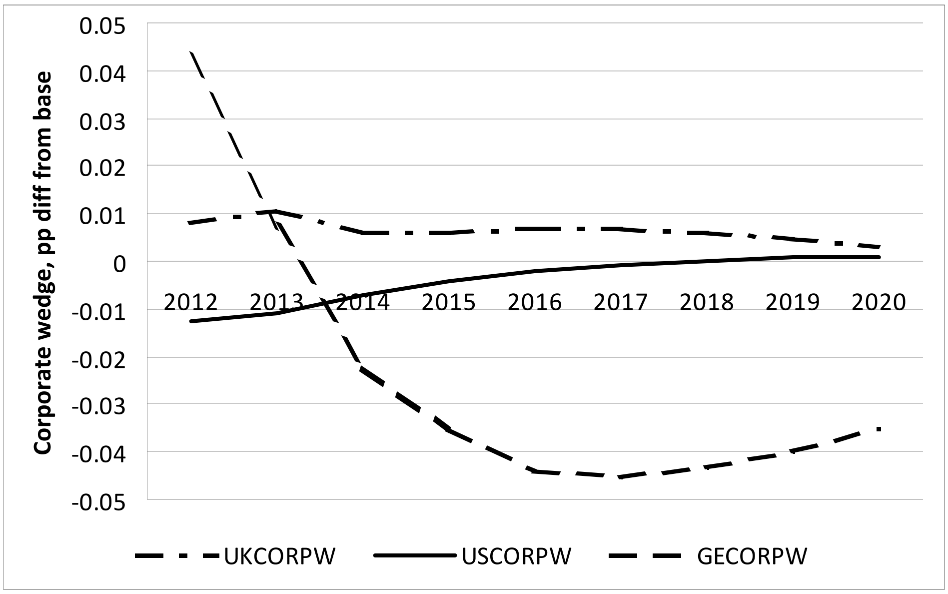


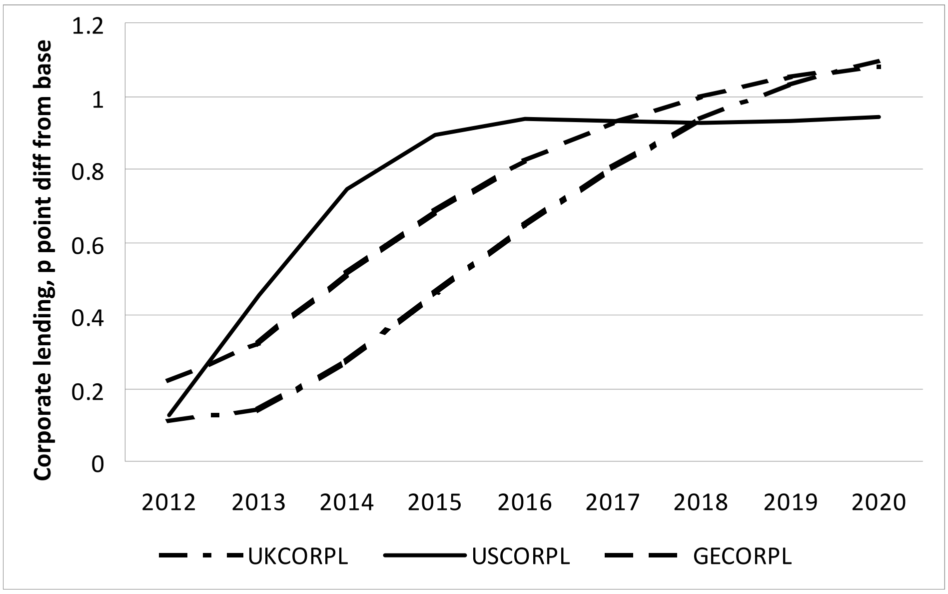
Interest rates, p point diff from base
0.06
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKINT
USINT
GEINT

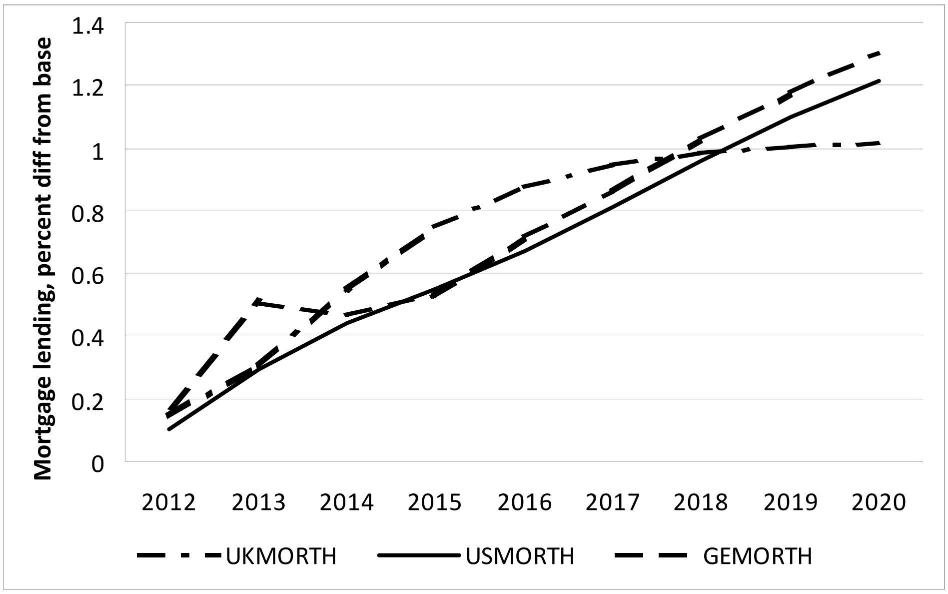
Chart Series 2: One percentage point shock to Nominal Monetary Target

