Financial stocks and flows in the time of COVID-19

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Abstract

In this paper we examine the economic effects of the COVID-19 shock in the United Kingdom and the various policy responses that were put in place. We do this through the lens of a 'stock-flow consistent' model in which financial flows between the various sectors, and the effects of these flows on the stocks of financial assets and liabilities, are carefully tracked. We find that the lockdown, imposed in response to the COVID-19 outbreak, led to large falls in consumption, investment, output and employment together with a rise in inflation. The increase in non-performing loans associated with the lockdown led to a fall in bank capital, which, in turn, led to rises in bank lending rates, as banks sought to bring their capital back to target, and falls in bank lending. We find that the Job Retention Scheme went some way to maintaining employment through the lockdown; the increases in government spending and the additional Quantitative Easing carried out by the Bank of England (to the extent this led to a fall in bond rates) helped support consumption, investment and output; the Coronavirus Business Interruption Loan Scheme and the Coronavirus Large Business Interruption Loan Scheme, by underwriting a proportion of the non-performing loans, greatly reduced the rise in bank lending rates; and that the cut in the Bank rate also helped keep lending rates lower than they would have been otherwise.

Key words: Sectoral balances, COVID-19, flow of funds, macroeconomic modelling.

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1 Introduction and motivation

The advent of COVID-19 brought with it a public health crisis and left governments with no choice but to close down large sectors of the economy, while providing unprecedented levels of support for firms and households. In addition, households' consumption and labour supply choices were greatly affected by the presence of COVID, with 'social consumption' falling close to zero and working-from-home becoming increasingly widespread. These effects have had major ramifications for the macroeconomy and for sectoral financial balances, with household saving rising dramatically while corporate and government borrowing were doing the same. And the accompanying financial flows will have had a major impact on the banking sector and financial stability more generally. In this paper, we examine the effects of COVID on the macroeconomy and financial stability in the United Kingdom. More specifically, we examine the extent to which various government interventions were able to offset the effects of COVID.

Given that our starting point is the effect of COVID on financial balances, it is important to examine these issues through the lens of a model that puts financial flows and stocks 'front and centre'. Specifically, we use a 'stock-flow consistent' model in our analysis. That is, we use a model in which we account for all financial flows between sectors, all financial stocks held by each sector and the links between stocks and flows in a consistent way. The model we use is similar to that of Burgess *et al*. (2016) and Chapter 11 in Godley and Lavoie (2012). Using such a model will enable us to examine the effects of COVID on household consumption and savings, corporate sector investment and the associated demand for credit, and the ability of the banking sector to fund this, as well as on government borrowing and debt. In addition, it will enable us to compare the different policy interventions that were made in response to COVID and assess their effects on financial stocks and flows.

The main advantages to using this type of model are the following. First, the model makes absolutely clear where the financial sector fits in and what it does. If we are to examine the effects of COVID on financial balances, it is clear that we need a good model of the financial system. Within the model, the paths for financial stocks and flows result from decisions taken by the agents of the model. If COVID has an effect on financial stocks and flows, it will come as a result of the actions taken by households, firms and the government to deal with the pandemic. In addition, financial stocks matter for the evolution of real and financial flows; that is, the financial effects of the decisions taken by households, firms and the government feed back into real outcomes for these agents and, hence, back into their future decisions.

This style of model, though, does have some disadvantages. The model is 'demand driven' and so does not easily enable us to examine the effects of changes in productivity brought about by the pandemic. Of course, to the extent that these 'supply' effects are swamped by the reduction in demand, this may not be such an issue. Agents within the model are not optimising, though again given their limited choice sets resulting from the pandemic, this may not be so important. And, expectations formation is somewhat arbitrary.[1]

[1] Agents are not required unrealistically, however, to have perfect information about the future or the functioning of the entire economy. They merely need to track their own accounts, present and past.

The remainder of this paper is set out as follows. We first discuss in Section 2 some of the voluminous amount of literature that has been developed to examine the effects of COVID and outline where our work fits in with this. We also discuss prior literature using stock-flow consistent models. In Section 3, we then set out our model and in Section 4 discuss how we calibrated the behavioural relationships within it. In Section 5, we construct a model-based scenario for the evolution of the UK economy in 2020-22 based on the assumption that the pandemic did not happen. In Section 6, we examine the effects of the COVID lockdown shock before examining the extent to which the additional government policies were able to soften the blow of the pandemic in Section 7. Section 8 concludes.

2 Literature review

In this paper, we contribute to two literatures: one that uses macroeconomic models to analyse the effects of COVID-19 and another that uses 'stock-flow consistent' (SFC) models to examine financial flows and stocks in response to more general shocks.

Since the beginning of 2020, there has been an explosion of research into the effects of the COVID-19 pandemic. In particular, many papers (eg, Eichenbaum *et al.* (2020)) have combined epidemiological (specifically SIR) models with standard macro models to look at the macroeconomic impact of the virus and the associated lockdowns as well as the trade-offs between the economic impact of different policies and the associated mortality rates. Other papers have examined the distributional impacts of the pandemic and the associated lockdowns, comparing the experience of young vs. old (eg, Glover *et al.* (2020)), men vs. women (eg, Alon *et al.* (2021)) and rich vs. poor (eg, Kaplan *et al.* (2020)). A third strand (eg, Baldwin and Tomiura (2020)) has examined the effects of the pandemic on international trade and global supply chains. We add to this literature by using a 'stock-flow consistent' model, which will allow us to track directly the extent to which increases in corporate distress (captured by non-performing loans and involuntary inventory accumulation) and corporate and government borrowing will put pressure on the banking sector and then feed back to the real economy.

Turning to the effects of policy interventions, with interest rates cut close to zero in the United Kingdom, the debate has turned to the efficacy of negative interest rates. Lilley and Rogoff (2020) argue that, when markets no longer believe that QE is sufficient to maintain inflation at target, central banks should move to negative rates. But Heider *et al.* (2019) and Kumhof and Wang (2020) argue that the zero lower bound applies to commercial bank deposit rates with the result that negative policy rates compress banks net interest margins and hence their willingness to lend. This logic also applies in our model. In terms of macroprudential policy, Drehmann *et al.* (2020) argue that banks should be allowed to use liquidity and capital buffers so they can support lending to the real economy. We examine the effects of a relaxation of the counter-cyclical capital buffer using our model below.

With fiscal policy the two issues are how the necessary fiscal expansion is financed and the long-term effects of the associated rise in government debt. Pacitti *et al.* (2020) show that if the fiscal expansion relies exclusively on borrowing, then the resulting high levels of government debt will leave the UK government vulnerable to a rise in interest rates and inflation. Gali (2020) suggests that financing the fiscal expansion through a monetary expansion could help the government avoid this problem. As our model enables us to track financial flows, we can examine how the banking system supports this expansion in government borrowing and debt and in which sector we would expect to observe the countervailing rise in net lending.

The SFC modelling approach is best described in Godley and Lavoie (2012), Caverzasi and Godin (2015), and Nikiforos and Zezza (2017) and underpins the model of Burgess *et al*. (2016). Dos Santos (2006) describes how SFC models incorporate detailed accounting constraints typically found in systems of national accounts. SFC models allow us to build a framework 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.

Our model is similar to Burgess *et al*. (2016), but simplified in some areas, including the assumption of a closed-economy, in order to focus on COVID-related effects. However, given the continued importance of non-bank finance, our model maintains the combined insurer and pension fund sector. Reissl (2021), outlines a UK-calibrated, hybrid agent-based SFC approach with heterogeneous expectations but without a separate non-bank finance sector. Caneli *et al.* (2021) describe the effects of different European Union COVID policies on the Italian economy, and Byrialsen *et al.* (2021) apply COVID scenarios and policies to the SFC model of Denmark outlined in Byrialsen and Raza (2020). However, we believe our model uniquely contributes to understanding the effects of COVID and related policy interventions in the United Kingdom through the use of the SFC modelling framework.

3 Model

In this section, we describe the stock-flow consistent (SFC) model that we use to examine the effects of the COVID lockdown and government support policies on financial flows and stocks. Rather than lay out every equation of the model, we concentrate on just the behavioural equations of each sector. That is, we discuss the decisions that agents in each sector need to take. A complete equation listing can be found in the annex.

Before discussing the behavioural equations for each sector, we first examine the balance sheet for each sector, together with the revaluation and transactions-flow matrices. These matrices make clear how financial flows between sectors and the stock of financial assets held by each sector are related. And they further demonstrate that the model is 'stock-flow consistent' in that every financial flow represents a debit for someone and a credit for someone else while, at the same time, leading to an increase in assets for one sector and a decrease in assets of another sector.

3.1 Balance sheet, revaluation and transactions-flow matrices

Table A lays out the balance sheet for each sector within the model. The model contains six sectors: households (H); non-financial companies (NFC), which we call 'firms'; insurance companies and pension funds (ICPF); the government (G); the Bank of England (BoE); and banks (B).

Table A: Sectoral balance sheets

	H	NFC	ICPF	G	BoE	Banks	Sum
Deposits	D_H	D_F	D_{ICPF}			$-D$	0
Housing	$P_{hse}H$						$P_{hse}H$
Mortgage lending	$-Mort$					$Mort$	0
Inventories		INV					INV
Capital		Pk					Pk
Pension wealth	ITR		$-ITR$				0
Loans		$-L$				L	0
Firm equity		$-V_F$	V_F				0
ICPF capital	V_{ICPF}		$-V_{ICPF}$				0
Bank capital	V_B					$-V_B$	0
Cash	M				-M		
Reserves					-R	R	0
Government Bills				$-B$	B_{BoE}	B_B	0
Government bonds			$BL_{ICPF}P_{BL}$	$-P_{BL}\,BL$	$BL_{BoE}P_{BL}$		0
Balance	$-NW_H$	$-NW_F$	0	$-NW_G$	0	0	$-(P_{hse}H+\text{INV}+Pk)$
Sum	0	0	0	0	0	0	0

Starting with the household sector, we can note that their assets consist of bank deposits, D_H, housing wealth, $P_{hse}H$, pension wealth, ITR, bank capital, V_B, ICPF capital, V_{ICPF}, and cash, M. Their liabilities consist of mortgage borrowing from the banks, $Mort$. Note that since there is no financial liability corresponding to housing wealth, housing will represent part of the net wealth of the economy as a whole. This is also true of capital and inventories, Pk and INV, respectively, which are assets for the firms. The firms' other assets are deposits, D_F, and their liabilities consist of bank loans, L, and equities V_F. Note that since we have recorded equity shares as part of the liabilities of the firm, their net worth, NW_F, can be either positive or negative. By contrast, the net worth of banks is represented by their capital, V_B, which we assume is owned by households. If this were to turn negative, then the banks would be insolvent. To stop that from happening, we assume that banks have to set their capital ratio (ie, the ratio of their equity value to the sum of their assets) greater than a regulatory minimum. The banks' assets are mortgage loans to households, loans to firms, government bills and reserves held at the central bank, R and their liabilities are deposits, D, and capital. Insurers and pension funds' assets are deposits, D_{ICPF}, government bonds, $P_{BL}BL_{ICPF}$ and domestic equity shares, V_F; their liabilities are the pension wealth of households, ITR, and, ICPF capital, V_{ICPF}, which, like bank capital, is owned by the households. However, much like some defined benefit pension funds in the UK, the ICPF sector in this version of the model can have negative net worth. The government issues bonds, BL, whose price is P_{BL}, and bills, B, to cover its borrowing needs and the Bank of England holds these as assets, B_{BoE} and $P_{BL}BL_{BoE}$, against which it issues reserves, R, to the banking system and cash, M, which is held by households. The remaining government bonds are held by insurers and pension funds, $P_{BL}BL_{ICPF}$, and the remaining bills are held by domestic banks, B_B. The net worth of the household, corporate and government sectors sums to the total value of fixed assets within the economy, which consists of housing and the capital stock.

Next, we turn to the revaluation matrix for this model. To ensure stock-flow consistency, we must also take account of capital gains and any other changes in balance sheet valuations of stocks. Table B shows capital gains and capital losses by sector. These matter for when we come to write down the transition equations for the net wealth held by each sector. The change in the value of a particular type of asset held by a particular sector will be equal to the value of their prior holdings of this type of asset, plus the capital gains on that prior holding plus net purchases of this type of asset at today's prices.

Table B: Revaluation matrix for the model

	H	NFCs	ICPF	G	BoE	Banks
Housing	$\Delta(P_{\mathrm{hse}}H)$					
Bonds			$\Delta P_{\mathrm{BL}}BL_{\mathrm{ICPF},-1}$	$-\Delta P_{\mathrm{BL}}BL_{-1}$	$\Delta P_{\mathrm{BL}}BL_{\mathrm{BoE},-1}$	
Capital		ΔPk_{-1}				
Firm equity		$-\Delta P_{V}V_{\mathrm{F},-1}$	$\Delta P_{V}V_{\mathrm{F},-1}$			
ICPF Capital	ΔV_{ICPF}		$-\Delta V_{\mathrm{ICPF}}$			
Bank capital	ΔV_{B}					$-\Delta V_{\mathrm{B}}$

Table C lays out the net transactions between each of our six sectors, measured at current prices. Black entries denotes credits (ie, are positive) and red entries denote debits. The column headed 'households' is the national income identity that can be read as 'GDP by expenditure ($C+P*I_{\mathrm{H}}+P*I+\Delta INV+P*G$) equals GDP by income (*Wages*+*Profits*+*Interest*+*Taxes*-*Transfers*)'. Here, C denotes nominal consumption, P denotes the price of the non-housing good in our model that can either be consumed or turned into capital via investment, I_{H} denotes real investment in housing, I denotes real investment in capital, INV denotes nominal inventories and G denotes real government spending. We can note that firms' purchases of capital goods (ie, investment) are made from other firms. These transactions form part of the capital account of firms. The 'Government' and 'Bank of England' columns between them represent the consolidated budget constraint for the public sector. The Bank of England makes a profit from its holdings of government bills and bonds, but this profit is redistributed to the government. Domestic firms distribute dividends to their owners (Div_{F}) while keeping part of their profits undistributed as retained earnings ($\Pi_{\mathrm{F,U}}$). Insurers and pension funds also pay dividends to their owners (Div_{ICPF}) while the remainder of their income is allocated to purchases of government bonds and firm equity and deposit accounts. The bottom of the first half of the table describes the various interest payments that are made on bills, bonds, deposits, loans to firms and mortgages.

