Monetary Policy and the Credit Rationing Effects of Liquidity

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Abstract

This paper studies monetary policy in a New Keynesian economy with frictional bank lending, rationalising evidence that lending conditions can remain tight despite liquidity injections. The model features a policy trade-off in which increases in banking sector liquidity can incentivise *more lending* by lowering the overnight rate and the marginal cost of funds, but can also incentivise *less lending* by compressing bank margins as interest rates approach the policy floor, worsening adverse selection and credit rationing. As a result, quantitative easing can exert a contractionary effect when the economy is away from the effective lower bound, with outcomes depending on borrower risk and the size of the programme. However, both channels raise inflation expectations, and so liquidity policies are always expansionary at the lower bound. An optimal policy analysis shows that internalising the credit-rationing externality modifies the standard policy trade-offs.

JEL: E5, E44, G21

Keywords: Monetary policy, quantitative easing, small business lending, credit rationing, bank liquidity

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1 Introduction

The toolkit of monetary policymakers has evolved considerably since the global financial crisis (GFC). In response to the effective lower bound on nominal interest rates, many central banks expanded their menu of policies to include forward guidance, asset purchasing programmes, negative interest rates, and liquidity policies aimed at supporting lending to the real economy.[1] While these balance-sheet policies are generally considered to have partially substituted for interest rate policy, a central challenge has been ensuring that the policy actions translate into improved lending conditions, particularly for small businesses. In practice, despite a sharp increase in banking sector liquidity after the GFC, euro area banks remained reluctant to lend to small businesses, even after the easing of the sovereign debt crisis. Figure 1 illustrates this disconnect, showing persistently sluggish loan growth (panel a) alongside a substantial and sustained rise in excess reserve balances (panel b).

This poses a puzzle as most macroeconomic theories of bank lending predict liquidity expansions to drive more lending and investment (see, e.g., Kashyap et al., 2002; Adrian and Shin, 2010; Carpenter et al., 2014), yet recent evidence suggests this is not always the case. For example, Diamond et al. (2024) find that bank reserve injections crowded out bank loans in the US, while Iyer et al. (2014) show that greater euro area liquidity from ECB balance sheet policies led to liquidity hoarding rather than increased small-business lending.[2]

In this paper, I rationalise this evidence using a New Keynesian macroeconomic model in which information frictions in small business lending interact with monetary policy implementation. The key mechanism is that policy-induced changes in bank profitability alter the opportunity cost of lending, generating endogenous credit rationing even in the presence of abundant liquidity.[3] The lending friction prevents banks from observing the risk characteristics of small firms in the economy, creating an adverse selection problem in credit markets. This generates a well-

[1]For example, the targeted longer-term refinancing operations (TLTROs) of the ECB `https://www.ecb.europa.eu/mopo/implement/omo/tltro/html/index.en.html`.

[2]Similarly, Acharya et al. (2019) find that the additional liquidity led to higher cash reserves and banks holding low-interest assets, but did not lead to more productive business lending. See also Gambacorta and Marques-Ibanez (2011), Joyce et al. (2011), Loutskina (2011), and Disyatat (2011).

[3]While some studies focus on bank conditions in affecting the bank-lending channel of monetary policy (see, e.g., Berger and Bouwman, 2009; Cornett et al., 2011; Martin et al., 2016), our focus follows evidence that adverse selection has been an important feature of European credit markets (see Albertazzi et al., 2021).