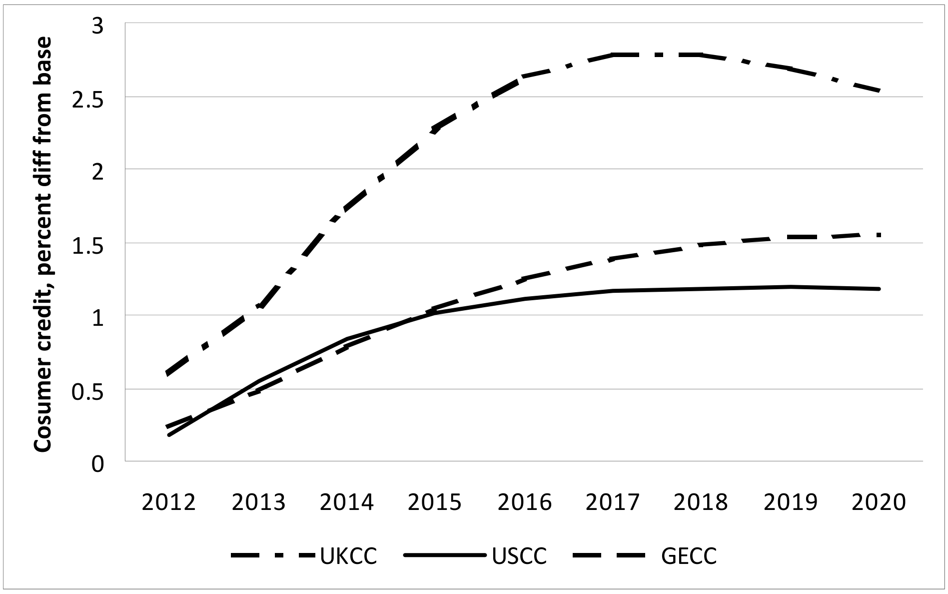


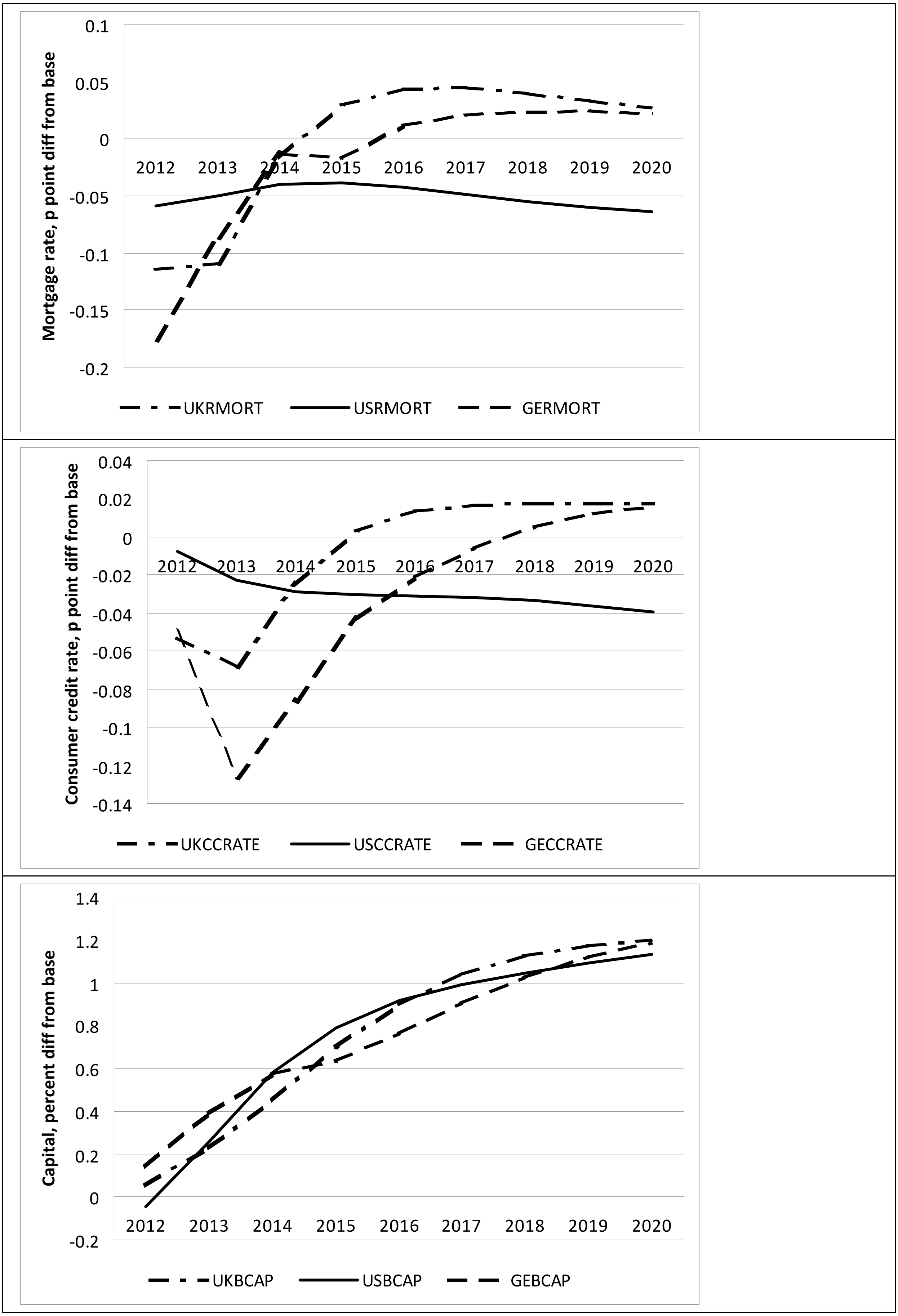


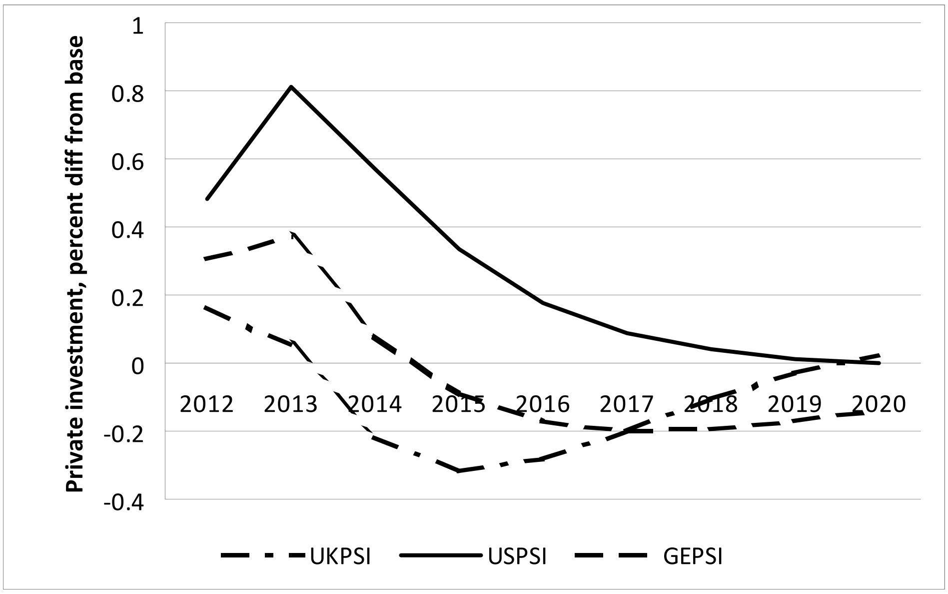



Corporate lending, p point diff from base
0
0.2
0.4
0.6
0.8
1
1.2
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKCORPL
USCORPL
GECORPL


Mortgage lending, percent diff from base
0
0.2
0.4
0.6
0.8
1
1.2
1.4
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKMORTH
USMORTH
GEMORTH


Cosumer credit, percent diff from base
0
0.5
1
1.5
2
2.5
3
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKCC
USCC
GECC


Mortgage rate, p point diff from base
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
2012 2013 2014 2015 2016 2017 2018 2019 2020
UKRMORT
USRMORT
GERMORT
Consumer credit rate, p point diff from base
0.04
0.02
0
-0.02
-0.04
-0.06
-0.08
-0.1
-0.12
-0.14
2012 2013 2014 2015 2016 2017 2018 2019 2020
UKCCRATE
USCCRATE
GECCRATE
Capital, percent diff from base
1.4
1.2
1
0.8
0.6
0.4
0.2
0
-0.2
2012 2013 2014 2015 2016 2017 2018 2019 2020
UKBCAP
USBCAP
GEBCAP


Private investment, percent diff from base
1
0.8
0.6
0.4
0.2
0
-0.2
-0.4
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKPSI
USPSI
GEPSI