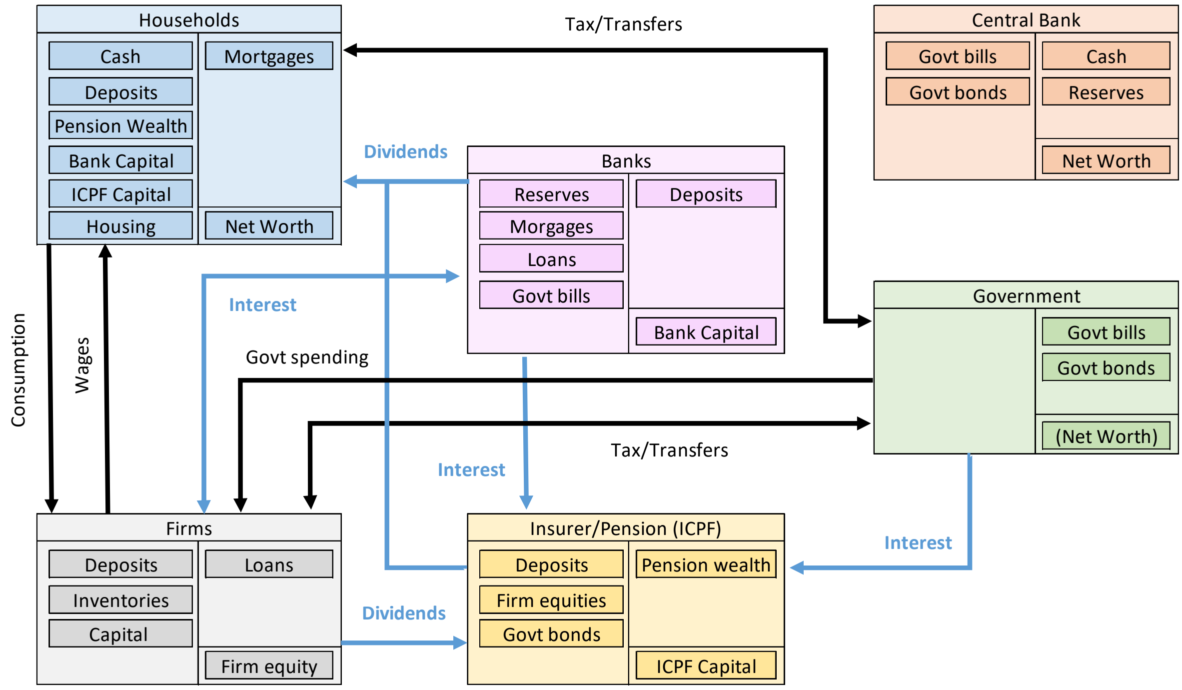
Table C: Transactions matrix for the model

		Households	Firms		ICPF		Government	Bank of England		Banks		Sum
			Current	Capital	Current	Capital		Current	Capital	Current	Capital	
Consumption		C	C									0
Housing investment		$P*I_H$	$P*I_H$									0
Fixed capital investment			$P*I$	$P*I$								0
Inventory accumulation			ΔINV	ΔINV								0
Government spending			$P*G$				$P*G$					0
Income tax		τ_H					τ_H					0
Corporation tax			τ_F				τ_F					0
Transfers to households		T_H					T_H					0
Transfers to firms			T_F				T_F					0
Wages		WB	WB									0
Annuity payments		*Ann*			*Ann*							0
Inventory financing cost			$i_L INV$							$I_L INV$		0
Entrepreneurial profit			Π_F	$\Pi_{F,U}$	Div_F					$i_L(L-INV-NPL)$		0
ICPF profits		Div_{ICPF}			Π_{ICPF}	$\Pi_{ICPF,U}$						0
Bank profits		Div_B								Π_B	$\Pi_{B,U}$	0
Bank of England profits							Π_{BoE}	Π_{BoE}				0
Interest on:	Mortgages	$i_L Mort$								$i_L Mort$		0
	Deposits	$i_D D_H$	$i_D D_F$		$i_D D_{ICPF}$					$i_D D$		0
	Bills						$i_B B$	$i_B B_{BoE}$		$i_B B_B$		0
	Bonds				$i_{BL} BL_{ICPF}$		$i_{BL} BL$	$i_{BL} BL_{BoE}$				0
Change in the stock of:	Mortgages	$\Delta Mort$									$\Delta Mort$	0
	Deposits	ΔD_H		ΔD_F		ΔD_{ICPF}					ΔD	0
	Pension wealth	*Pens*				ΔITR						0
	Loans to firms			ΔL							ΔL	0
	Reserves								ΔR		ΔR	0
	Cash	ΔM							ΔM			0
	Firm Equities			$P_{v,F}\Delta v_F$		$P_{v,F}\Delta v_F$						0
	Bills						ΔB		ΔB_{BoE}		ΔB_B	0
	Bonds					$P_{BL}\Delta BL_{ICPF}$	$P_{BL}\Delta BL$		$P_{BL}\Delta BL_{BoE}$			0
Loan defaults				NPL							NPL	0
	Sum	0	0	0	0	0	0	0	0	0	0	0

The lower part of the transactions matrix describes the flow of funds. Households use their funds to acquire cash, deposits and pension wealth. (Uses of funds enter the table negatively and so are shown in red.) Firms' sources of funds include borrowing from banks and share issuance. (Sources of funds enter the table positively and so are shown in black.) We also assume that firms default on a proportion of their loans. These non-performing loans reduce the amount of net new loans that firms obtain as residual finance for investment and also reduce bank capital. Insurers and pension funds use their profits to pay a dividend and the remainder, plus any additional increases in household pension wealth, to acquire deposits, government bonds and firm equity.

Chart 1 brings this all together by illustrating the flows of funds between sectors as well as each sector's balance sheet.

Chart 1: Financial links between sectors



3.2 Decisions taken by households

In our model, households need to decide how much to consume, how much to invest in housing, by how much to increase their mortgage borrowing and how to allocate their savings between cash and deposits.

Starting with consumption, we assume a consumption function of the form:

$$c = \alpha_1(E(yd) + nl) + \alpha_2 nw_{h,-1} \tag{1}$$

Where *c* denotes real consumption, E(*yd*) denotes expected real disposable income, *nl* denotes real net new borrowing and nw_h denotes household real net wealth. Here, and everywhere else in the model, we assume that expectations are adaptive:

$$E(yd) = (1+g)\left(E(yd_{-1}) + \varepsilon\left(yd_{-1} - E(yd_{-1})\right)\right) \tag{2}$$

Where *g* is the average growth rate of the model economy.

To keep things simple, we assume that households invest in housing so as to ensure a constant growth rate in the real stock of housing in line with the growth of the economy:

$$I_H = gH_{-1} \tag{3}$$

Where I_H denotes real investment in housing and *H* is the real housing stock.

Each period, households repay a constant fraction δ_{rep} of their outstanding loans:

$$Rep = \delta_{rep} Mort_{-1} \tag{4}$$

Where *Rep* denotes mortgage repayments and *Mort* denotes mortgage borrowing. Similarly, we assume that the gross amount of new mortgage lending, *GL*, is a constant fraction of total housing wealth:

$$GL = \eta (P_{hse} H)_{-1} \tag{5}$$

Where P_{hse} denotes house prices.

Households allocate their net lending between increasing their holdings of cash, deposits and pension wealth.

We assume that households hold enough cash to finance a given fraction, λ, of their consumption:

$$M = \lambda P c \tag{6}$$

Where *M* denotes household cash holdings and *P* denotes the price level.

Households pay pension contributions, *Pens*, as a fixed proportion of the previous period's nominal disposable income, *YD*, and these contributions add directly to households' accumulated pension wealth, *ITR*:

$$Pens_t = \varrho YD_{t-1} = \Delta ITR \tag{7}$$

Finally, households allocate the remainder of their funds to deposits, D_H:

$$D_H = NW_H + Mort - V_B - V_{ICPF} - P_{hse} H - ITR - M \tag{8}$$

Where NW_H denotes nominal net household wealth, V_B denotes bank capital and V_{ICPF} denotes ICPF capital. Recall that we have assumed that households own the banks and ICPFs.

3.3 Decisions taken by firms

In our model, firms need to decide how much to produce, how much to invest, how many workers to employ and where to set wages and prices.

Given their expected sales, *E*(*s*), we assume that firms set output, *y*, to push their inventories, *inv*, towards a target ratio of inventories to sales equal to σ_T.

$$y = E(s) + \gamma(\sigma_T E(s) - inv_{-1}) \tag{9}$$

In terms of investment, we follow Godley and Lavoie (2006) and assume that investment depends on capital utilisation (proxied by the output to capital ratio) and the real interest rates that they face (ie, that on bank loans to firms). This results in the investment function:

$$I = (g_k + \delta)k_{-1} = \left(\gamma_0 + \gamma_u \frac{y}{k_{-1}} - \gamma_r r_L + \delta\right) k_{-1} \quad \textbf{(10)}$$

Where k denotes the real capital stock, g_k denotes the growth rate of the capital stock, δ denotes the depreciation rate for capital and r_L denotes the real rate of interest on bank lending to firms.

We assume that firms adjust their employment, N, towards their desired employment level, which will be given by output divided by trend productivity, pr:

$$N = N_{-1} + \eta_N \left(\frac{y}{pr} - N_{-1}\right) \quad \textbf{(11)}$$

Nominal wage growth depends on the previous period's inflation rate and the trend rate of productivity growth:

$$ln(W) = ln(W_{-1}) + g + \pi_{-1} \quad \textbf{(12)}$$

Where W denotes the nominal wage per head, π denotes the inflation rate

Prices are set as a mark-up, φ, over a weighted average of current and previous periods 'normal unit cost', which in turn is given by the wage rate divided by trend productivity:

$$P = (1 + \varphi)\left((1 - \sigma_N)\frac{W}{pr} + \sigma_N\left(1 + i_{L,-1}\right)\frac{W_{-1}}{pr_{-1}}\right) \quad \textbf{(13)}$$

Where i_L denotes the nominal rate of interest on bank loans to firms.

Firms aim to finance a fraction ψ_u of their investment with bank loans and the remaining proportion by issuing new equity. New equity issuance will be given by:

$$v_F = v_{F,-1} + (1 - \psi_u)\frac{P_{-1}I_{-1}}{P_v} \quad \textbf{(14)}$$

Where v_F denotes firm equities and P_v denotes their price.

We assume that firms distribute dividends, Div, as a constant proportion of the previous period's profits, Π_F:

$$Div = \psi_d \Pi_{F,-1} \quad \textbf{(15)}$$

And we assume that firms grow their deposits in line with wage growth:

$$D_F = D_{F,-1}\frac{W}{W_{-1}} \quad \textbf{(16)}$$

Finally, we note that since firms cannot predict profits or equity prices with certainty, any mistakes they make lead to them borrowing more or less from the banks. That is, bank loans, *L*, are the residual source of funding for firms in this model:

$$L = L_{-1} + P * I + \Delta INV - \Pi_{F,U} - P_v \Delta v_f - NPL + \Delta D_F \quad \textbf{(17)}$$

Where *INV* denotes the nominal value of inventories, which will be given by $\frac{WN}{y} inv$, $\Pi_{F,U}$ denotes retained earnings and NPL denotes non-performing loans. These are assumed to be a constant fraction, *npl*, of loans issued during the previous period:

$$NPL = npl * L_{-1} \quad \textbf{(18)}$$

3.4 Decisions taken by the government

In our model, the Treasury sets government spending, transfers to households and firms and the effective tax rates, θ_h and θ_f. We assume that real government spending and transfers grow at the average growth rate of the economy, g. The government finances its deficit through the issue of bills and bonds. We assume that bonds are supplied on demand and any residual financing needs are met through the issue of bills.

Following Godley and Lavoie (2006), we assume that the central bank (ie, the Bank of England) sets the interest rate on bills (the policy rate), i_B, and bonds, i_{BL}, as well as the level of government bonds it holds on its balance sheet (ie, the level of Quantitative Easing). It supplies cash and reserves on demand against government bonds and bills. Given that we've assumed the Bank of England sets its demand for bonds based on monetary policy considerations, it is clear that the residual here will be Bank of England holdings of government bills, which will move to ensure that the balance sheet is balanced.

3.5 Decisions taken by insurance companies and pension funds (ICPFs)

We assume that households have defined contribution pensions. At retirement, they spend their pot of savings on an annuity. We assume that annuity payments, *Ann*, represent a fraction of accumulated pension wealth, *ITR*:

$$Ann_t = \zeta ITR_{t-1} \quad \textbf{(19)}$$

ICPFs distribute their dividends as a fixed proportion, λ_{ICPF}, of gross output in the economy.

ICPF net worth is equal to their assets, A_{ICPF}, less their liabilities, ie, household pension wealth:

$$V_{ICPF} = A_{ICPF} - ITR \quad \textbf{(20)}$$

The ICPF sector faces a portfolio allocation problem in that it needs to allocate its funds across government bonds, firm equity and deposits. We assume that the target 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 to the method used by Brainard and Tobin (1968) and we impose the condition that these shares must sum to unity in every period by definition. Further, we impose the condition that the sum over all assets of the response to a change in any of the rates of return has to be zero. What this means is that a shock that causes the share of one particular asset in the ICPF's portfolio to increase will also mean that the shares of the other asset in the ICPF's portfolio must fall. In terms of signs, we can note that a rise in the rate of return on one particular asset will increase the demand for that asset at the expense of the other assets. Finally, we can note that the response of demand for an asset to a rise in its own rate of return should be the same as the response to an equivalent fall in all the other rates of return with its own rate staying put. Putting all this together gives us:

$$\begin{pmatrix} \frac{P_V v_F}{A_{ICPF,-1}} \\ \frac{P_{BL} BL_{ICPF}}{A_{ICPF,-1}} \\ \frac{D_{ICPF}}{A_{ICPF,-1}} \end{pmatrix} = \begin{pmatrix} \lambda_{1,0} \\ \lambda_{2,0} \\ 1 - \lambda_{1,0} - \lambda_{2,0} \end{pmatrix} + \begin{pmatrix} \lambda_{1,1} & -\lambda_{1,2} & -\lambda_{1,1} + \lambda_{1,2} \\ -\lambda_{1,2} & \lambda_{2,2} & -\lambda_{2,2} + \lambda_{1,2} \\ -\lambda_{1,1} + \lambda_{1,2} & -\lambda_{2,2} + \lambda_{1,2} & \lambda_{1,1} + \lambda_{2,2} - 2\lambda_{1,2} \end{pmatrix} \begin{pmatrix} r_k \\ i_{BL} \\ i_D \end{pmatrix} \quad \textbf{(21)}$$

Where BL_{ICPF} denotes ICPF holdings of bonds, P_{BL} is the price of a bond, i_{BL} is the interest rate on a bond, i_D is the interest rate on deposits and the dividend yield, r_k, is defined by:

$$r_k = \frac{Div_F}{V_{F,-1}} \quad \textbf{(22)}$$

Equity prices, P_V, adjusts to bring the demand for equities from ICPFs (given by the top line of equation **(21)**) into line with the supply of equities from firms (given by equation **(14)**).

As stated earlier, the interest rate on bonds is assumed to be fixed by the central bank. To keep life simple, we assume that all government bonds are consols, ie, government debt that pays the bearer £1 after each quarter in perpetuity. So, if we denote the outstanding stock of bonds by BL, then the total flow of interest paid on all government bonds each period is simply £BL, their total value will be £$P_{BL}BL$, and hence their interest rate will be given by $i_{BL} = \frac{BL}{P_{BL}BL} = \frac{1}{P_{BL}}$.

As, ICPFs expected asset holdings will not, in general, equal their actual holdings, on account of capital gains and losses, we assume that their holdings of deposits act as a flexible buffer to absorb any unexpected changes in financial wealth. So, we replace the third line of the matrix equation with:

$$D_{ICPF} = A_{ICPF} - P_V v_F - P_{BL} BL_{ICPF} \quad \textbf{(23)}$$

3.6 Decisions taken by banks

In our model, banks accept all deposits that firms and households wish to hold with them and that they issue loans to firms and mortgages to households on demand. We assume that banks hold enough reserves to match a certain proportion, ρ, of their deposits. Banks' remaining assets consist of domestic government bills. We assume that they 'mop up' all the domestic bills that are not held by the Bank of England. Their remaining net worth is held as bank capital. Banks distribute their dividends as a fixed proportion, λ_b, of gross output in the economy, Y.

The key decisions made by banks in our model are where to set their deposit and loan rates. For simplicity, we assume that they set their deposit rate as a mark-up on the base rate (rate of interest on bills) set by the Bank of England the previous period.

$$i_D = i_{B,-1} + add \tag{24}$$

Banks set the rate of interest on loans in order to ensure that they make a target level of profits, which, in turn, enables them to accumulate enough capital to manage fluctuations in non-performing loans while maintaining a normal capital adequacy ratio that is higher than the capital adequacy ratio imposed on them by the macro and microprudential regulatory authorities. Now, the banks' actual profits, Π_B, will be given by:

$$\Pi_B = i_{l,-1}(L_{-1} + Mort_{-1} - NPL) + i_{B,-1}B_{B,-1} - i_{D,-1}D_{-1} \tag{25}$$

Where *NPL* denotes non-performing loans. The change in banks' holdings of capital, V_B, will be given by:

$$V_B = V_{B,-1} + \Pi_B - \lambda_B Y_{-1} - NPL \tag{26}$$

So, the target profit for the banks, Π_B^T, will be given by:

$$\Pi_B^T = V_B^T - V_{B,-1} + \lambda_B Y_{-1} + npl * L_{-1} \tag{27}$$

where V_B^T is the banks' target for their capital.

We assume that banks aim to adjust gradually to their normal capital ratio. That is:

$$V_B^T = V_{B,-1} + \beta_B\big(ncar(L_{-1} + Mort_{-1}) - V_{B,-1}\big) \tag{28}$$

Putting all this together suggests that banks will wish to set the loan rate such that:

$$i_L = \frac{\Pi_B^T - i_{B,-1}B_{B,-1} + i_{D,-1}D_{-1}}{(1-npl)L_{-1} + Mort_{-1}} \tag{29}$$

4 Data and calibration

4.1 Data

Before using our model, we need to take a stand on the data analogues for our model series. Tables D and E show 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. All data is quarterly. Where data is available at a higher frequency, we take quarterly averages. Financial and real stock variables are taken as end-quarter values. Variables not shown in this table are calculated from those shown in the table using the identities within the model. This ensures that the model remains stock-flow consistent.