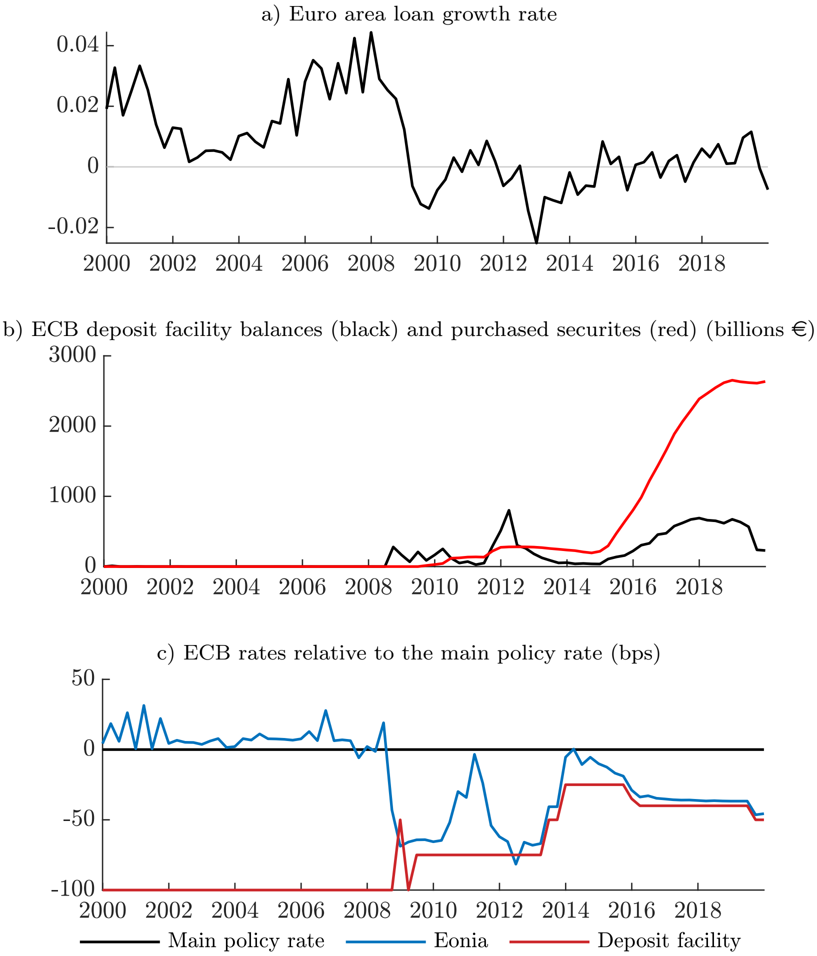

Figure 1: Source: ECB. Loans are those to euro area NFCs reported by MFIs. Purchases securities includes the stock of securities purchased as part of the various asset purchase programmes since 2009.

established effect, explored by Ikeda (2020) and Swarbrick (2023) in relation to the GFC, under which banks ration credit and build up excess reserves when firm risk is high. Crucially, this adverse selection channel links monetary policy implementation to lending incentives, with the interest rate corridor providing a margin by which policy affects the opportunity cost of lending and therefore the incentive to ration credit to small businesses.

An important implication is that a narrowing of the interest corridor, such as that caused by the ELB in the euro area (Figure 1, panel c), can increase the incentive to ration small business loans, offsetting the expansionary effects of low rates and the unconventional policy measures. This creates a tension whereby when the bank funding rate falls, activity may be stimulated through the standard interest rate channel, but lending incentives may simultaneously weaken as rates approach the floor, compressing net margins and increasing the relative attractiveness of holding reserves. This mechanism is supported by empirical evidence presented in Section 2, which shows that while central bank asset purchases and falling bank funding costs predict higher bank reserve balances and more lending in the euro area, a squeezing of the policy corridor is a significant and quantitatively important predictor of the opposite outcome.

Much of the large literature examining the links between liquidity and macroeconomic outcomes has focused on how private provision of liquidity can tighten during crises, amplifying shocks and motivating a stabilizing role for liquidity easing policies.[4] From this perspective, lending contractions can stem from banks facing liquidity crises arising from moral hazard (Holmström and Tirole, 1997; Gertler and Karadi, 2011; He and Krishnamurthy, 2013; Holden et al., 2020); maturity mismatch (Diamond and Dybvig, 1983; Allen and Gale, 1998; Diamond and Rajan, 2001; Farhi and Tirole, 2012); and the bank network structure or geographical dislocation (Allen and Gale, 2000; Elliott et al., 2014; Glasserman and Young, 2016). However, since this paper focuses on the rationing of credit to small businesses, the proposed model builds on Stiglitz and Weiss's (1981) work on adverse selection, which shows how credit markets can shut down due to information frictions.[5] The key contribution of this paper is to examine the role of liquidity and monetary policies when liquidity provision is abundant but lending remains constrained.