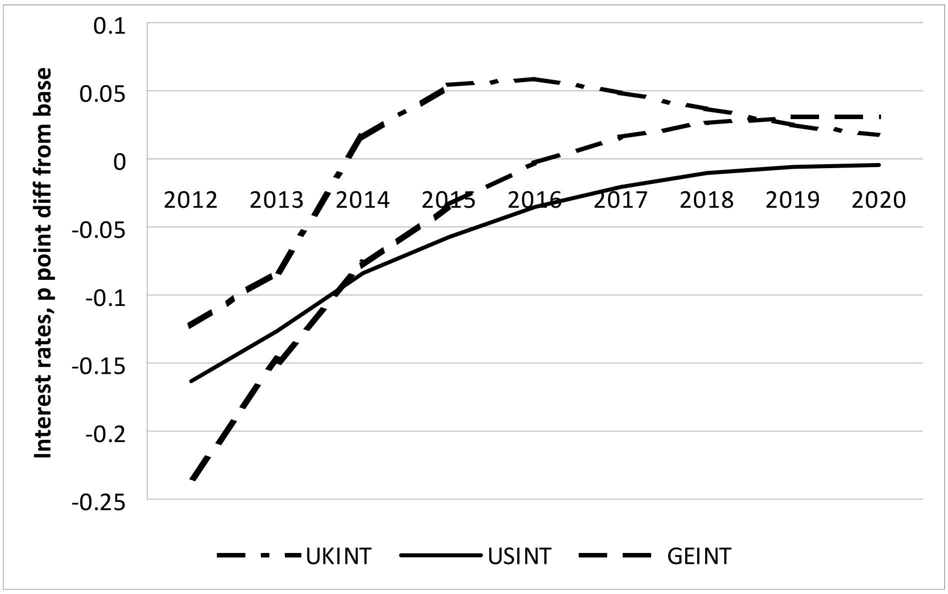
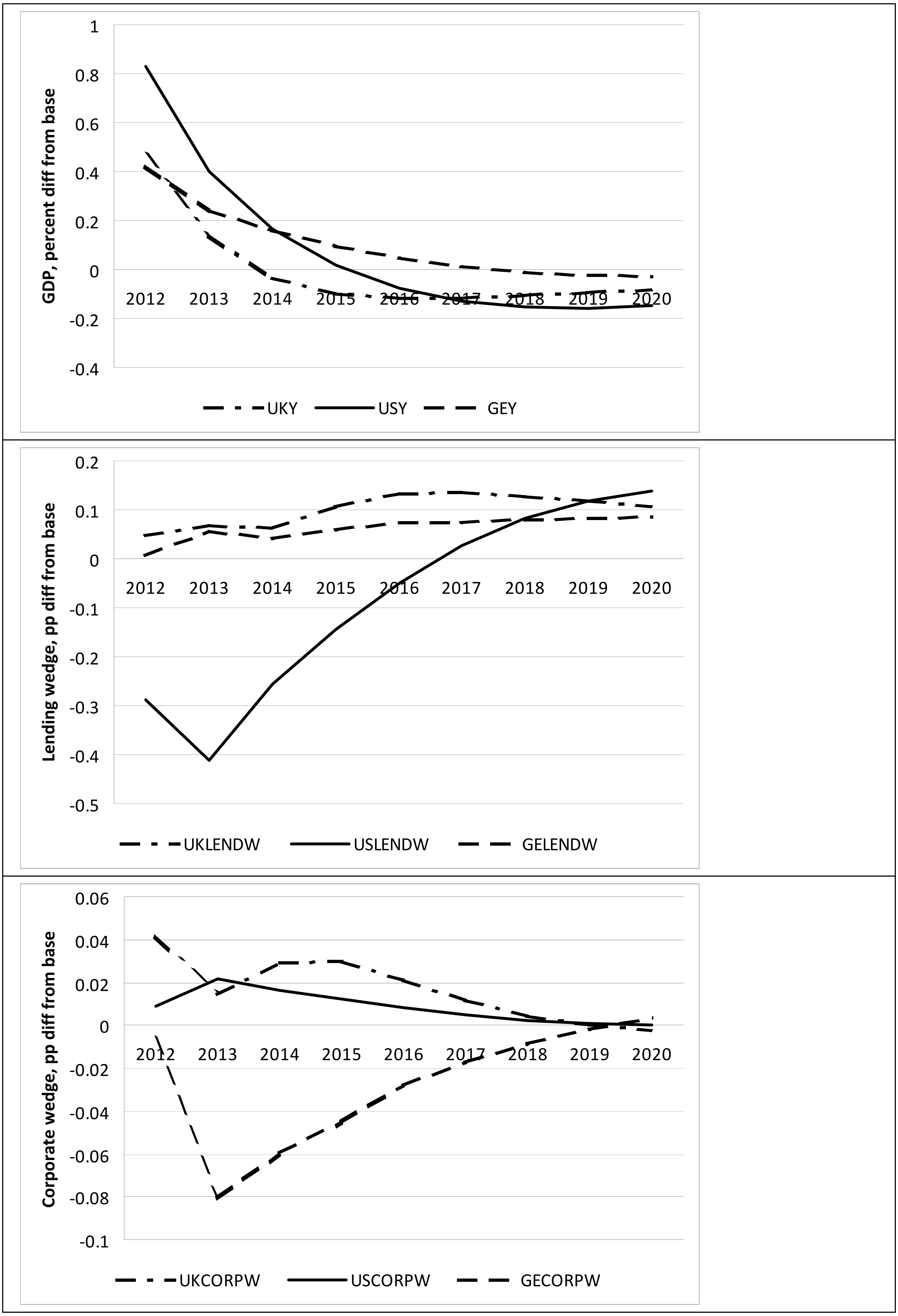
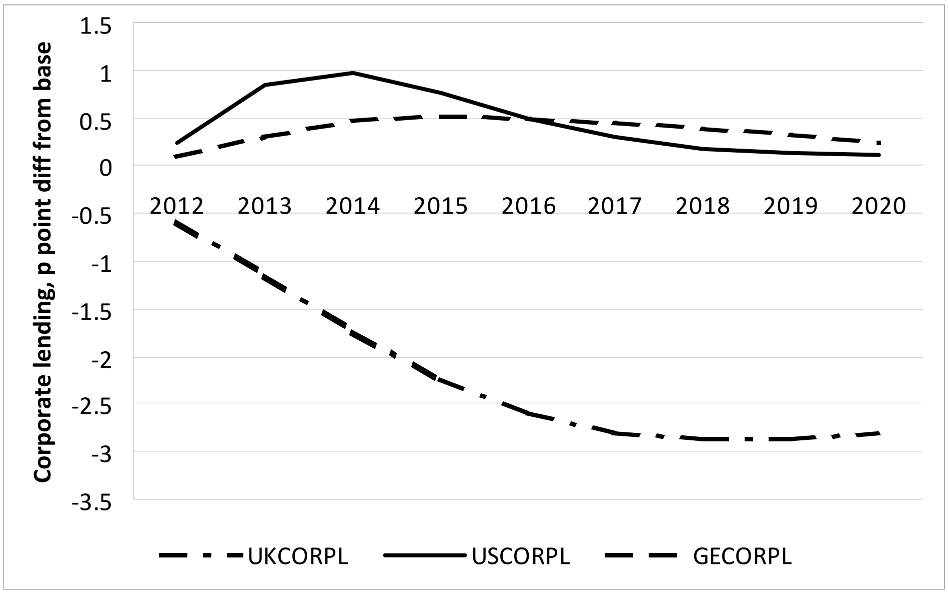