Table D: Data sources for stock variables used in the model

Variable description	Mnemonic	Source used and identifying code
Bank capital	V_B	ONS: NNYJ+NNYK
Bonds issued	$P_{BL}BL$	ONS: YEQF
Bonds held by Bank of England	$P_{BL}BL_{BoE}$	Bank of England: RPQZ4TM
Cash	M	ONS: AVAB
Firm deposits	D_F	ONS: NNZF
Firm equity	V_F	ONS: NOQA
Household deposits	D_H	ONS: NNMP
Housing wealth	$P_{HSE}H$	Constructed by the authors; calculations available on request.
ICPF deposits	D_{ICPF}	ONS: NIYD
Inventories	INV	Constructed by the authors; calculations available on request.
Lending to firms	L	ONS: NOPK
Mortgage lending	$Mort$	ONS: NNRP
Pension wealth	ITR	ONS: NPYL
Physical capital	k	Constructed by the authors; calculations available on request.
Reserves	R	ONS: BL22

Although our behavioural model is large and complicated, it is significantly simpler than the full set of national accounts published by the ONS. This is true in two particularly important respects: the number of rows in both the income and financial accounts is significantly lower in our model than in the published national accounts; and the behavioural equations impose a number of zero restrictions on the behaviour of particular sectors (eg, all investment is only carried out by non-financial companies). These are both potential obstacles to our goal of modelling the financial balances for each sector of the UK economy.

To examine how much of a problem these issues might be, we calculate the financial balance ('net lending') of each sector in our model and compare these with net lending in the National Accounts. For the model to be a useful lens to look at the economy, we need our series to be sufficiently 'close' to the equivalent series in the National Accounts. Charts 2-6 shows the extent to which our behavioural equations successfully model net lending for each sector. In each case the dark blue line shows net lending as published in the latest vintage of the *UK Economic Accounts*, published by the ONS, and the pink line shows the series implied by the data we are using in our model.

Table E: Data sources for flow variables used in the model

Variable description	Mnemonic	Source used and identifying code
Annuity payments	Ann	ONS: ROYP
Business investment	$P*I$	ONS: GAO4
Compensation of employees	WB	ONS: ROYI+ROYH +CAEN
Change in inventories	ΔINV	ONS: CAEX-DMUN
Consumption	C	ONS: RPQM
Consumption deflator	P	ONS: RPQM/HFC1
Dividends paid by banks	Div_{B}	ONS: NHFH-NHFF
Dividends paid by firms	Div_{F}	ONS: ROCH+ROCI-ROAZ-ROBA
Dividends paid by pension funds	Div_{ICPF}	ONS: NHON
Employment rate	N	ONS: MGSR
Government spending	$P*G$	ONS: NMRP+D7QK
Housing investment	$P*I_{\mathrm{H}}$	ONS: NPQS-GAO4-D7QK
Interest payments on firm deposits	$i_D D_F$	ONS: J4WR
Interest payments on household deposits	$i_D D_H$	ONS: ROYM
Interest payments on loans to firms	$i_{\mathrm{L}}L$	ONS: J4WT
Interest payments on mortgages	$i_{\mathrm{L}}Mort$	ONS: ROYU
Interest rate on bills	i_{B}	Bank of England: Base rate
Interest rate on bonds	i_{BL}	Bank of England: 10-year nominal zero-coupon spot rate
Non-performing loans	NPL	ONS: TFHB
Taxes on households	τ_{H}	ONS: RPHR
Taxes on firms	τ_{F}	ONS: RPJW+ROXC-ROXF-ZJZH+L8NA+M9X7+NTAR
Transfers to households	TR_{H}	ONS: GZVX
Transfers to firms	TR_{F}	ONS: RPWU

For the non-financial corporations and public sector, net lending implied by the data series we use in our model is fairly close to net lending in the UK data. Unfortunately, for the household, banking and ICPF sectors, net lending implied by data series used in our model is generally higher than net lending in the UK data. This reflects the fact that the United Kingdom is running a current account deficit; this would show up in the flow-of-funds data as positive net lending by the rest of the world as shown in Chart 7. As our model is one of a closed economy, this net lending has to show up as a positive in one, or more, domestic sectors. That is, our model interprets the net borrowing by the corporate and public sectors from abroad as net lending by the banking and ICPF sectors. This problem is particularly prevalent for the banking sector, where much cross-border lending actually flows between banks before moving onto the household, corporate or public sectors.

In terms of using our model to analyse the effects of COVID and the associated policies, we do not see this as a major problem. Over 2020 Q1 to Q3, the UK current account deficit improved slightly (from 4% of GDP to 3.2% of GDP), but this change in net lending by the foreign sector was small relative to the large changes in net lending by other sectors that were the result of the COVID shock. Given that, we feel comfortable using our model to analyse the effects on net lending of the COVID shock.

Chart 2: Household net lending

Chart 3: Corporate sector net lending

Chart 4: Public sector net lending

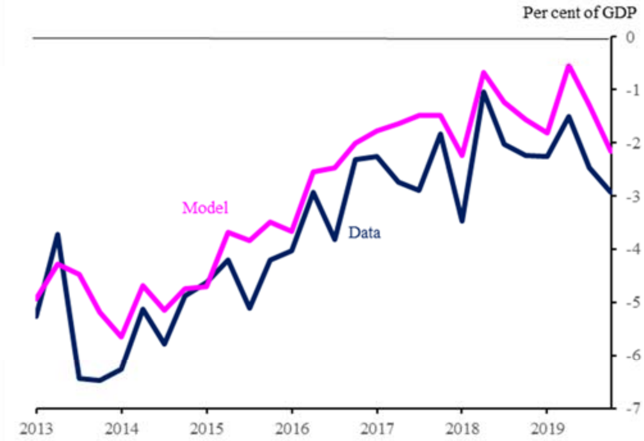


Chart 5: Banks net lending

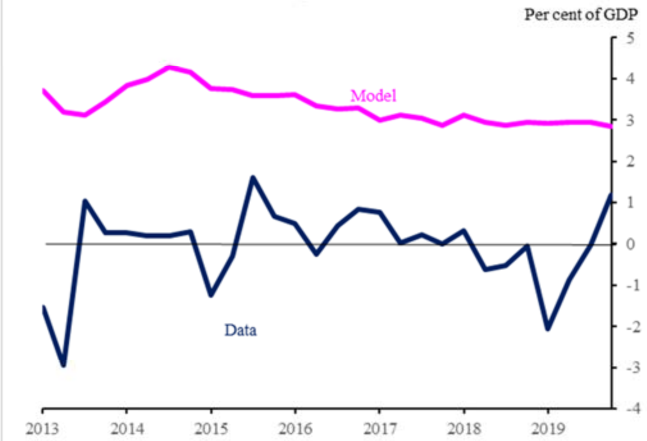


Chart 6: Pension funds net lending

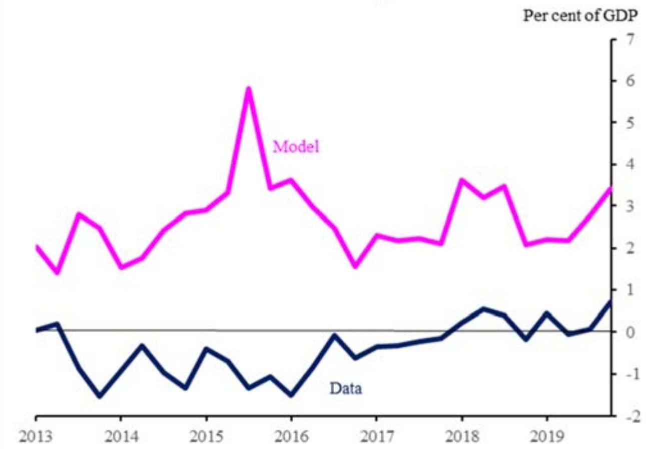
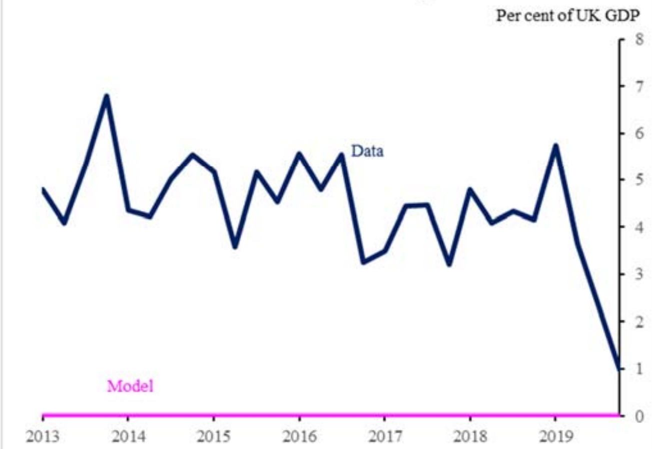


Chart 7: Rest of the world net lending



4.2 Calibration

The structural parameters in our model, together with their calibrated values are shown in Table F, below.

Table F: Calibrated parameters

Variable	**Description**	**Value**
α_1	Marginal propensity to consume out of income	0.7
α_2	Marginal propensity to consume out of wealth	0.011
add	Spread of deposit rate over bill rate	0.0008
β_b	Speed of adjustment of bank capital towards normal	0.6
δ	Rate of depreciation of fixed capital	0.032
δ_{rep}	Ratio of personal loans repayments to stock of loans	0.04
ε	Parameter in expectation formation	0.1 (0.5 in equation for expected sales)
η	Ratio of new mortgage loans to housing wealth	0.0495
η_n	Speed of adjustment of actual employment to desired employment	0.14
g	Growth rate of productivity	0.004
γ_0	Exogenous growth in the real stock of capital	-0.051
γ_r	Relation between the real interest rate on loans and growth in the stock of capital	0
γ_u	Relation between the utilization rate and growth in the stock of capital	0.15
θ_h	Income tax rate	0.16
θ_f	Corporation tax rate	0.55
λ_{10}	Parameter in ICPF demand for equities	0.680
λ_{11}	Parameter in ICPF demand for equities	2
λ_{12}	Parameter in ICPF demand for equities	1
λ_{13}	Parameter in ICPF demand for equities	1
λ_{20}	Parameter in ICPF demand for bonds	0.269
λ_{21}	Parameter in ICPF demand for bonds	1
λ_{22}	Parameter in ICPF demand for bonds	2
λ_{23}	Parameter in ICPF demand for bonds	1
λ_b	Parameter determining dividends of banks	0.0037
λ_c	Parameter in households demand for cash	0.22
λ_{ICPF}	Parameter determining dividends of ICPFs	0.003
ncar	Normal capital adequacy ratio of banks	0.14
npl_k	Proportion of Non-performing loans	0.0021
φ	Mark-up	0.55
ψ_d	Ratio of dividends to gross profits of firms	0.40
ψ_u	Ratio of retained earnings to investment	0.92
ρ	Reserve asset ratio	0.185
σ_n	Parameter influencing normal historic unit costs	0.24
σ_T	Target inventories to sales ratio	0.26
ϱ	Ratio of pension contributions to income	0.0957
ζ	Ratio of annuities to pension wealth	0.0091

For all equations involving expectations (except that for expected sales), we use adaptive expectations and set the speed of adjustment equal to 0.1. That is, for each variable x, we set:

$$E(x) = (1+g)\left(E(x_{-1}) + 0.1\big(x_{-1} - E(x_{-1})\big)\right) \quad \textbf{(30)}$$

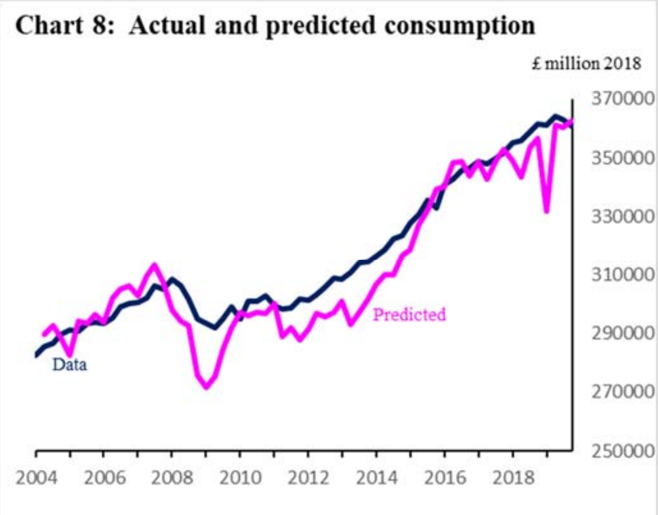
Where g is the average growth rate of x. For expected sales we follow Godley and Lavoie (2012) and assume that expectations adjust more rapidly. In particular, we have:

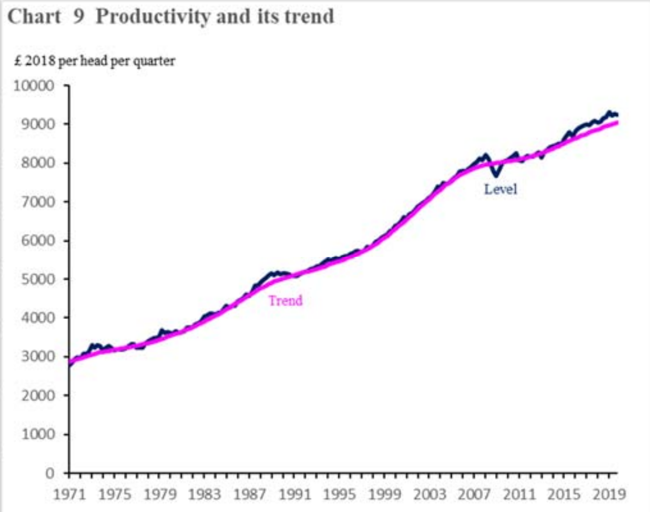
$$E(s) = (1+g)\left(E(s_{-1}) + 0.5\big(s_{-1} - E(s_{-1})\big)\right) \quad \textbf{(31)}$$

In order to generate a sensible path for consumption, we imposed the following consumption function:

$$c = 0.7(yd + nl) + 0.011nw_{h,-1} \quad \textbf{(32)}$$

This implies the path for consumption shown in Chart 8 (pink line), which, though much more volatile, is in line with the path for actual consumption in the UK data (blue line), at least since the Great Recession.





The parameters affecting the other decisions of households are set as follows. We set δ_{rep} to 0.04, the average proportion of outstanding mortgages paid off each quarter in the UK data from 2004 Q1 to 2019 Q4. In turn, this implies a value for η of 0.0495. We set cash holdings as a proportion of consumption, λ, equal to 0.22, its average value in UK data between 2004 Q1 and 2019 Q4. Finally, we set pension contributions as a proportion of household income, ϱ, equal to 0.0957, its average value in UK data between 2004 Q1 and 2019 Q4.

For the investment function, we set the depreciation rate of capital, δ, to 0.032, the average depreciation rate we applied when calculating the capital stock series. We then estimate γ_0, γ_u and γ_r using OLS estimation of the following equation:

$$g_k = \gamma_0 + \gamma_u \frac{y}{k_{-1}} - \gamma_r r_L \quad \textbf{(33)}$$

We used UK data on the real capital stock, utilisation (defined as our measure of real output divided by the previous period's capital stock) and the real interest rate on bank lending to corporates between 2004 Q1 and 2019 Q4. Unfortunately, when we estimated this equation, the coefficient on the real interest rate was incorrectly signed. So, we set γ_r to zero and re-estimated the equation. The OLS results are show in Table G, below.

Table G: Estimation output for our investment equation

Dependent Variable: G_K
Method: Least Squares
Date: 02/02/21 Time: 12:05
Sample (adjusted): 2004Q2 2019Q4
Included observations: 63 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-0.053131	0.006686	-7.946583	0.0000
U	0.151451	0.018216	8.314213	0.0000

R-squared	0.531224	Mean dependent var	0.002424
Adjusted R-squared	0.523539	S.D. dependent var	0.002686
S.E. of regression	0.001854	Akaike info criterion	-9.711310
Sum squared resid	0.000210	Schwarz criterion	-9.643274
Log likelihood	307.9063	Hannan-Quinn criter.	-9.684551
F-statistic	69.12614	Durbin-Watson stat	0.868694
Prob(F-statistic)	0.000000		

For the equation for employment, we first created a series for 'trend productivity' by HP-filtering UK data for GDP divided by the employment rate. This series is shown in Chart 9, above. Note that the average quarterly growth rate of productivity as measured by GDP divided by the employment rate was 0.37%. This is the value to which we set g in our calibration. We then estimated equation **(12)** by ordinary least squares. The results, presented in Table H, suggest a value of η_N equal to 0.14.