The approach of modelling information frictions faced by lenders relates to the literature studying the balance sheet channel of monetary policy (such as Bernanke et al., 1999; Christiano et al., 2005). Typically, models of financial frictions link monetary policy transmission to borrower balance sheets through a financial accelerator, whereby a monetary expansion raises asset prices and collateral values. In contrast, this model abstracts from the balance sheet channel. Here, the effects of a monetary expansion are ambiguous as they depend more critically on how the expansion is implemented and how it affects banking sector liquidity, bank balance sheet composition, bank profitability, and the opportunity cost of lending. The key issue is how the shock

[4]See, as key contributions from a very large literature, Bernanke and Gertler (1989), Kiyotaki and Moore (1997), Holmström and Tirole (1998), Adrian and Shin (2010), Gertler and Karadi (2011), Brunnermeier and Sannikov (2014).

[5]The model, which builds on Akerlof's (1970) seminal study on the lemons problem, has been extended in many papers in the years since, including, for example Bester (1985), Mankiw (1986), Williamson (1986), De Meza and Webb (1987), Besanko and Thakor (1987), House (2006), Ikeda (2020).

or policy action interacts with banks' incentive to ration credit.

It is the presence of private information that gives rise to banks, since a financial intermediary is required to produce information and screen potential borrowers (Ramakrishnan and Thakor, 1984; Bhattacharya and Thakor, 1993).[6] This leads to the prominent role of lending standards in shaping the transmission mechanism of monetary policy, consistent with recent evidence (e.g. Gründler and Scharler, 2025).

The theoretical model explicitly incorporates monetary policy implementation in the presence of information frictions. Banking sector liquidity is endogenous to macro-financial conditions, and banks may choose to hold excess reserves in equilibrium. Because of this, the interest rate paid on reserves affects bank profitability, liquidity demand, and ultimately lending behavior (see also Disyatat, 2011). While standard New Keynesian models abstract from implementation details and contain no endogenous excess reserves, this framework incorporates a corridor system explicitly and studies how its design affects equilibrium outcomes.[7]

Several existing studies explicitly examine the role of the interest rate corridor (see, e.g., Bindseil, 2000; Whitesell, 2006). These typically focus on trade-offs between interest rate volatility, interbank market activity, and monetary transmission under frictions such as interbank market search costs (Bech and Monnet, 2016) and balance sheet risk (Whitesell, 2006; Bindseil and Jabłecki, 2011). In contrast, this paper shows how the corridor affects lending conditions through a profitability channel, even in the absence of interbank frictions. The underlying mechanism is that the floor rate competes with risky lending as an alternative use of liquidity, and this trade-off shapes banks' willingness to intermediate.

By highlighting the profitability channel, the analysis also relates to recent work on the contractionary effects of negative interest rates within corridor systems (e.g., Abadi et al., 2023; Eggertsson et al., 2023), where binding deposit rate floors compress margins and weaken monetary policy transmission. In contrast, the channel here operates via adverse selection, providing

[6] We also allow for large firms in the model with no private information. These firms can raise finance efficiently using a bond market. In fact, the distinction between small and large firms in the model is unrelated to size as we assume all firms require a single unit of capital. Rather large and small firms are characterised by the presence of private information and un-diversifiable risk; two key characteristics of small businesses.

[7] Focus shifted away from money growth rules during the 1980s but there has been renewed interest since the ELB began constraining monetary policy in advanced economies. See, for example, Belongia and Ireland (2022).

a distinct profitability-based rationale for credit rationing as policy rates approach the floor.

This paper makes two main contributions to our understanding of monetary policy transmission in the presence of financial frictions. First, I provide novel empirical evidence on the relationship between the interest rate corridor and lending conditions in the euro area, documenting how corridor adjustments predict lending outcomes even controlling for standard policy measures. Second, I develop a theoretical framework that rationalizes why liquidity provision can fail to stimulate lending when information frictions are severe, highlighting that the design of monetary policy implementation itself becomes crucial for credit allocation.

The remainder of the paper proceeds as follows. Section 2 presents empirical evidence from the euro area on the links between the policy corridor and lending conditions. Section 3 develops the theoretical model, and section 4 derives key results and examines the quantitative implications. Section 5 derives optimal policy results in a simplified version of the model, and section 6 concludes.