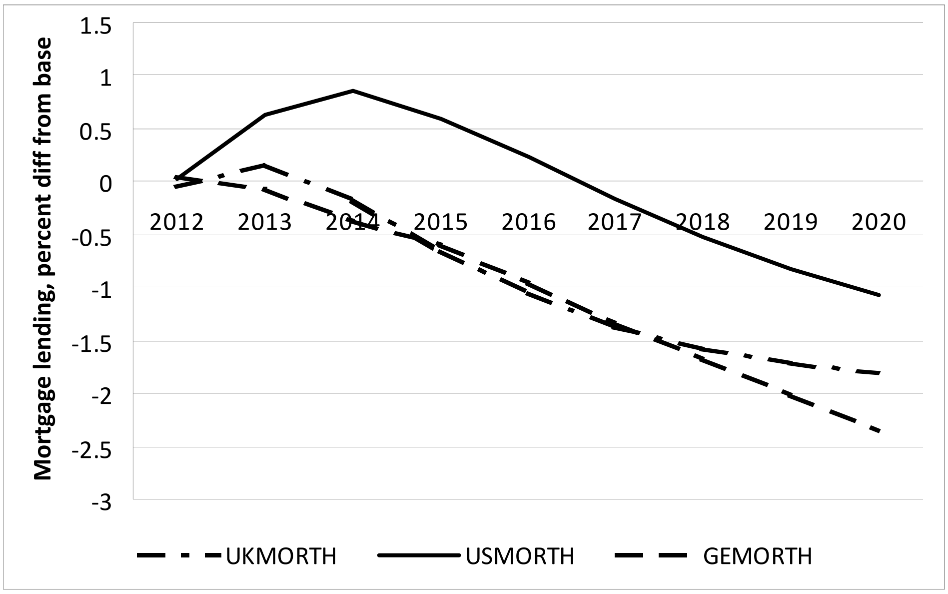
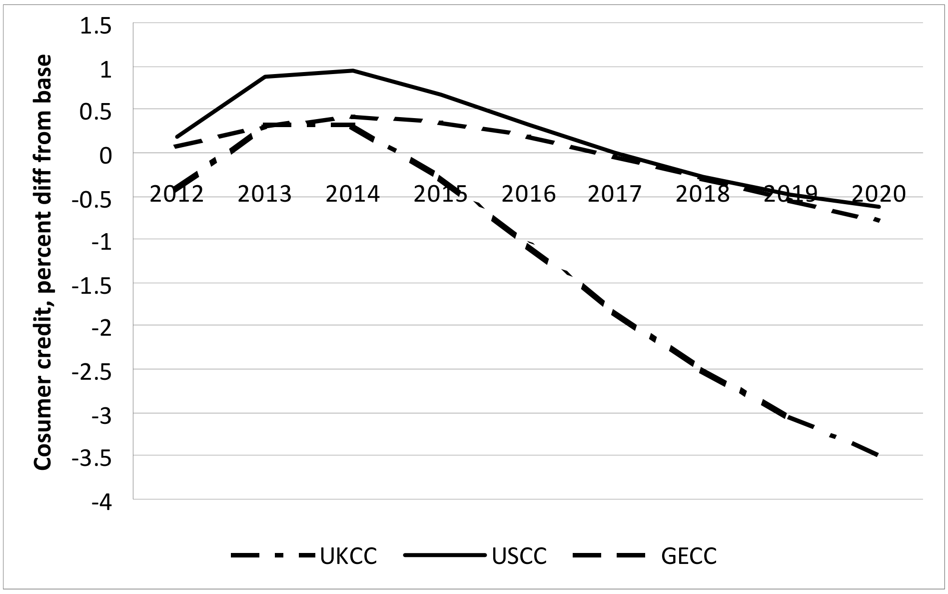