Table H: Estimation results for the employment equation

Dependent Variable: DN
Method: Least Squares (Gauss-Newton / Marquardt steps)
Date: 01/22/21 Time: 12:31
Sample (adjusted): 1971Q2 2019Q4
Included observations: 195 after adjustments
DN=C(1)*(GDP/PRTREND2-MGSR(-1))

	Coefficient	Std. Error	t-Statistic	Prob.
C(1)	0.140102	0.013568	10.32588	0.0000

R-squared	0.354419	Mean dependent var	0.004615
Adjusted R-squared	0.354419	S.D. dependent var	0.232266
S.E. of regression	0.186622	Akaike info criterion	-0.514353
Sum squared resid	6.756553	Schwarz criterion	-0.497569
Log likelihood	51.14945	Hannan-Quinn criter.	-0.507557
Durbin-Watson stat	1.009532		

The parameters affecting the other decisions of firms are set as follows. We set the target ratio of stocks to output, σ_T, equal to 0.60, the average ratio of stocks to sales in UK data between 2009 Q1 and 2019 Q4.[2] We set the mark-up of price over historic normal unit cost to 0.55. Chart 10 shows the dividend pay-out ratio – ie, the ratio of dividends to corporate profits – implied by our dataset. As can

[2] Prior to 2009, the ratio of inventories to sales was trending downwards in the United Kingdom. Since around 2009, the ratio has stabilised. Hence, our choice of time period.

be seen, this ratio was fairly stable between 2004 and 2012 at around 0.2 but rose subsequently to around 0.4 between 2013 and 2019. Given these data, we set the dividend pay-out ratio, ψ_D, to 0.4. Following Godley and Lavoie (2006), we assume that firms aim to finance 92% of their investment out of internal funds, ie, we set ψ_U to 0.92.

Chart 10: Dividend pay-out ratio

For the public sector, the only parameters we need to set are the tax rates. We set the average tax rate on household income, θ_h, to 16% and the average tax rate on corporate profits, θ_f, to 55%. These numbers reflect the average effective rates in the UK data from 2004 Q1 to 2019 Q4.

Turning to the ICPF sector, we set the annuity rate (ie, the ratio of annuity pay-outs to pension wealth), ζ, to 0.91%, its average value in the UK data from 2004 Q1 to 2019 Q4. And we set the ratio of ICPF dividend pay-outs to GDP, λ_{ICPF}, to 0.3%, its average value in the UK data over the same period.

We then need to set the parameters of the ICPF's portfolio allocation problem. Chart 11 shows the shares of bonds, deposits and equities in ICPFs' assets (given our calculations) in the UK data between 2013 Q3 and 2019 Q4 and Chart 12 shows the associated rates of return. We can see that between 2013 Q1 and 2019 Q4, the rate of interest on bonds fell by 145 basis points (0.0036 in terms of the units in the model). At the same time, the share of bonds in the ICPF's portfolio fell by 0.71 percentage points (ie, 0.0071 in terms of the units in the model). This suggests that a value for λ_{22} of 2 is reasonable. To maintain symmetry, we also set λ_{11} and λ_{33} to 2 and λ_{ij} to 1 for $i, j = 1,2,3$ $i \neq j$.

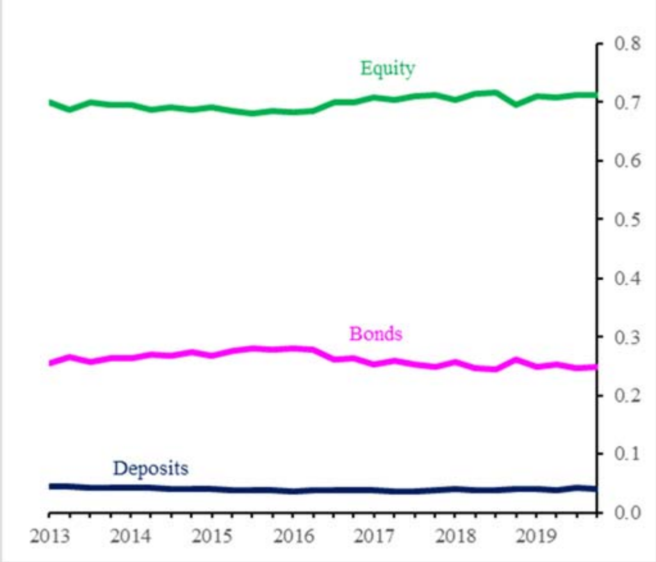


Chart 11: Asset shares

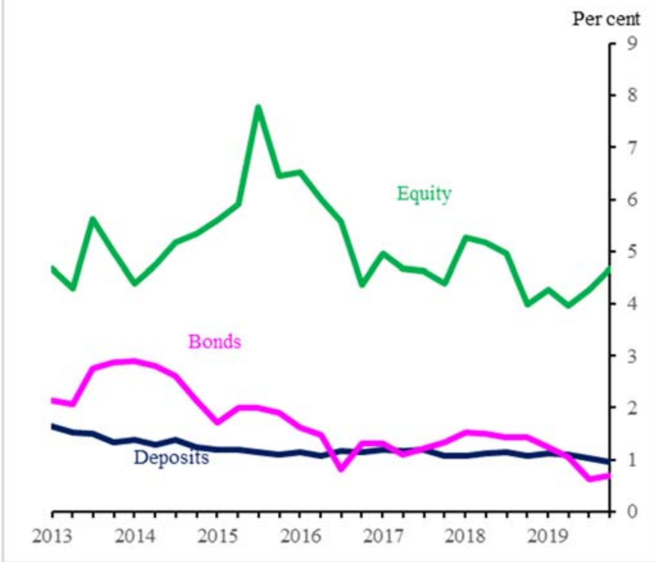


Chart 12: Rates of return

Given these values for the λs, we set the remaining parameters of the portfolio allocation problem to ensure that the average shares of bonds, equities and deposits in the ICPFs' portfolios are implied by the average returns on each of these assets over the period 2013 Q1 to 2019 Q4. This results in the following representation of the ICPF portfolio allocation equations:

$$\begin{pmatrix} \frac{p_V v_F}{A_{ICPF,-1}} \\ \frac{p_{BL} BL_{ICPF}}{A_{ICPF,-1}} \\ \frac{D_{ICPF}}{A_{ICPF,-1}} \end{pmatrix} = \begin{pmatrix} 0.680 \\ 0.269 \\ 0.051 \end{pmatrix} + \begin{pmatrix} 2 & -1 & -1 \\ -1 & 2 & -1 \\ -1 & -1 & 2 \end{pmatrix} \begin{pmatrix} r_k \\ i_{BL} \\ i_D \end{pmatrix} \tag{34}$$

The parameters affecting the decisions of banks are set as follows. The proportion of non-performing loans, *npl*, is set to 0.21%, its average value in UK data from 2004 Q1 to 2019 Q4. We set the ratio of bank reserves to deposits, ρ, equal to 0.185, its average value in the UK data between 2017 Q1 and 2019 Q4.[3] We set the normal capital adequacy ratio to 0.14, its average value in the UK data between 2012 Q1 and 2019 Q4.[4] We set the ratio of bank dividend payments to GDP, λ_b, equal to 0.0037, its average value in the UK data between 2004 Q1 and 2019 Q4. We set the spread of deposit rates over the bill rate to 19 basis points, its value in 2019 Q4. And, finally, following Godley and Lavoie (2006), we set the speed of adjustment of bank capital to normal levels, β_B, to 0.6.

5 A benchmark counterfactual

In order to examine the implications of COVID-19 for financial stocks and flows, we first need to produce a counterfactual simulation for 2020 on the assumption that COVID-19 never happened. In order to do that, we start with data on financial and real flows and stocks for 2019 Q4 and then use the model to project forward what we might have expected to happen in 2020. Table I shows the values we use for all our financial and real stock variables in 2019 Q4.

[3] This ratio appears to have been trending upwards over our data sample. However, between 2017 and 2019 it stabilised; hence our choice of time period.

[4] This ratio fell during the financial crisis before rising to a new level in 2012, higher than pre crisis levels, since when it has stabilised. Hence, our choice of time period.

Table I: 2019 Q4 values for stock variables

Variable	Description	2019 Q4 value	Data series/calculation
A_{ICPF}	ICPF assets	£4,438,883 million	$P_{BL}BL_{ICPF}+V_F+D_{ICPF}$
B_B	Bank holdings of bills	£399,807 million	$D+V_B-Mort-L-R$
B_{BoE}	Bank of England holdings of bills	£126,322 million	$M+R-P_{BL}BL_{BoE}$
B	Total supply of bills	£526,129	B_B+B_{BoE}
$P_{BL}BL_{ICPF}$	ICPF holdings of bonds	£1,100,272 million	$P_{BL}BL- P_{BL}BL_{BoE}$
$P_{BL}BL_{BoE}$	Bank of England holdings of bonds	£434,990 million	Bank of England: RPQZ4TM
$P_{BL}BL$	Total supply of bonds	£1,535,262 million	ONS: YEQF
BL_{ICPF}	ICPF real holdings of bonds	1888 million	$i_{BL}P_{BL}BL_{ICPF}$
BL_{BoE}	Bank of England real of bonds	747 million	$i_{BL}P_{BL}BL_{BoE}$
BL	Total real supply of bonds	2635 million	$i_{BL}P_{BL}BL$
D_H	Household deposits	£1,734,963 million	ONS: NNMP
D_F	Firm deposits	£753,155 million	ONS: NNZF
D_{ICPF}	ICPF deposits	£179,126 million	ONS: NIYD
D	Total supply of deposits	£2,667,244 million	$D_H+D_F+D_{ICPF}$
V_F	Nominal stock of firm equities	£3,159,485 million	ONS: NOQA
v_F	Real stock of firm equities	3,159,485 million	We normalise the price of equities, P_e, in 2019 Q4 to 1
$P_{HSE}H$	Nominal stock of housing	£5,488,661 million	Constructed by the authors; calculations available on request.
H	Real stock of housing	6,677,855 million	See description in text below.
INV	Nominal stock of inventories	£96,872 million	Constructed by the authors; calculations available on request.
inv	Real stock of inventories	146,873 million	Constructed by the authors; calculations available on request.
ITR	Pension wealth	£3,782,413 million	ONS: NPYL
R	Reserves	£478,817 million	ONS: BL22
M	Cash	£82,543 million	ONS: AVAB
$M0$	Base money supply	£561,360 million	$M+R$
K	Nominal stock of capital	£1,628,181 million	Pk
k	Real stock of capital	1,599,475 million	Bank of England calculations
L	Bank lending to firms	£405,768 million	ONS: NOPK
$Mort$	Mortgage lending	£1,447,570 million	ONS: NNRP
V_B	Bank capital	£243,844 million	ONS: NNYJ+NNYK
V_{ICPF}	ICPF capital	£656,470 million	A_{ICPF} - ITR
V	Nominal household wealth	£10,541,324 million	$D_H+P_{Hse}H+ITR-Mort+V_B+V_{ICPF}+M$
v	Real household wealth	10,120,625 million	V/P

In order to calculate some of these, we require 2019 Q4 values for various prices and interest rates. To calculate an initial house price we first note that real housing investment in 2019 Q4 was £26,605 million (in 2018 prices).[5] Given our calibration of the growth rate, g, equation **(3)** then implies that the

[5] We calculated 'real housing investment' as 'total gross fixed capital formation' (ONS Code: NPQT) less 'business investment' (ONS Code: NPEL) less 'government investment' (ONS Code: G93X).

real housing stock in 2019 Q3 will be given by $\frac{I_{H,2019Q4}}{g}$, which will equal £6,651,250 million (in 2018 prices) and the real housing stock in 2019 Q4 will be given by $H_{2019Q3}+I_{H,2019Q4}$, which will equal £6,677,855 million (in 2018 prices). Given our value for the nominal housing stock, this implies that the house price, P_{HSE}, in 2019 Q4, will be equal to 0.8219. We set the initial price of firm equities to 1. As discussed in section 3.5, above, the price of a bond, P_{BL}, will be equal to the inverse of the bond rate, i_{BL}. We set this equal to 0.6865% *per annum* (ie, 0.0017), the 10-year nominal zero-coupon spot rate in 2019 Q4 calculated by the Bank of England. For all other prices, P, we use the implicit consumption deflator ((ABJQ+HAYE)/HFC1), which was equal to 1.0179 in 2019 Q4. The quarterly inflation rate, π, of this measure of the price level was equal to 0.03% in 2019 Q4.

We also need 2019 Q4 values for a number of our flow variables. These are shown in Table J, below. Armed with these initial conditions, we are now in a position to generate a baseline simulation. That is, a projection based on the model of what would have happened in 2020 – 22 had it not been for COVID.

Table J: 2019 Q4 values for other variables

Variable	Description	2019 Q4 value	Data series/calculation
Π_F	Firm profits	£88,015 million	Constructed by the authors; calculations available on request.
G	Real government spending	118,436 million	ONS: NMRY+G93X
PI	Nominal investment	£56,574 million	ONS: GAO4
N	Employment rate	0.617	ONS: MGSR
pr	Trend productivity	905,379 million	Constructed by the authors; calculations available on request.
i_B	Interest rate on bills	0.75% pa	Bank of England Policy Rate
i_L	Interest rate on loans	5.12% pa	ONS: (J4X3+J4WT)/(NNRP+NOPK)
i_D	Interest rate on deposits	0.94% pa	ONS: (J4X2+J4WR)/(NNMP+NNZF)
r_k	Dividend yield	4.84% pa	ONS: (ROCH+ROCI-ROAZ-ROBA)/NOPK
s	Real sales	554,475 million	ONS: (ABJQ+HAYE+NPQS+NMRP)*HFC1/(ABJQ+HAYE)
T_H	Transfers to households	£60,279 million	ONS: GZVX
T_F	Transfers to firms	£1,540 million	ONS: RPWU
W	Nominal wage	£594,125 million	ONS: (ROYI+ROYH+CAEN)/MGSR
Y	Nominal output	£565,760 million	ONS: ABJQ+HAYE+NPQS+NMRP+CAEX-DMUN
y	Real output	555,785 million	Y/P
NUC	Normal unit cost	0.6562	W/pr
UC	Unit cost	0.6596	WN/y
YD	Nominal disposable income	£377,048	Constructed by the authors; calculations available on request.
yd	Real disposable income	367,206 million	$YD/P-v\pi$
$E(yd)$	Expected real disposable income	328,479 million	Constructed by the authors using equation **(2)**

Chart 13 shows the projections from our model for the growth rate of real GDP and its components while Chart 14 shows our projection for the inflation rate. The counterfactual projection suggests a strong increase in consumption growth that pulls up output growth. (We explain below where the rise in consumption growth comes from.) Investment growth increases in the latter part of the period as it responds to the higher output. The projected growth rates all look higher than we might have expected, but, given that we are interested only in constructing a baseline against which we can compare the effects of the COVID shock and associated government policies, we remain sanguine about this. Inflation actually falls and then remains low over the period. To understand why this happens, we note from Charts 15 and 16 that the increase in output growth results in increases in employment and productivity growth. By keeping normal unit costs in check, this increase in productivity growth acts to keep inflation low.

Chart 13: Annual growth rates of GDP, consumption, investment and government spending

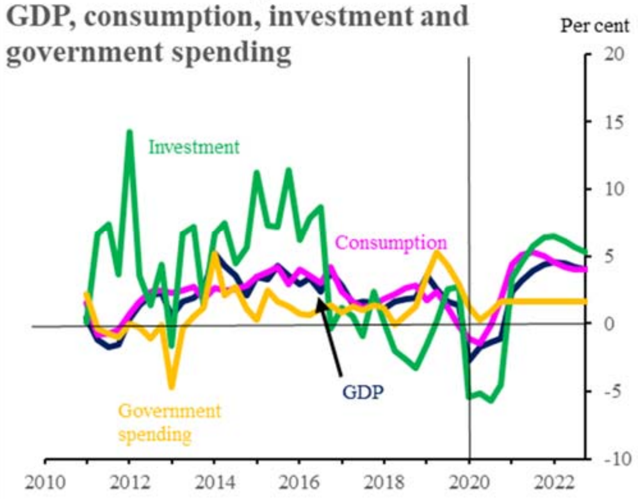


Chart 14: The inflation rate

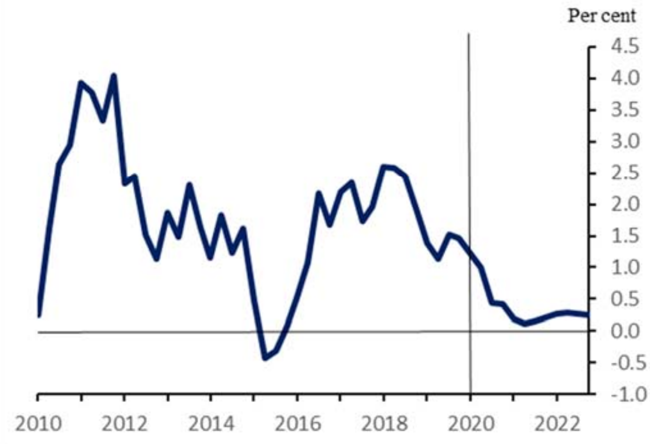


Chart 15: The employment rate

Chart 16: Productivity and real and nominal wage growth

Charts 17 to 22 show what happens to financial variables in our benchmark simulation.

Chart 17: Interest rates

Chart 18: Bank capital

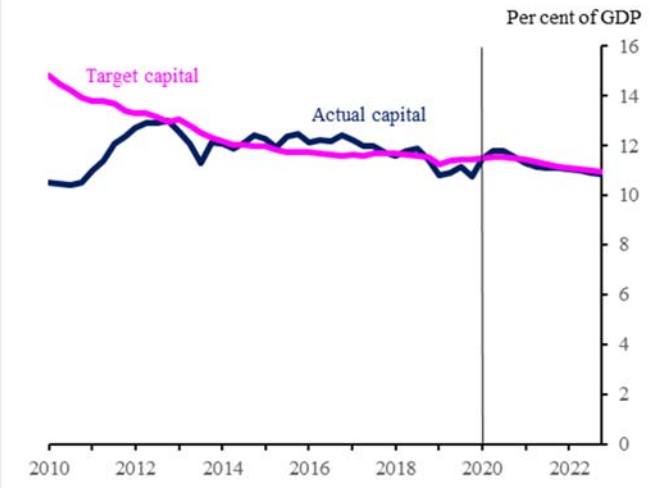


Chart 19: Mortgages, loans and banks' customer funding gap

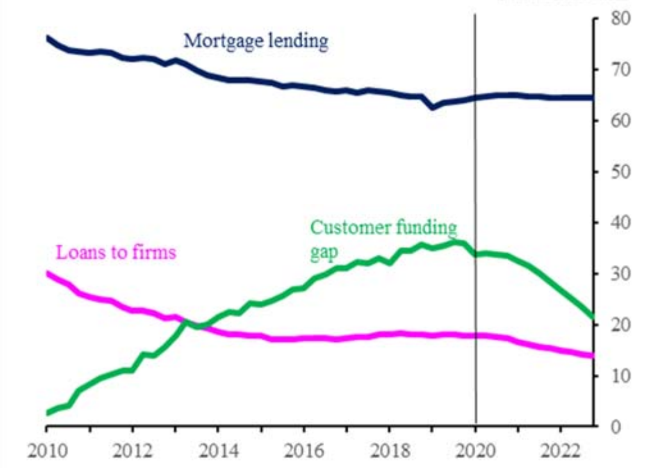


Chart 20: Stocks of equities, bills and bonds

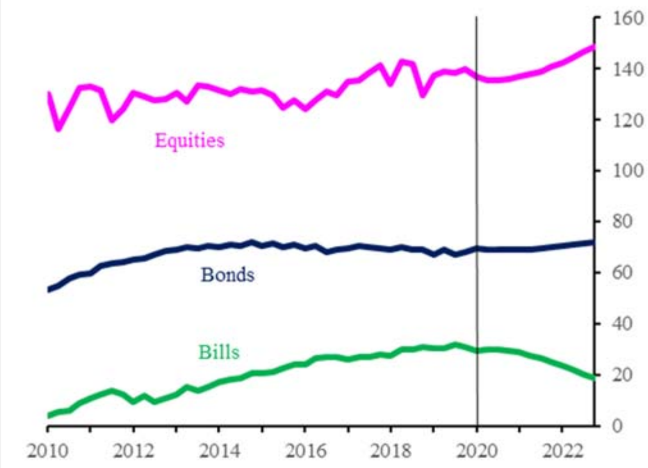
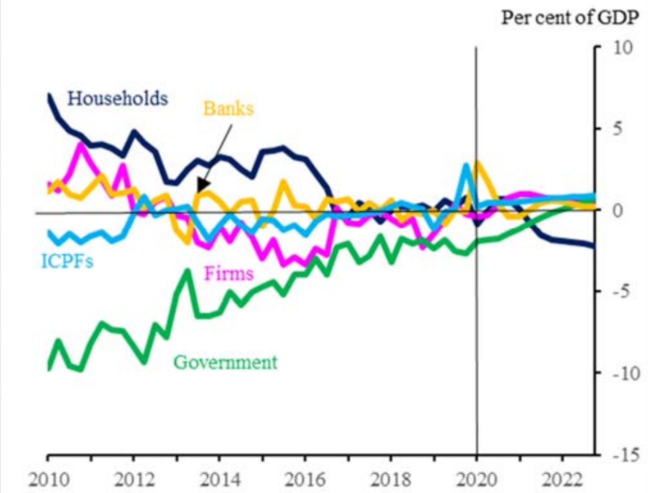


Chart 21: Equity and bond prices

Chart 22: Sectoral financial balances



As shown in Chart 17, we assume that the Bank of England would have kept its policy rate fixed at 0.75% in the absence of the COVID shock. Further, we assume that bond rates would have remained unchanged at 0.6865%. In practice, we might have expected rates to rise in response to the high growth rate of output, but we consider the ‘unchanged rate’ assumption fine for the purposes of generating a benchmark simulation. With bill rates unchanged, our model implies that banks do not change their deposit rates. At the same time, they are able to reduce their loan rates while still maintaining enough capital to meet their regulatory requirement, as shown in Chart 18.[6] This reduction in loan rates lowers mortgage interest payments from households to banks. In turn, this means that household disposable income increases, and it is this increase in household disposable income that leads to the strong rise in consumption growth we noted earlier. Chart 19 shows that this implies the build-up of problems for the banks in funding their loans. The increase in consumption leads to a fall in deposits. Although loans to firms are also falling, deposits are falling faster, which means that the banks' 'customer funding gap' (defined as deposits less loans) is falling. Again, we might expect banks to raise their deposit rates in order to deal with this problem, but this channel is missing from the model. That said, we are still content to assume constant deposit rates in our benchmark case as we can examine whether the COVID shock and associated policies make the banks' funding problems worse or better than in the benchmark.

Chart 21 shows that equity prices rise in our benchmark simulation and, as a result, the stock of equities rises as a proportion of GDP as shown in Chart 20. Bond prices remain static given our assumption of constant bond rates. With demand for bonds relatively flat, and the government reducing its deficit, there is less need for the government to issue bills and so these fall as a proportion of GDP as shown in Chart 20. Finally, Chart 22 shows financial balances by sector in the benchmark simulation. Net lending by all sectors stays fairly close to zero over the forecast period. However, we can see that the household sector is increasing its net borrowing while the public sector is reducing its net borrowing. Again, this probably results from our constant interest rate assumption. If the Bank of England responds to the high output growth by raising its policy rate and other interest rates rose commensurately, then the value of household pension wealth would fall, encouraging households to save more and spend less.

In this section, we have used our model to produce a reasonable benchmark simulation. In particular, the model has given us a projection for what we might have expected to happen over 2020-22 in the absence of the COVID shock. In the following section, we examine the implications of the COVID-19 shock for financial stocks and flows by comparing a simulation of the model that adds the direct effects of the 'lockdown' brought about by COVID to our benchmark simulation while holding all other government policies unchanged. In Section 7, we then go on to examine the effects of the various policies that the government and Bank of England used to reduce the disruption to the economy caused by the COVID shock.

6 How did the COVID 'lockdown' affect financial stocks and flows?

On March 23rd 2020, in response to the large increase in the number of COVID cases in the United Kingdom, the Prime Minister ordered everyone to 'stay at home' to stop the spread of the virus. This lockdown represented a major shock to the UK economy as all non-essential shops were closed, workers were told to 'work from home' if they could, only going in to work if absolutely necessary, social gatherings were banned and all non-essential travel was forbidden. In this section, we examine the effects of this lockdown on financial stocks and flows.

[6] The fall in loan rates looks large and results from a gap between loan rates implied by our model and those in the real world. This is because, in our model, banks do not charge any risk premia (ie, to take account of counterparty credit risk or any other risks associated with their loans). They simply supply loans on demand at the lowest rate they can afford.

In order to do examine the effects of this 'lockdown shock' in isolation, we need to develop a counterfactual scenario where no government policy interventions are applied other than to lock the economy down. We modelled the lockdown as affecting both demand and supply. In particular, we assumed that the closure of non-essential shops led to a fall in both consumption and expected sales, while the increase in uncertainty brought about by COVID more generally led to a fall in investment in both housing and capital as well as a fall in equity prices. More specifically, we implemented the supply, demand and uncertainty effects via adding shocks to equations **(31)**, **(1)**, **(3)**, **(10)** and **(21)** as follows:

$$E(s) = (1 + g - \varepsilon_{Es})\left(s_{-1} + 0.5\left(s_{-1} - E(s_{-1})\right)\right) \tag{35}$$

$$c = (1 - \varepsilon_c)\left(\alpha_1(E(yd) + nl) + \alpha_2 nw_{h,-1}\right) \tag{36}$$

$$I_H = (1 - \varepsilon_{I,H})gH_{-1} \tag{37}$$

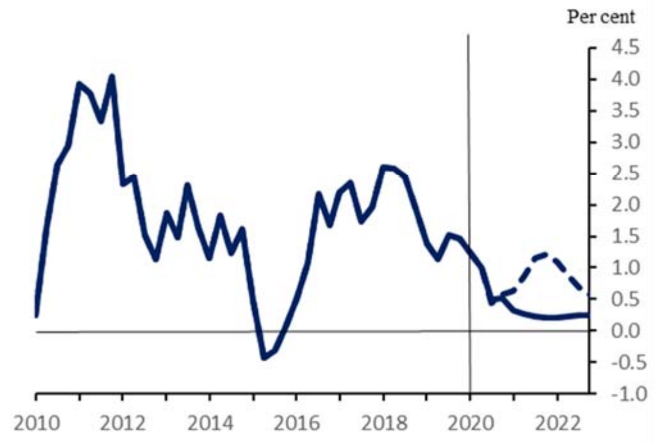
$$I = \left((1 - \varepsilon_I)\left(\gamma_0 + \gamma_u \frac{y}{k_{-1}} - \gamma_r r_L\right) + \delta\right)k_{-1} \tag{38}$$

$$\begin{pmatrix} \frac{P_V v_F}{A_{ICPF,-1}} \\ \frac{P_{BL} BL_{ICPF}}{A_{ICPF,-1}} \\ \frac{D_{ICPF}}{A_{ICPF,-1}} \end{pmatrix} = \boldsymbol{\lambda_0} + \boldsymbol{\Lambda}\begin{pmatrix} r_k \\ i_{BL} \\ i_D \end{pmatrix} - \begin{pmatrix} \frac{\varepsilon_{Pv} v_F}{A_{ICPF,-1}} \\ 0 \\ 0 \end{pmatrix} \tag{39}$$

We set ε_c, ε_I and ε_{IH} to 0.2, implying 20% lower consumption, investment and housing investment, for the period 2020 Q2 to 2021 Q1 (the period during which we assume the lockdown is in place). In line with these assumed effects of the lockdown, we set ε_{Es} to 0.2 in 2020 Q2, implying a 20% fall in the level of expected sales as the lockdown hits, and to -0.2 in 2021 Q2, as the lockdown is lifted. We set ε_{Pv} to 0.1 for the period of the lockdown (ie, 2020 Q2 to 2021 Q1), implying a 10% fall in equity prices per period. Finally, we also assumed that the lockdown would lead to an increase in the share of non-performing loans, from 0.21% to 5% for the period 2020 Q2 to 2021 Q1, as the lockdown meant that some firms would go out of business or cease loan repayments (absent any other policy intervention).[7]

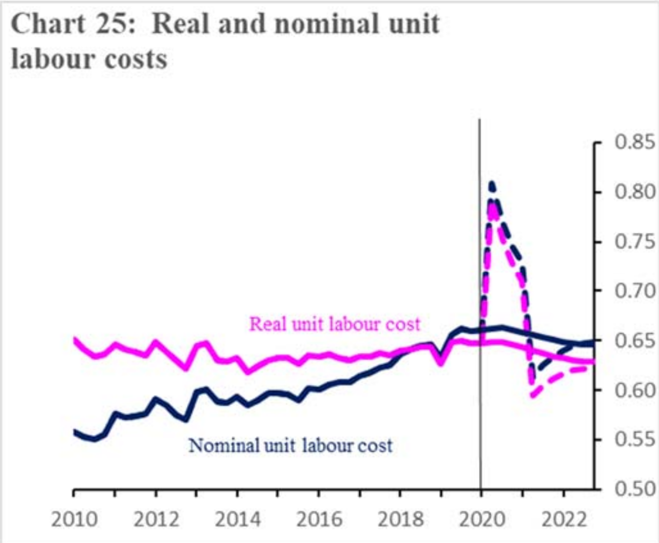
Chart 23: Effect of the lockdown shock on real GDP, consumption and investment

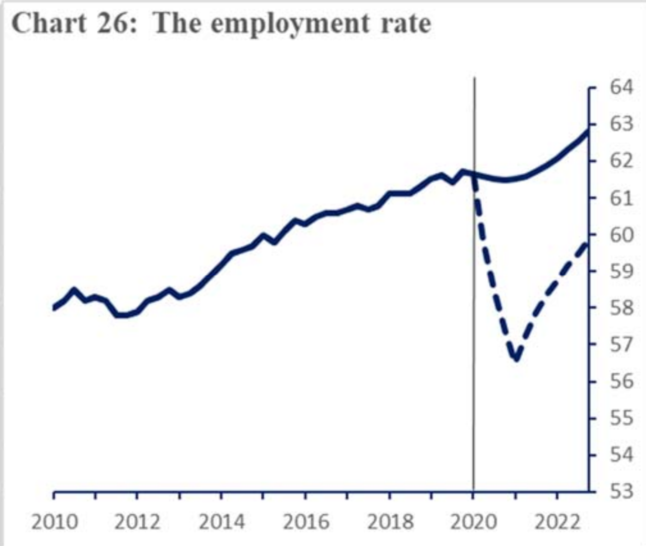
Chart 24: The inflation rate



[7] This is roughly in line with the Bank of England's May 2020 desktop stress-testing exercise reported in Bank of England (2020).

Chart 23 shows the effect of the lockdown on GDP, consumption and investment. Unsurprisingly, consumption, investment and output all sharply contract (by 20%, 26% and 20%, respectively) in 2020 Q2 and bounce back strongly in 2021 Q2. Note, however, that the shock results in a permanent fall in the level of consumption, investment and output. Chart 24 shows that the lockdown also leads to a temporary rise in inflation. This results from the sharp increases in both real and nominal unit labour costs illustrated in Chart 25 as output falls by more than employment and wages hold up. Chart 26 shows the employment response to the lockdown shock. The Chart suggests that the employment rate falls from 61.6% to 56.5%, which, assuming no response from participation, would imply a rise in the unemployment rate of roughly 8 percentage points (from 4% to 12%).





Turning to financial variables, Chart 27 shows the effect of the lockdown shock on bank lending and deposits. The shock results in a large increase in deposits, as households are unable to spend and so save their income instead. With lending flat to falling, this increase in deposits means that banks have no problem funding their new loans out of deposits. However, the increase in non-performing loans resulting from the lockdown eats into bank capital. Chart 28 shows that banks find themselves with less capital than their target. As a result they raise loan rates to try and rebuild their capital. As Chart 29 shows, loan rates increase sharply, from 2.0% to 7.8%, before falling again once banks have restored their capital to their desired level. Chart 30 shows that after the sharp fall in equity prices associated with the COVID shock, equity prices rebound once the lockdown ends, while still remaining lower than they would have been absent the shock at the end of 2022.