Interest rates, p point diff from base
0.1
0.05
0
-0.05
-0.1
-0.15
-0.2
-0.25
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKINT
USINT
GEINT

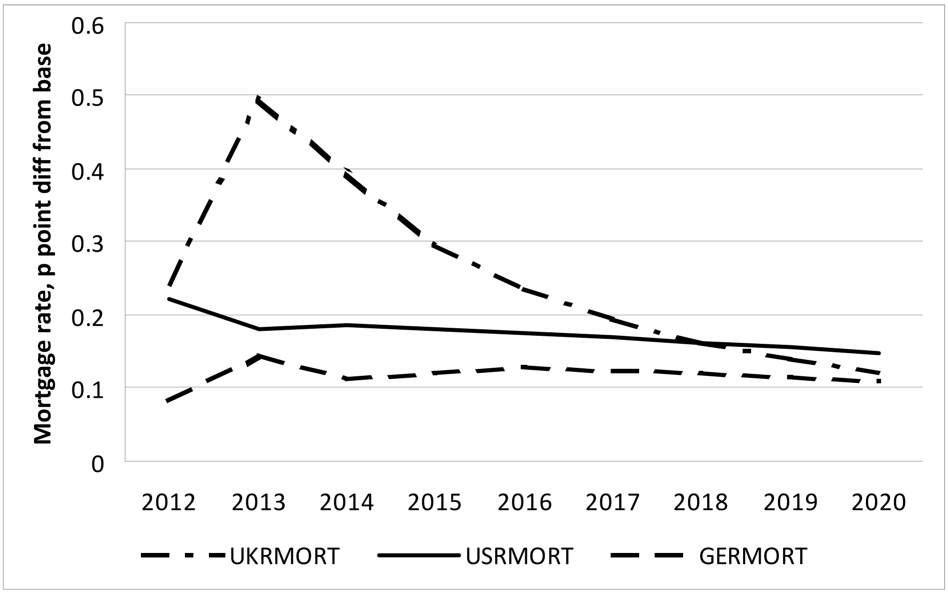
Chart Series 3 – Shocks to Government Consumption (1% of GDP permanent increase)