Chart 27: Bank lending and deposits

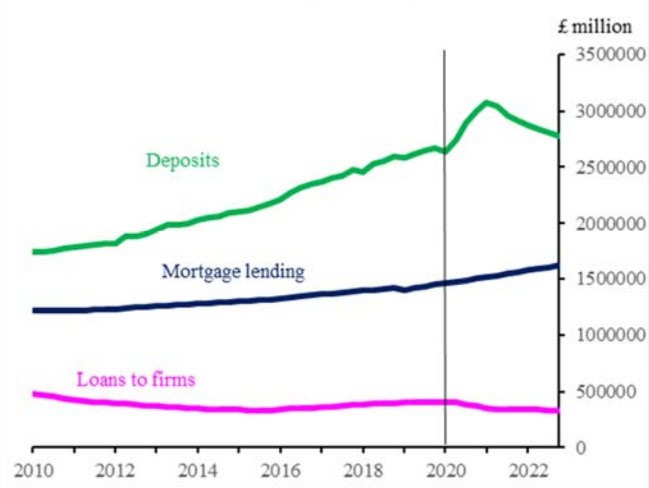


Chart 28: Bank capital

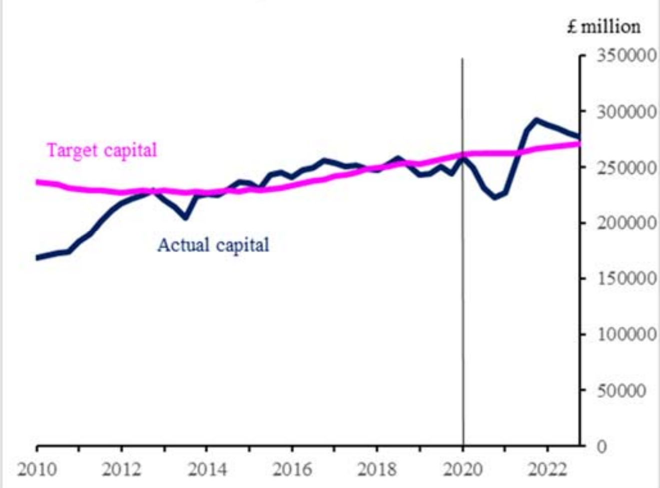


Chart 29: Interest rates

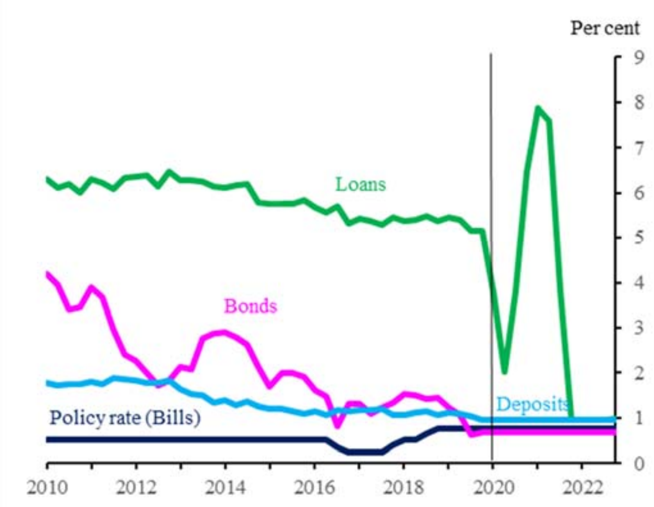
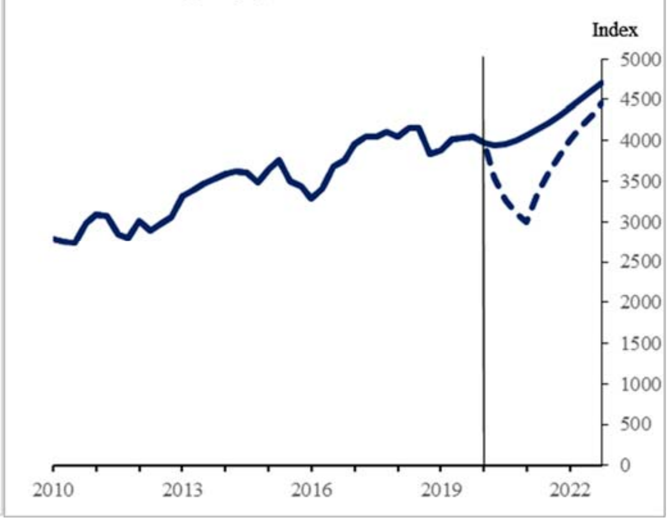
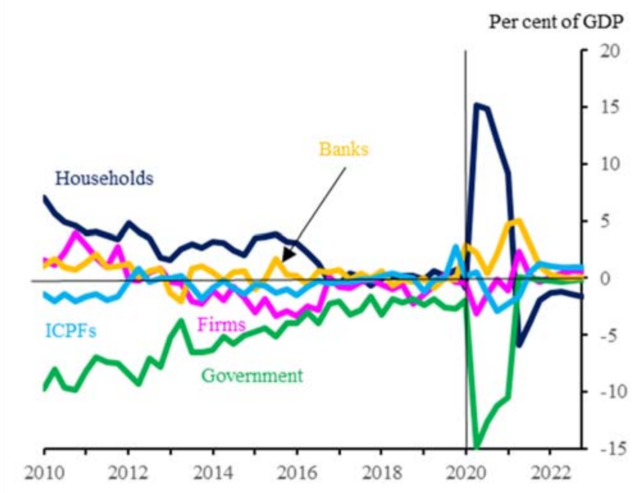


Chart 30: Equity prices



Finally, Chart 31 shows net lending by sector. We can see that the shock leads to a large rise in net lending by households. This is because actual employment falls slower than the desired level of employment to match the reduced output. Therefore, wages do not fall as much as consumption and households effectively have 'forced saving'. The rise in household net lending is matched by an equally large rise in net borrowing by the government, resulting from the large fall in tax revenue brought about by the shock. Firm profit falls, and therefore retained earnings and dividends do too. But, investment does not fall by as much as retained earnings, so firms must initially borrow (roughly 3% of GDP at the peak in 2020 Q2) to cover that gap. However, as shown in Chart 27, the stock of outstanding loans falls because of the increase in non-performing loans. Similarly, ICPF's net borrowing increases (roughly 3% of GDP at the peak in 2020 Q4) because their income is reduced as firm dividends fall but annuity payments continue as normal. This takes the form of a reduction in their asset holdings, with the reduced demand for equities contributing to their price fall. Banks' net lending, on the other hand, rises as their profits rise.

Chart 31: Sectoral financial balances



7 The effects of public sector policy interventions

Table K lists the particular government and central bank policies that we consider in this paper, together with the relevant model variable(s) affected by the policy. The government and Bank of England instigated these policies to minimise the adverse effects of the COVID-induced lockdown on the economy generally and on the financial and corporate sectors specifically. In this section, we discuss the effects of each of these policies on the real economy and on financial stocks and flows as implied by our model.

Table K: Government policies

Policy	Variable affected
Extra NHS funding	Government spending
Job retention scheme and other grants/reliefs for businesses	Government transfers to PNFCs, which are passed on to households
Extension of universal credit and self-employed income support scheme	Government transfers to households
Covid Corporate Financing Facility	Bank of England purchases of corporate loans
Coronavirus Business Interruption Loan Scheme and the Coronavirus Large Business Interruption Loan Scheme	Government transfer to banks
Term Funding Scheme for Small and Medium-sized Enterprises	Bank of England purchases of commercial banks bills
Releasing the Counter-Cyclical capital Buffer	Banks' target capital adequacy ratio
Interest rate cut	Short-term interest rate
Extra Quantitative Easing	Bank of England purchases of government bonds

7.1 The Job Retention Scheme

As illustrated in the previous section, we would expect the COVID lockdown to have led to a large increase in the unemployment rate. In order to counter this, the government set up the 'Job Retention Scheme' (also known as the 'Furlough' scheme). This scheme enabled firms to retain and continue to pay their employees during the lockdown by the government paying 80% of the wages of employees that were temporarily put on furlough. According to Francis-Devine and Powell (2021), by midnight on 14 June 2021, the scheme had resulted in 11.6 million employees on furlough at a cost of £66 billion. In order to implement this within our model, we needed to set the number of furloughed workers each period. We experimented with different numbers until we had achieved a smooth fall in employment over the period of lockdown (2020 Q2 to 2021 Q1) while ensuring that the government spent £66 billion on the scheme.

Chart 32 shows the effect of the scheme on the employment rate. As can be seen, the employment rate still falls, but the fall is much smaller and slower. The Chart suggests that the employment rate falls from 61.6% to 58.5%, which, assuming no response from participation, would imply a rise in the unemployment rate of roughly 5 percentage points (from 4% to 9%). That is, our model suggests that the Job Retention Scheme on its own would have reduced the rise in unemployment by roughly 3 percentage points. The scheme, however, results in government net borrowing increasing to 17.1% of GDP, as shown in Chart 33. In the lockdown scenario with no Job Retention Scheme, government net borrowing only rises to 14.9% of GDP. Household sector net lending is the counterpart of this; household net lending rises to 17.0% of GDP with the scheme in place (as shown in Chart 33) as opposed to only 15.1% of GDP in the lockdown scenario.

Chart 32: The employment rate

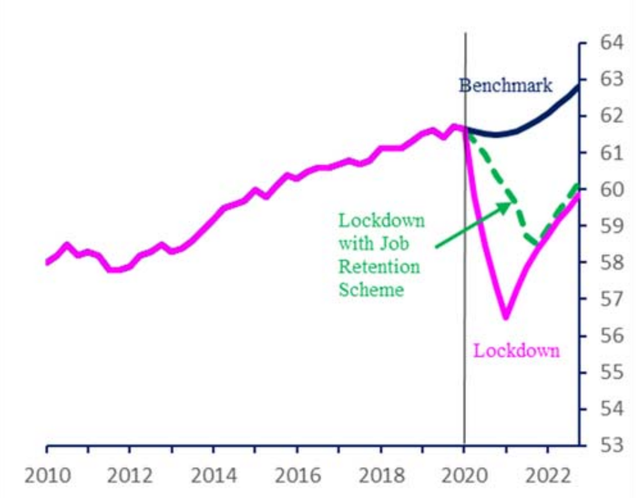
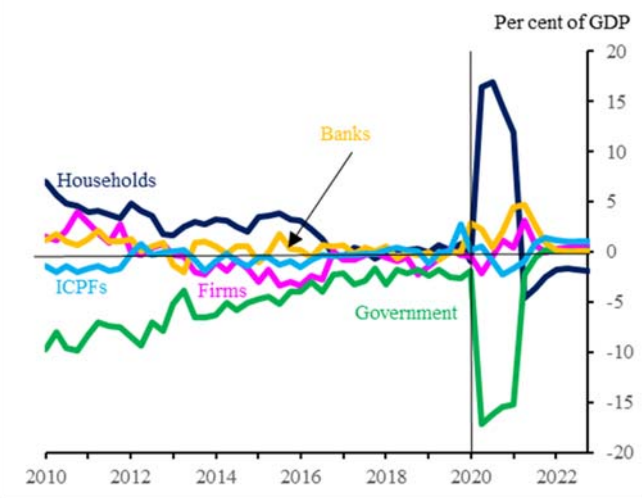


Chart 33: Sectoral financial balances



7.2 *Increased government spending and support for households*

In addition to the furlough scheme, the government set up the 'Self-employed income support scheme' to cover a proportion of the lost earnings of the self-employed. They also extended universal credit to a larger group of households. In the context of our model, we can think of both of these policies resulting in increased transfers from the government to households. Our best guess is that these transfers were worth around £25 billion through the course of the lockdown.[8] The government also increased its own 'consumption' spending, *PG* in our model, by spending roughly an additional £18 billion on the National Health Service (NHS) in response to the pandemic.[9] In addition to the obvious health benefits, these policies were aimed at reducing the negative effects of the lockdown on consumption and GDP that resulted from the lockdown

Given our calibration, the additional £4.5 billion per quarter spending on the NHS amounted to 3.7% of government spending in 2020 Q1. So, in the model we incorporate the government spending increase through a 3.7% increase in real government spending each quarter from 2020 Q2 to 2021 Q1. That is, our equation for real government spending became:

$$G = \left(1 + g + \varepsilon_g\right)G_{-1} \qquad \textbf{(40)}$$

Where ε_g is set to 0.037 for 2020 Q2 through to 2021 Q1.

Similarly, we implement the 'Self-employed income support scheme' as an increase in government transfers to households of 10% per quarter between 2020 Q2 and 2021 Q1. This amounts to approximately £25 billion over this period.

$$TR_h = (1 + g + \varepsilon_{TRh})(1 + \pi)TR_{h,-1} \qquad \textbf{(41)}$$

Where ε_{TRh} is set to 0.1 for 2020 Q2 through to 2021 Q1. The transfer directly affects household disposable income leading to higher consumption.

Chart 34 plots real GDP, consumption and investment for the 'lockdown' scenario (solid line) and the same scenario but with the additional government spending and transfers to households. As can be seen, the increase in government spending does have a positive effect on consumption, investment and output, but the effect is small and only becomes noticeable after lockdown is over. The result is that household net borrowing rises by even more than in the lockdown scenario as the additional transfers are saved. This is shown in Chart 35, which plots sectoral balances in the 'lockdown plus extra government spending' scenario. The chart shows that government net borrowing increases as household net lending increases. The additional government spending does help firm profits a little. Chart 35 shows that firm net borrowing rise to 2.3% of GDP relative to 3.0% without the additional government spending.

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[8] See Cost of self-employment grant scheme UK 2021 | Statista and Budget 2021: Sunak announces extension to universal credit £20 top up - BBC News for some evidence on this.

[9] See £7 billion for NHS and social care for COVID-19 response and recovery - GOV.UK (www.gov.uk) for some evidence on this.

Chart 34: Effect of the increased government spending and transfers on real GDP, consumption and investment

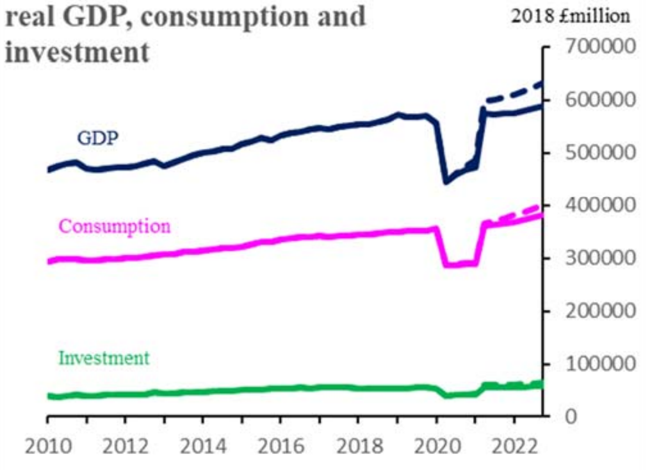
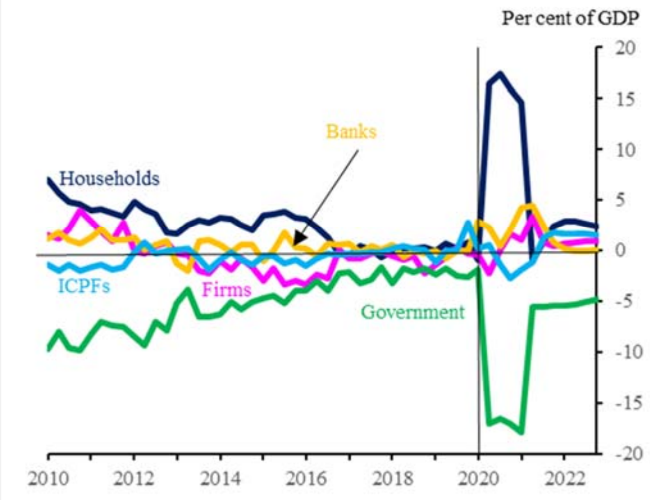


Chart 35: Sectoral financial balances



Taken at face value, these results might suggest that the increased government transfers to the household sector were not needed, given that the household sector was already a large net borrower. However, our model does not provide the complete picture. In particular, these transfers were intended to ensure that the households most affected by the lockdown were supported. Since our model is an aggregate macroeconomic model, it simply does not capture distributional issues and so is unable to assess the ability of these transfers to 'shore up' the incomes of the poorest households.

7.3 Government schemes to encourage lending to the corporate sector

As we showed above, the COVID lockdown shock led to a large fall in investment and a fall in the stock of loans to corporates. In addition, the fall in corporate sector profits meant that corporate sector net borrowing increased. In order to try and encourage the banks to continue to lend to the corporate sector, with a view to increasing investment and, so, raising output and profits, the government and the Bank of England enacted a number of lending schemes.

7.3.1 The COVID Corporate Financing Facility

The COVID Corporate Financing Facility (CCFF) was a joint HM Treasury and Bank of England lending facility aimed at helping larger, investment-grade firms to manage the pressure on their cash-flows created by the lockdown. The loans were provided via the direct purchase of newly-issued short-term commercial paper. Between March 2020 and March 2021, the scheme lent over £37 billion, with peak purchasing of over £20 billion in May 2020. Although the scheme is now closed to new lending, the CCFF will continue to hold commercial paper until March 2022.[10]

In terms of our model, CCFF loans are a liability of the firms and an asset for the Bank of England. As the facility is a form of lending, CCFF loans appear as a flow of funds between the Bank of England and the capital account of firms. As intended, the facility eases the cash flow of firms (ie, reduce their demand for bank loans) as can be seen from their 'demand for bank loans' equation:

$$\Delta L = P * I + UC * \Delta \mathrm{Inv} + \Delta D_F - \Pi_{F,U} - P_v \Delta v_F - \mathrm{NPL} - \Delta CCFF \quad \textbf{(42)}$$

---

[10] See Covid Corporate Financing Facility (CCFF) on the Bank of England's website for more details on this scheme.

From the Bank of England's side, the increase in their holdings of corporate debt means a reduction in their holdings of other assets, given that they supply cash and reserves (their liabilities) on demand. Hence, the equation for the Bank of England's balance sheet now implies:

$$B_{BoE} = R + M - P_{BL}BL_{BoE} - CCFF \quad \textbf{(43)}$$

We set the change in the stock of CCFF loans to £20 billion in 2020 Q2, £7 billion in 2020 Q3 and £5 billion in each of 2020 Q4 and 2021 Q1. We unwind the CCFF over 2021 Q2 to 2022 Q1 at the rate of £9.25 billion a quarter.

As we said earlier, under lockdown, firms reduce their demand for bank loans. The CCFF facility reduces this net demand for bank loans further, as shown in Chart 36. However, because output and investment are demand determined, and firm deposits remain high, this facility does not impact output or employment. In reality, firm heterogeneity means some firms will have needed to draw on the CCFF facility and others not, and some will have drawn on it for precautionary reasons. Again our model does not capture this heterogeneity among firms and so will miss this demand for CCFF loans. As a result of the reduced demand for bank lending, the commercial banks' capital requirement will be lower, and therefore the interest rate on loans is also slightly lower than without the facility, as shown in Chart 37. However, this does not stop the commercial bank's capital levels falling below their long-run target because the short-run target adjusts slowly. Therefore, banks still raise the interest rate on loans under this intervention, but not as much as under lockdown alone.

Chart 36: Bank lending

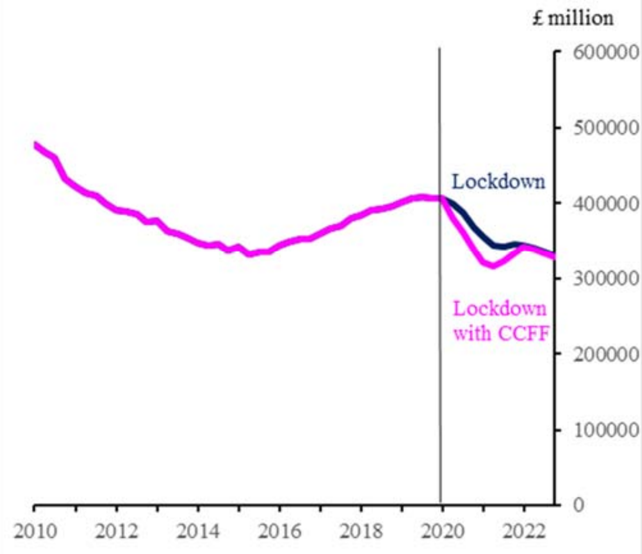
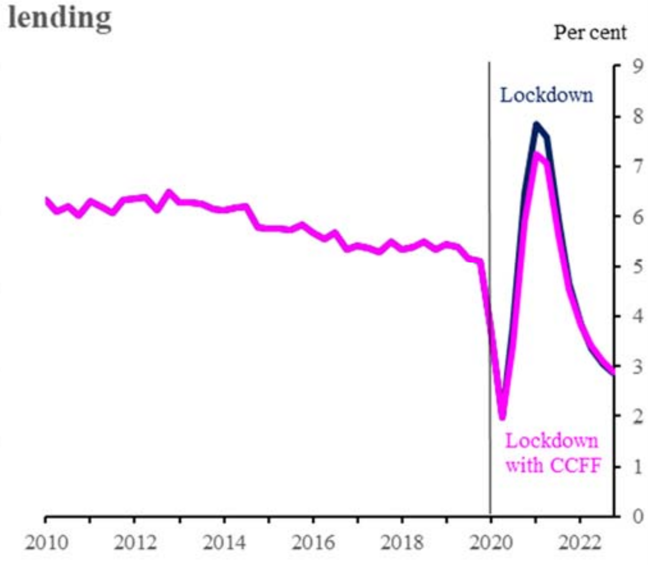


Chart 37: Interest rate on bank lending



7.3.2 The Coronavirus Business Interruption Loan Scheme and the Coronavirus Large Business Interruption Loan Scheme

The Coronavirus Business Interruption Loan Scheme (CBILS) and Coronavirus Large Business Interruption Loan Scheme (CBILS) were lending schemes through which loans by accredited lenders were 80% guaranteed by the government in case of default.[11] We represent this in the model by having the government pay banks 80% of the non-performing loans from firms during the 2020 Q2 to 2021 Q1 period. As a result, the fall in bank capital resulting from the large increase in non-performing loans is cushioned by this policy. In turn, this enables banks to maintain their capital at their desired capital adequacy ratio with only a small rise in interest rates, as shown in Charts 38 and 39. In terms of financial balances, the policy results in a small increase in household and firm net lending, as shown in Chart 40 where the solid lines show net lending under the ‘lockdown’ scenario and the dashed lines show net lending when the CBIL and CLBIL schemes are in place. Finally, we can note that the cost to the government of running these schemes amounts to less than one tenth of one percent of total government spending during 2021 in our model. As a result, implementing this scheme has no discernible effect on public-sector net lending, as shown in Chart 40.

Chart 38: Bank capital

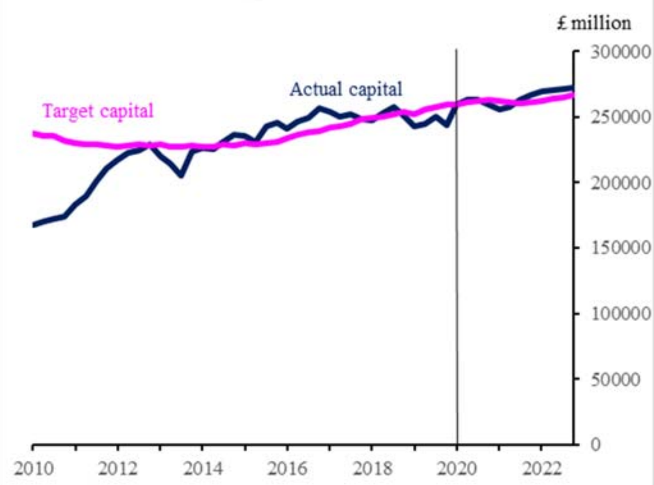
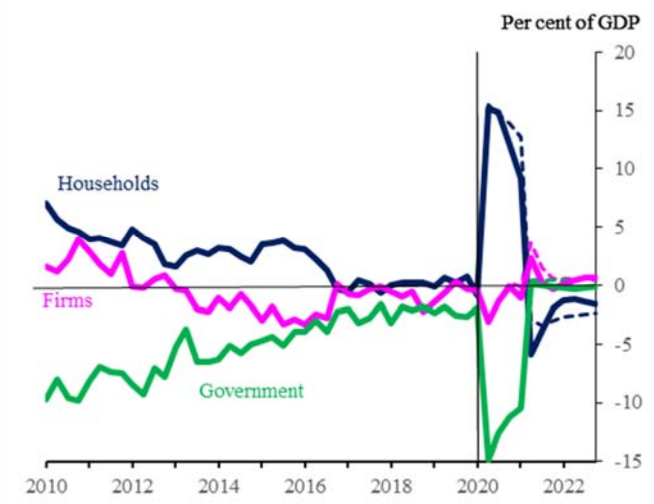


Chart 39: Interest rate on bank lending

Chart 40: Sectoral financial balances



[11] See Coronavirus Large Business Interruption Loan Scheme (CLBILS) for more details on this scheme.

7.3.3 The Term Funding Scheme with additional incentives for Small and Medium Enterprises

The idea of the Term Funding scheme with additional incentives for Small and Medium-sized Enterprises (TFSME) was to enable banks to continue lending to small and medium-sized enterprises (SMEs) at low lending rates despite not being able to reduce their deposit rates. Specifically, the Bank of England, through the TFSME, lent money to the banks at an interest rate very close to the Bank rate. These liabilities could then finance lending to firms at low interest rates without the banks having to reduce their deposit rates and/or suffer reduced profitability. Beginning in March 2020, by June 2021 approximately £89 billion net had been lent through this scheme.

In terms of our model, TFSME loans would be an asset of the Bank of England and a liability of the banks and the loans would appear as a flow of funds between the capital accounts of the Bank of England and the banks. Interest payments on the loans would appear as a flow of funds between the current accounts of the banks and the Bank of England. The Bank of England's profits would now be given by:

$$\Pi_{BoE} = i_{B,-1}\left(B_{BoE,-1} + TFSME_{-1}\right) + BL_{BoE,-1} \tag{44}$$

And its balance sheet equation by:

$$B_{BoE} = R + M - P_{BL}BL_{BoE} - TFSME \tag{45}$$

Profits of the banks would now be given by:

$$\Pi_B = i_{L,-1}(L_{-1} + Mort_{-1} - NPL) + i_{B,-1}\left(B_{B,-1} - TFSME_{-1}\right) - i_{D,-1}D_{-1} \tag{46}$$

And their balance sheet by:

$$B_B = D + TFSME + V_B - L - Mort - R \tag{47}$$

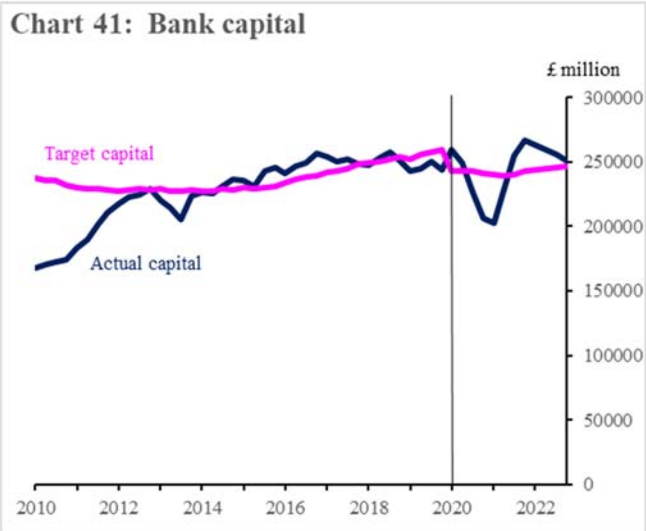
Importantly, the equation for their lending rate would now become:

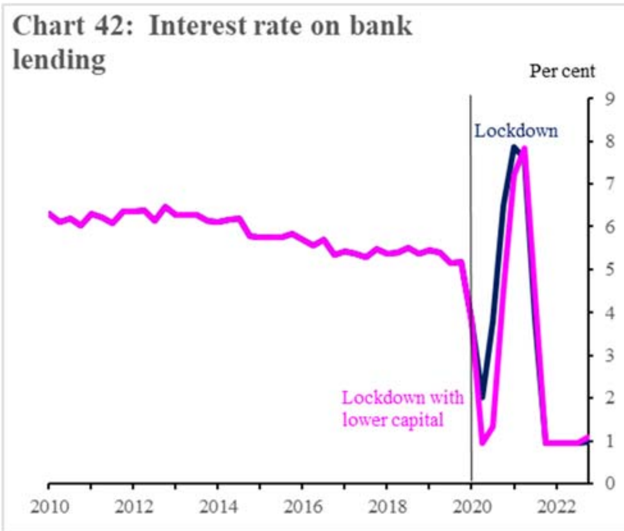
$$i_L = \frac{\Pi_B^T - i_{B,-1}B_{B,-1} + i_{B,-1}TFSME_{-1} + i_{D,-1}D_{-1}}{(1-npl)L_{-1} + Mort_{-1}} \tag{48}$$

As long as $i_B < i_D$, then a rebalancing of the banks' liabilities from deposits to the TFSME would result in a lower interest rate on loans and/or an increase in bank lending, as envisaged when the scheme was set up. Unfortunately, in our model the banks have no control over their deposits. This means that all that happens with the TFSME is that the Bank of England gives cash to the banks enabling them to buy the bills that the Bank of England is no longer holding since it has replaced bills with TFSME loans on its balance sheet. In future work, we intend to look at a model in which the ICPFs hold bills and banks alter their deposit rates so as to affect the relative demand for bills and deposits. At that point, we might expect the model to capture the desired effects of the TFSME.

7.4 Releasing the Counter-Cyclical capital Buffer (CCyB)

As we have noted above, the COVID lockdown shock puts pressure on the banks' holding of capital (Chart 28). This means that they have to raise the interest rate on their lending sharply to rebuild capital (Chart 29). In order to reduce this effect, the Bank of England's Financial Policy Committee (FPC) reduced the counter-cyclical capital buffer (CCyB) held by banks. The CCyB is a discretionary capital buffer applied by the Bank of England's Financial Policy Committee (FPC) to allow for UK bank capital requirements to be relaxed to absorb stress during a crisis. The FPC reduced the CCyB from 1% to 0% in March 2020. In our model, we examine the effects of permanently reducing the normal capital adequacy requirements of the banks from 14% to 13%. This lowers the banks' long-run target for their capital, which, in turn, enables them to lower their lending rates relative to previous. Chart 41 and 42 show the effects of this policy.





Relative to both the baseline and lockdown scenarios, releasing the CCyB results in the banks lowering the rate on loans to their minimum (the rate on bills), which is more than in the lockdown scenario. Relative to the lockdown scenario, this interest rate then increases less when the intervention is applied.

7.5 Loosening monetary policy

7.5.1 Reducing the Bank rate

At special meetings on 10 and 19 March 2020, the Bank of England Monetary Policy Committee (MPC) voted to reduce Bank Rate by 50 basis points to 0.25% and then by a further 15 basis points to 0.1%. In the model, we equate the Bank Rate with the interest rate on government bills and so reduce this rate to 0.1% from 2020 Q2 onwards. And, given the deposit rate is a simple mark-up on the rate on bills, deposit rates will fall by 65 basis points as well.

Within our model, changes in interest rates have little effect on consumption, investment or GDP. This is because consumption only depends on income and wealth and the elasticity of investment to interest rates was set to zero, in line with UK data. However, the cut in Bank Rate will lead to falls in the deposit and loan rates of banks as shown in Chart 43. The fall in bank deposit rates – by lowering banks' funding costs – enables them to increase their capital without having to raise loan rates by as much as they would otherwise.

Chart 43: Interest rates on bank deposits and bank lending

7.5.2 Quantitative Easing (QE)

At the special meeting on 19 March 2020, the MPC voted to increase the Bank of England's holdings of UK government bonds and sterling non-financial investment-grade corporate bonds by £200 billion. This was followed by announcements in June and November 2020 to purchase a further £100 billion and £150 billion respectively, taking the total purchases to £450 billion. In the model, we've applied these announced purchases across Q2, Q3, and Q4 2020.

QE involves the Bank of England buying bonds from the ICPF sector. We implement this in the model by shocking the central bank bond purchases equation:

$$BL_{BoE} = BL_{BoE,-1} + \varepsilon_{QE} \tag{49}$$

And, similarly, we shock the ICPF bond holdings equation:

$$BL_{ICPF} = \frac{A_{ICPF,-1}\left(\lambda_{2,0} - \lambda_{2,1} i_D + \lambda_{2,2} i_{BL} - \lambda_{2,e} E(r_k)\right)}{P_{BL}} - \varepsilon_{QE} \tag{50}$$

This leads to the ICPFs holding excess deposits (the residual asset for the sector). The increase in deposits leads to an increase in the demand for bank reserves, which are supplied by the central bank. This rise in reserves (a liability for the central bank) matches a portion of the rise in the central bank's bond holdings (an asset); the remaining increase in bond holdings is offset by a reduction in the central bank's holdings of bills. The reduction in the central bank's holdings of bills is matched by an increase in bank holdings of bills. The increase in banks' holdings of bills added to the rise in their reserves will then exactly match the rise in bank deposits. As a result, in our model, QE will have no real effects.

In reality, frictions in the government bond market will mean that the increased demand for bonds from the central bank will raise their price, ie, reduce longer-run interest rates, through the portfolio balance channel. And ICPFs, as a result of finding themselves with a higher proportion of their portfolios in deposits than they wanted will want to reallocate their portfolios and so increase their demand for bonds and other financial assets. This then raises the price of all 'similar' assets and lowering the cost of equity finance for firms. So, to examine the effects of the additional QE within our model we also reduce the long-run interest rate, i_{BL}, over 2020 in line with the UK data. That is, we set the rate to 0.5483 in 2020 Q1, 0.2636 in 2020 Q2 and 0.2234 in 2020 Q3 and subsequently. The effects of this shock – the cut in bond rates and the increase in central bank bond holdings – is shown in Charts 44 - 47. In each case, the solid lines denote the original lockdown scenario and the dashed lines denote a scenario with both the lockdown shock and the cut in bond rates/increase in central bank bond holdings

As shown in Chart 44, the reduction in bond rates leads to a slight fall in loan rates while having no effect on deposit rates (by assumption in our model). The reduction in bond rates raises bond prices by definition. But, the increase in QE also raises equity prices via the 'portfolio rebalancing' channel, as ICPFs seek to switch some of the enforced holdings of deposits into increasing their holdings of equities. This is shown in Chart 45. Charts 46 and 47 show that the falls in bond and loan rates and rise in equity prices lead to small increases in consumption, investment and GDP and also support employment, where the fall is much smaller than in the 'lockdown' scenario.