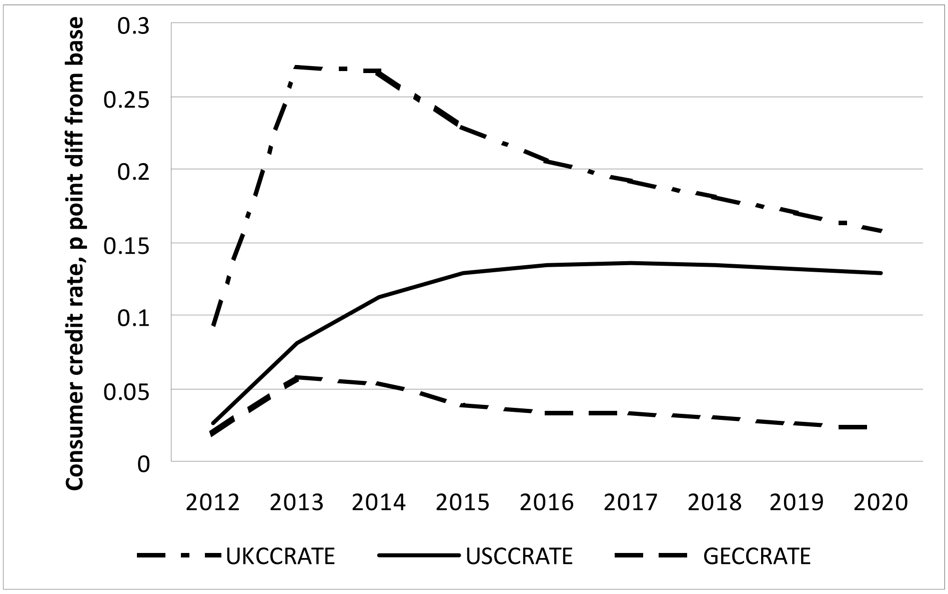


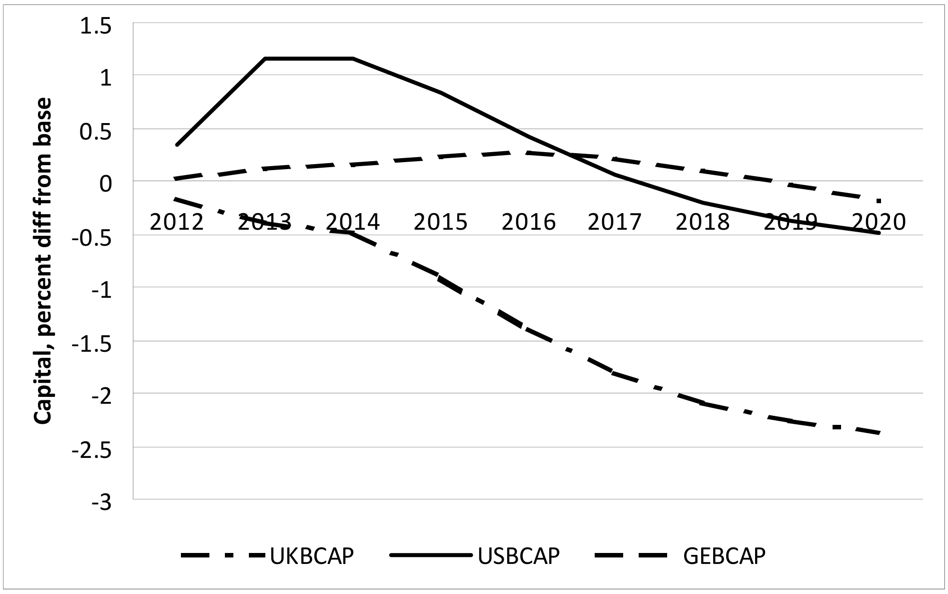

Corporate lending, p point diff from base
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKCORPL
USCORPL
GECORPL

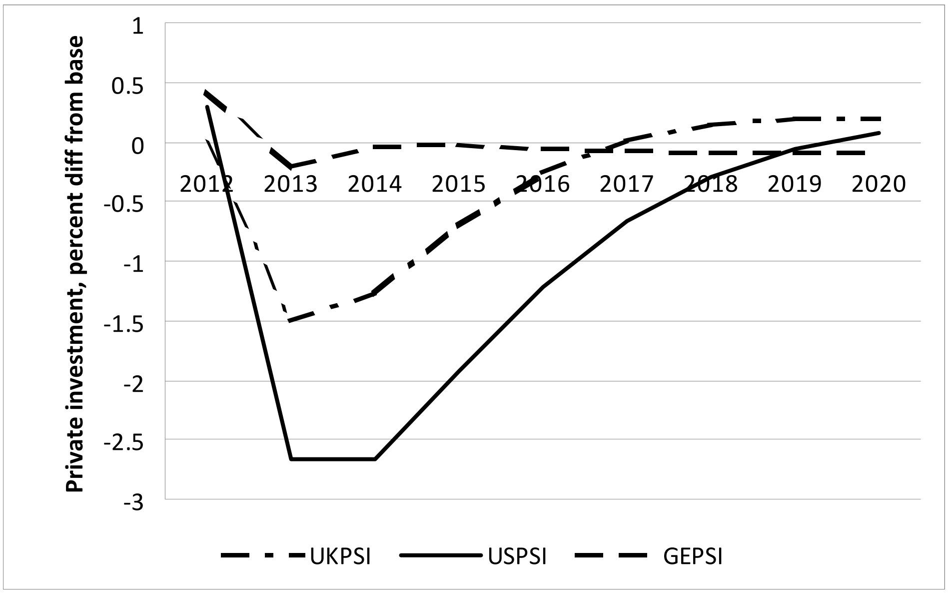

Mortgage lending, percent diff from base
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKMORTH
USMORTH
GEMORTH


Cosumer credit, percent diff from base
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
-3.5
-4
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKCC
USCC
GECC

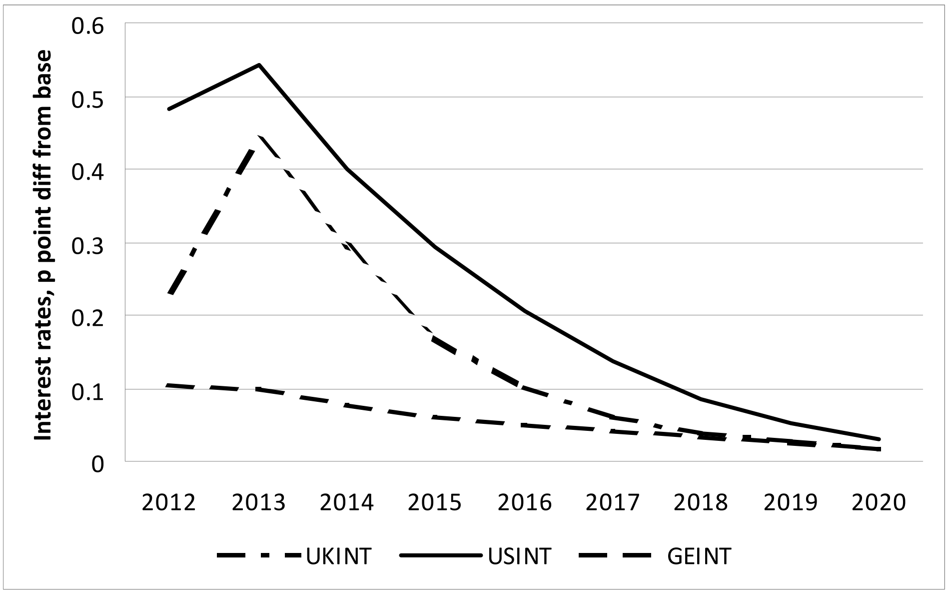

Mortgage rate, p point diff from base
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKRMORT
USRMORT
GERMORT


Consumer credit rate, p point diff from base
0.3
0.25
0.2
0.15
0.1
0.05
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKCCRATE
USCCRATE
GECCRATE


Capital, percent diff from base
1.5
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKBCAP
USBCAP
GEBCAP



Private investment, percent diff from base
1
0.5
0
-0.5
-1
-1.5
-2
-2.5
-3
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKPSI
USPSI
GEPSI



Interest rates, p point diff from base
0.6
0.5
0.4
0.3
0.2
0.1
0
2012
2013
2014
2015
2016
2017
2018
2019
2020
UKINT
USINT
GEINT

Appendix 1: The Structure and Use of the NiGEM Model

For a macroeconometric model to be useful for policy analyses, particular attention must be paid to its long-term equilibrium properties. At the same time, we need to ensure that short-term dynamic properties and underlying estimated properties are consistent with data and well-determined. As far as possible, the same long run theoretical structure of NiGEM has been adopted for each of the major industrial countries, except where clear institutional or other factors prevent this. As a result, variations in the properties of each country model reflect genuine differences in data ratios and estimated parameters, rather than different theoretical approaches. The model has been in use at the National Institute since 1987, but it has developed and changed over that time. Some of its development was initially financed by the ESRC, but since 1995 it has been funded by its user community of public sector policy institutions. These currently include the Bank of England, the ECB, the IMF, the Bank of France, the Bank of Italy and the Bundesbank as well as most other central banks in Europe along with research institutes and finance ministries throughout Europe and elsewhere.

Each quarter since 1987 the model group has produced a forecast baseline that has been published in the Institute *Review* and used by the subscribers as a starting point for their own forecasts. The forecast is currently constructed and used out to beyond 2031 each quarter, although the projection beyond 2015 is a stylised use of the long run properties of the model. Since 1998, the model has also been used by the EFN Euroframe group to produce forecasts for the European Commission. Forecasts are produced based on assumptions and they do not always use forward looking behaviour. In policy analyses the model can be switched between forward looking, rational expectations mode and adaptive learning for consumers, firms, labour and financial markets. Policy environments are very flexible, allowing a number of monetary and fiscal policy responses. The model has been extensively used in projects for the European Commission, UK government departments and government bodies throughout the world. It has also contributed to a number of Institute ESRC projects.

Production and price setting

The major country models rely on an underlying constant-returns-to-scale CES production function with labour-augmenting technical progress.

$$Q = \gamma\left[s(K)^{-\rho} + (1-s)(Le^{\lambda t})^{-\rho}\right]^{-1/\rho} \qquad \text{(A1)}$$

where is Q is real output, K is the total capital stock, L is total hours worked and t is an index of labour-augmenting technical progress. This constitutes the theoretical background for the specifications of the factor demand equations, forms the basis for unit total costs and provides a measure of capacity utilization, which then feed into the price system. Barrell and Pain (1997) show that the elasticity of substitution is estimated from the labour demand equation, and in general it is around 0.5. Demand for labour and capital are determined by profit maximisation of firms, implying that the long-run labour-output ratio depends on real wage costs and technical progress, while the long-run capital output ratio depends on the real user cost of capital

$$Ln(L) = \left[\sigma \ln\{\beta(1-s)\} - (1-\sigma)\ln(\gamma)\right] + \ln(Q) - (1-\sigma)\lambda t - \sigma\ln(w/p) \qquad \text{(A2)}$$

$$Ln(K) = \left[\sigma \ln(\beta s) - (1-\sigma)\ln(\gamma)\right] + \ln(Q) - \sigma\ln(c/p) \qquad \text{(A3)}$$

where w/p is the real wage and c/p is the real user cost of capital. The user cost of capital is influenced by corporate taxes and depreciation and is a weighted average of the cost of equity finance and the margin adjusted long real rate, with weights that vary with the size of equity markets as compared to the private sector capital stock. Business investment is determined by the error correction based relationship between actual and equilibrium capital stocks. Government investment depends upon trend output and the real interest rate in the long run. Prices are determined as a constant mark-up over marginal costs in the long term.