Chart 44: Interest rates

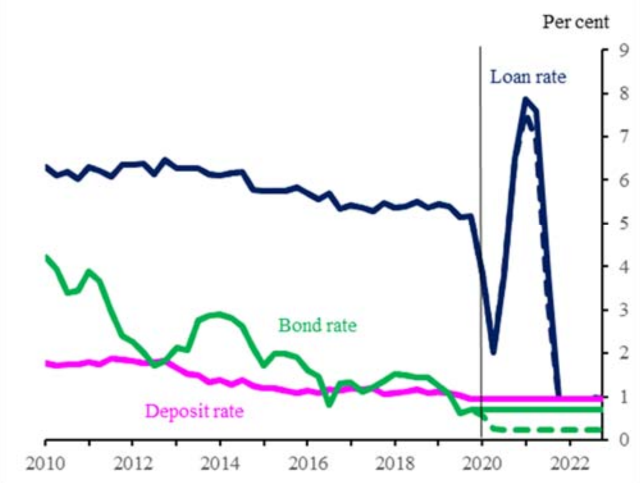


Chart 45: Bond and equity prices

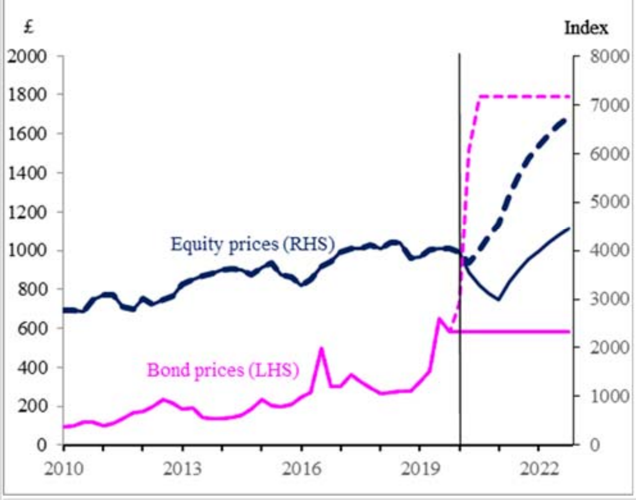


Chart 46: Effect of the increased government spending and transfers on real GDP, consumption and investment

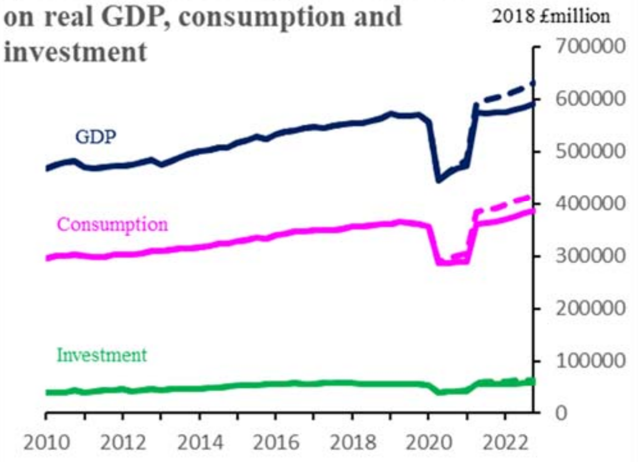


Chart 47: The employment rate

8 Conclusions

In this paper, we have examined the effects of the COVID-19 shock and the various policy responses that were put in place. We do this through the lens of a 'stock-flow consistent' model in which financial flows between the various sectors, and the effects of these flows on the stocks of financial assets and liabilities, are carefully tracked. Our exercise has demonstrated the usefulness of these models since we were able to directly incorporate most of the government policies and the channels through which they operated without having to appeal to unspecified 'frictions'.

Using our model, we constructed a benchmark counterfactual simulation that showed how we might have expected the UK economy to evolve in the absence of the COVID-19 shock. We then constructed an alternative counterfactual simulation where we attempted to model the direct effects of the lockdown imposed in response to the Public Health implications of COVID. By comparing these simulations, we found that the lockdown led to large falls in consumption, investment, output and employment together with a rise in inflation. Furthermore, absent any other policy interventions, the lockdown would have resulted in a large increase in non-performing loans that would have implied a fall in bank capital. This, in turn, would have led to large rises in bank lending rates, as banks sought to bring their capital back to target, and falls in bank lending. Finally, we found that the shock led to a large rise in net lending by households matched by an equally large rise in net borrowing by the government. Corporate net borrowing increased a little as did that of ICPFs; this was roughly matched by a rise in net lending by the banking sector.

To tackle the negative employment implications of the lockdown, the government implemented the Job Retention Scheme. Using our model, we found that this scheme went some way to maintaining employment through the lockdown. In addition, we found that the increase in QE, via its effect on bond rates, also acted to boost employment relative to where it would have fallen absent such an intervention. In addition to this scheme, the government supported consumption via the Self-employed income support scheme' and the economy more generally by increasing its own spending. The result was a small increase in consumption and output relative to what would have happened absent this intervention, but at the cost of an even larger rise in government net borrowing (and similar rise in household net lending).

On the monetary policy side, we found that the cut in the base rate from an already low rate had little impact on output and employment, though it did help reduce the rise in bank lending rates that we might have seen absent the intervention. The increase in QE, by reducing bond rates, did have a positive effect on consumption, investment, output and employment. It also led to increases in bond and equity prices as ICPFs sought to rebalance their portfolios.

Given that the banks' potential problems with capital resulted from non-performing loans, the government introduced the Coronavirus Business Interruption Loan Scheme and the Coronavirus Large Business Interruption Loan Scheme. By underwriting a proportion of the non-performing loans, the government was able to reduce the loss of bank capital through this channel, resulting in banks not having to raise lending rates anywhere near as high as would otherwise have been the case.

The model was able to assess the implications of these policies acting on bank capital, ICPF and central bank holdings of government bonds, etc, precisely because it is designed to analyse the determinants of financial flows between sectors and the resulting stocks of assets and liabilities. But, the model does have a number of important simplifications and assumptions that may have affected some of the results. Much of the dynamics of the model are driven by the long-run targets. It is possible that these may have changed in response to the COVID shock or, indeed, may have been changing as it was. We also assumed that prices were set as a fixed mark-up on normal historic unit costs. If the mark-up were endogenous, then the short-run inflation impacts of the COVID shock and the policy responses could be different. Similarly, if wage growth responded to the unemployment rate, then policies acting to reduce the rise in unemployment would also result in higher wage inflation, leading to positive feedback through prices.

Another limitation of our work is that we used a ‘closed economy’ model. As we showed, this limits our ability to fully explain financial flows across the five sectors we consider, particularly the banking sector. Including a Rest of the World sector would enable a more realistic calibration of the financial asset holdings in the model. It would also add interesting dynamics through imports, exports, the exchange rate and capital flows. Adding a wider range of financial instruments, such as corporate bonds, bank equities, and maturing government bonds would allow more nuanced dynamics from issuing sectors and a stronger effect from portfolio allocation decisions. Including a wider range of non-bank financial sectors, facing different regulatory constraints, and with a range of different behaviours and portfolios would enrich the portfolio allocation dynamics. And finally, including collateralised lending with marked to market collateral prices, such as repo, would enable important financial stability channels to be tested.

Another issue with our work is the lack of heterogeneity within sectors. Hetereogeneity within sectors, is an important driver of both model dynamics and real world policy choices. In particular, the large rise in household net lending that we saw in the United Kingdom in response to the COVID shock concealed a wider range of household experiences, with some households able to carry on as normal while others were really struggling to deal with the shock. Unfortunately, we were unable to pursue such differences in experience using our model. In addition, the CCFF and the TFSME schemes were both designed to target individual firms that were basically solvent, but needed funding to tide them over the COVID shock; something that we could not model given our level of aggregation.

In future work, we hope to begin to incorporate some of these important aspects of reality. But, that said, we feel that by using this style of model we were able to answer some important questions about the effects of the lockdown shock on financial flows and stocks as well as assess how the different government policy responses were able to mitigate these effects.

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Annex: Complete equation listing for the model

Households equations

Income and consumption decisions

$$YP = WB + Ann + Div_B + Div_{ICPF} + i_{D,-1}D_{H,-1}$$
$$\tau_H = \theta_H YP$$
$$YD = YP - \tau_H + T_H - r_{L.-1}Mort_{-1}$$
$$NW_H = NW_{H,-1} + YD + \Delta(P_{HSE}H) + \Delta V_B + \Delta V_{ICPF} - C - PI_H$$
$$nw_H = \frac{NW_H}{P}$$
$$C = Pc$$
$$c = \alpha_1(E(yd) + nl) + \alpha_2 nw_{H,-1}$$
$$E(yd) = (1+g)\Big(E(yd_{-1}) + \varepsilon\big(yd_{-1} - E(yd_{-1})\big)\Big)$$
$$yd = \frac{YD}{P} - \pi NW_{H,-1}$$

Mortgage and housing markets

$$I_H = \Delta H = gH_{-1}$$
$$GL = \eta(P_{hse}H)_{-1}$$
$$\eta = \big(g + \pi + \delta_{rep}\big)\frac{Mort_{-1}}{(P_{hse}H)_{-1}}$$
$$P_{hse} = (1+\pi)P_{hse,-1}$$
$$NL = GL - REP$$
$$Rep = \delta_{rep}Mort_{-1}$$
$$Mort = Mort_{-1} + NL$$
$$nl = \frac{NL}{P}$$

Asset allocation decisions

$$Pens_t = \rho YD_{-1}$$
$$ITR = ITR_{-1} + Pens$$
$$M = \lambda C$$
$$D_H = NW_H + Mort - P_{HSE}H - ITR - V_B - V_{ICPF} - M$$
$$NL_H = YD - C - PI_H$$

Firms equations

Output and investment decisions

$$y = E(s) + E(inv) - inv_{-1}$$
$$E(s) = (1+g)\Big(E(s_{-1}) + \varepsilon\big(s_{-1} - E(s_{-1})\big)\Big)$$
$$E(inv) = inv_{-1} + \gamma(\sigma_T E(s) - inv_{-1})$$
$$inv = inv_{-1} + y - s$$
$$k = k_{-1}(1 + g_k)$$
$$g_k = \gamma_0 + \gamma_u\frac{y}{k_{-1}} - \gamma_r r_L$$
$$I = (g_k + \delta)k_{-1}$$

$$\pi = \frac{P - P_{-1}}{P_{-1}}$$
$$r_l = \frac{1 + i_l}{1 + \pi} - 1$$
$$s = c + I + I_H + G$$
$$S = Ps$$
$$INV = inv * UC$$
$$GDP = S + UC\Delta inv$$
$$K = Pk$$

Pricing and costing decisions

$$ln(W) = ln(W_{-1}) + g + \pi_{-1}$$
$$N = N_{-1} + \eta_N \left(\frac{y}{pr} - N_{-1}\right)$$
$$pr = (1 + g)pr_{-1}$$
$$WB = W * N$$
$$UC = \frac{WB}{y}$$
$$NUC = \frac{W}{pr}$$
$$NHUC = (1 - \sigma_N)NUC + \sigma_N\left(1 + i_{L,-1}\right)NUC_{-1}$$
$$P = (1 + \varphi)NHUC$$

Financial implications for the firms

$$\Pi_F = S - WB + \Delta INV - i_{l,-1}INV_{-1} - \tau_F + T_F + i_{D,-1}D_{F,-1}$$
$$\tau_F = \theta_F\left(Y - WB - i_{l,-1}INV_{-1} + i_{D,-1}D_{F,-1}\right)$$
$$\Pi_{F,U} = \Pi_F - Div_F - i_{L,-1}(L_{-1} - INV_{-1}) + i_{L,-1}NPL$$
$$D_F = D_{F,-1}\frac{W}{W_{-1}}$$
$$L = L_{-1} + PI + \Delta INV - \Pi_{F,U} - P_v\Delta v_f - NPL + \Delta D_F$$
$$NPL = npl * L_{-1}$$
$$v_F = v_{F,-1} + (1 - \psi_U)\frac{P_{-1}I_{-1}}{P_v}$$
$$r_k = \frac{Div}{P_{v,-1}v_{F,-1}}$$
$$NL_F = \Pi_{F,U} - PI - \Delta INV$$

Government equations

$G = (1+g)G_{-1}$
$T_H = (1+g)(1+\pi)T_{H,-1}$
$T_F = (1+g)(1+\pi)T_{F,-1}$
$PSBR = PG + i_{B,-1}\left(B_{BoE,-1} + B_{B,-1}\right) + BL_{BoE} + BL_{ICPF} + T_H + T_F - \tau_H - \tau_F = -NL_G$
$B = B_{-1} + PSBR - P_{BL}\Delta BL$
$Debt = B + BL$

Bank of England equations

$\Pi_{BoE} = i_{B,-1}B_{BoE,-1} + BL_{BoE}$
$B_{BoE} + P_{BL}BL_{BoE} = R + M = M_0$
$P_{BL} = \frac{1}{i_{BL}}$
i_B, i_{BL} and BL_{BoE} are set exogenously
Bonds, reserves and cash are supplied on demand
Bank of England buys all the bills that it demands

Banks equations

Deposit rates, monetary and credit aggregates
Bank deposits, loans to firms and mortgages are supplied on demand
$R = \rho D$
$B_B = B - B_{BoE}$
$B_B = D + V_B - L - Mort - R$
$BLR = \frac{B_B}{D}$
$i_D = max\left(i_{D,-1} + \xi(z_1 - z_2), 0\right)$
$z_1 = 1$ if $BLR < bot$, 0 otherwise
$z_2 = 1$ if $BLR > top$, 0 otherwise

The determination of lending rates
$i_L = i_D + spread$
$V_{B,T} = V_{B,-1} + \beta_B\left(NCAR(L_{-1} + Mort_{-1}) - V_{B,-1}\right)$
$\Pi_{B,U,T} = V_{B,T} - V_{B,-1} + E(npl)L_{-1}$
$E(npl) = E(npl_{-1}) + \varepsilon\left(s_{-1} - E(s_{-1})\right)$
$Div_B = \lambda_B GDP$
$\Pi_{B,T} = Div_B + \Pi_{B,U,T}$
$\Pi_B = i_{L,-1}(L_{-1} + Mort_{-1} - NPL) + i_{B,-1}B_{B,-1} - i_{D,-1}D_{-1}$
$$spread = \frac{\Pi_{B,T} - i_{B,-1}B_{B,-1} + i_{D,-1}\left(D_{-1} - \left(1 - E(npl)\right)L_{-1} - Mort_{-1}\right)}{\left(1 - E(npl)\right)L_{-1} + Mort_{-1}}$$
$\Pi_{B,U} = \Pi_B - Div_B = NL_B$
$V_B = V_{B,-1} + \Pi_{B,U} - NPL$

ICPFs equations

$$Ann = \zeta ITR_{-1}$$
$$\Pi_{ICPF} = BL_{ICPF,-1} + i_{D,-1}D_{ICPF,-1} + Div_F - Ann_t$$
$$Div_{ICPF} = \lambda_{ICPF}GDP_{-1}$$
$$NL_{ICPF} = \Pi_{ICPF,t} - Div_{ICPF,t}$$
$$\Delta V_{ICPF} = NL_{ICPF} + BL_{ICPF}\Delta P_{BL} + v_F\Delta P_v$$
$$\Delta A_{ICPF} = \Delta ITR + \Delta V_{ICPF}$$
$$\frac{P_v \mathrm{v}_F}{A_{ICPF,-1}} = \lambda_{1,0} - \lambda_{1,1}i_D + \lambda_{1,2}i_{BL} + \lambda_{1,3}E(r_k)$$
$$\frac{BL_{ICPF}}{i_{BL}A_{ICPF,-1}} = \lambda_{2,0} - \lambda_{2,1}i_D + \lambda_{2,2}i_{BL} + \lambda_{2,3}E(r_k)$$
$$D_{ICPF} = A_{ICPF} - P_v\mathrm{v}_F - BL_{ICPF}$$
$$E(r_k) = E\left(r_{k,-1}\right) + \varepsilon\left(r_{k,-1} - E\left(r_{k,-1}\right)\right)$$