Labour market
NiGEM assumes that employers have a right to manage, and hence the bargain in the labour market is over the real wage. Real wages, therefore, depend on the level of trend labour productivity as well as the rate of unemployment. Labour markets embody rational expectations and wage bargainers use model consistent expectations. The dynamics of the wage market depend upon the error correction term in the equation and on the split between lagged inflation and forward inflation as well as on the impact of unemployment on the wage bargain (Anderton and Barrell 1995). There is no explicit equation for sustainable employment in the model, but as the wage and price system is complete, the model delivers equilibrium levels of employment and unemployment. An estimate of the NAIRU can be obtained by substituting the mark-up adjusted unit total cost equation into the wage equation and solving for the unemployment rate. Labour supply is determined by demographics, migration and the participation rate.

Consumption, personal income and wealth
Consumption decisions are presumed to depend on real disposable income and real wealth in the long run, and follow the pattern discussed in Barrell and Davis (2007). Total wealth is composed of both financial wealth and tangible (housing) wealth where the latter data is available.

$$\ln(C) = \alpha + \beta \ln(RPDI) + (1-\beta)\ln(RFN + RTW) \qquad \text{(A4)}$$

where C is real consumption, $RPDI$ is real personal disposable income, RFN is real net financial wealth and RTW is real tangible wealth. The dynamics of adjustment to the long run are largely data based, and differ between countries to take account of differences in the relative importance of types of wealth and of liquidity constraints. As Barrell and Davis (2007) show, changes in financial (dlnNW) and especially housing wealth (dlnHW) will affect consumption, with the impact of changes in housing wealth having five times the impact of changes in financial wealth in the short run. They also show that adjustment to the long run equilibrium shows some inertia as well.

$$\mathrm{dln}C_t = \lambda(\ln C_{t-1} - \ln PI_{t-1}) + b_1 \mathrm{dln}RPDI_t + b_2 \mathrm{dln}NW_t + b_3 \mathrm{dln}HW_t \qquad \text{(A5)}$$

Al Eyd and Barrell (2005) discuss borrowing constraints, and investigate the role of changes in the number of borrowing constrained households. It is common to associate the severity of borrowing constraints with the coefficient on changes in current income (dlnRPDI) in the equilibrium correction equation for consumption, where d is the change operator and ln is natural log,

Financial markets
We generally assume that exchange rates are forward looking, and 'jump' when there is news. The size of the jump depends on the expected future path of interest rates and risk premia, solving an uncovered interest parity condition, and these, in turn, are determined by policy rules adopted by monetary authorities as discussed in Barrell, Hall and Hurst (2006):

$$RX(t) = RX(t+1)[(1+rh)/(1+ra)](1+rprx) \qquad \text{(A6)}$$

where *RX* is the exchange rate, *rh* is the home interest rate set in line with a policy rule, *ra* is the interest rate abroad and *rprx* is the risk premium. . Nominal short term interest rates are set in relation to a standard forward looking feedback rule. Forward looking long rates are related to expected future short term rates

$$(1+LR_t) = \Pi^{T}_{j=1},\ (1+SR_{t+j})^{1/T} \qquad (A7)$$

We assume that bond and equity markets are also forward looking, and long-term interest rates are a forward convolution of expected short-term interest rates. Forward looking equity prices are determined by the discounted present value of expected profits

Public sector

We model corporate (CTAX) and personal (TAX) direct taxes and indirect taxes (ITAX) on spending, along with government spending on investment and on current consumption, and separately identify transfers and government interest payments. Each source of taxes has an equation applying a tax rate (TAXR) to a tax base (profits, personal incomes or consumption). As a default we have government spending on investment (GI) and consumption (GC) rising in line with trend output in the long run, with delayed adjustment to changes in the trend. They are re-valued in line with the consumers' expenditure deflator (CED). Government interest payments (GIP) are driven by a perpetual inventory of accumulated debts. Transfers (TRAN) to individual are composed of three elements, with those for the inactive of working age and the retired depending upon observed replacement rates. Spending minus receipts give us the budget deficit (BUD), and this flows onto the debt stock.

$$BUD = CED*(GC+GI)+TRAN+GIP-TAX-CTAX-MTAX \qquad (8)$$

We have to consider how the government deficit (BUD) is financed. We allow either money (M) or bond finance (debt).

$$BUD = \Delta M + \Delta DEBT \qquad (9)$$

rearranging gives:

$$DEBT= DEBT_{t-1} - BUD - \Delta M \qquad (10)$$

In all policy analyses we use a tax rule to ensure that Governments remain solvent in the long run (Barrell and Sefton 1997),. This ensures that the deficit and debt stock return to sustainable levels after any shock. A debt stock target can also be implemented. The tax rate equation is of the form:

$$TAXR = f(\text{target deficit ratio - actual deficit ratio}) \qquad (11)$$

If the Government budget deficit is greater than the target,(e.g. -3 % of GDP and target is -1% of GDP) then the income tax rate is increased.

External trade

International linkages come from patterns of trade, the influence of trade prices on domestic price, the impacts of exchange rates and patterns of asset holding and associated income flows. The volumes of exports and imports of goods and services are determined by foreign or domestic demand, respectively, and by competitiveness as measured by relative prices or relative costs. The estimated relationships also include measures to capture globalization and

European integration and sector-specific developments. It is assumed that exporters compete against others who export to the same market as well as domestic producers via relative prices; and demand is given by a share of imports in the markets to which the country has previously exported. Imports depend upon import prices relative to domestic prices and on domestic total final expenditure. As exports depend on imports, they will rise together in the model. The overall current balance depends upon the trade balance and net property income form abroad which comprised flows of income on gross foreign assets and outgoings on gross foreign liabilities. Gross National Product (GNP) is gross Domestic Product (GDP) plus net factor income from foreigners.