2 Motivating evidence from the euro area

Focusing on the euro area is insightful for several reasons. The European banking sector plays an especially important role in providing credit to the real economy, with around 70% of business debt in the form of bank loans compared to 35% in the United States.[8]. Small and medium-sized enterprises are also relatively important for economic activity, accounting for around two thirds of private-sector employment in Europe versus around one half in the United States (see Carbo-Valverde and Rodríguez-Fernández, 2016). This highlights the systemic importance of bank lending for credit conditions faced by small firms.

The euro area is also a useful laboratory because the ECB's operating framework has generated rich variation in the return on reserves. The ECB's corridor is defined by the rates on its two standing facilities, the marginal lending facility (LF) and the deposit facility (DF), with the main refinancing operations (MRO) rate typically lying between them. In periods of abundant liquidity, the overnight market rate (Eonia) falls below the main policy rate, and the spread

[8]See Holm-Hadulla, Musso, Nicoletti and Tujula (2022) who also show these numbers were previously higher; 85% in Europe in 2008 and 50% in the U.S. See also Gambacorta, Yang and Tsatsaronis (2014)

between Eonia and the deposit facility rate becomes a key determinant of banks' outside option.** As a result, changes in the floor rate and the effective spread to the floor can affect lending incentives even when conventional policy rates move little (see Figure 1, panel c).[9]

In this section, we document a robust relationship between the spread to the floor and bank lending, controlling for macroeconomic conditions, credit risk, and ECB asset purchases. These patterns motivate the theoretical mechanism developed in the subsequent section.

2.1 Corridor Effects on Lending

To explore the relationship between the interest corridor and bank lending conditions, I estimate the following specification using monthly data between 2008–2019:

$$\ln X_t = \alpha_X + \beta_X s_t + \boldsymbol{\gamma}'_{\mathbf{X}} \cdot \mathbf{z}_t + u_{X,t} \tag{2.1}$$

for $X \in \{L, DF\}$, where L_t and DF_t are total euro area bank lending and excess reserves respectively, and s_t is either the corridor between the ECB's main refinancing rate and deposit facility rate, or the spread between the overnight market rate (Eonia) and the deposit facility rate.[10] $\mathbf{z}$ is a vector of controls including GDP, inflation, Eonia, credit risk, and ECB asset purchases.[11]

Table 1 reports the results. The central finding is that a 25 basis point wider ECB interest rate corridor predicts 2.2% higher lending and substantially lower excess reserve balances in the euro area.[12] Conditional on the market interest rate, a wider corridor predicts higher lending,

[9] The Federal Reserve did not operate an explicit corridor system, rather relied on open market operations to target the federal funds rate. Since 2008, the Fed began paying interest on excess reserves (IOER), moving towards a floor system. Other central banks including the Bank of England and Bank of Canada operated corridor systems and moved towards floor systems following the GFC, with corridor widths also subject to adjustment.

[10] Note that since October 2019, the ECB has targeted a new euro short-term rate, replacing Eonia (see Nicoloso and Tsonchev, 2019, Box 1, p.23).

[11] L_t is the stock of loans by monetary and financial institutions (MFIs) to non-financial institutions (NFIs) in the euro area; and DF_t is the total use of the central bank deposit facility. Controls include total euro area log nominal GDP and CPI (HCIP) inflation, the Eonia rate (source ECB), Gilchrist and Mojon's (2018) measure of credit risk of euro area NFIs, and the stock of total asset purchase programmes (APPs), which includes all securities held by the eurosystem for monetary policy purposes.

[12] This is the case controlling for economic activity (growth or level), financial risk, the short-term market interest rate (Eonia), inflation, and ECB asset purchases. The results are robust to dropping controls or additionally including the main policy interest rate and a time trend. Monthly data 2008M1–2019M12, where lending is measured as the loans vis-à-vis euro area NFCs reported by MFIs excl. ESCB, excess reserves is total balances at the ECB standing deposit facility, economic activity is log euro area GDP, and financial risk is proxied using Gilchrist and Mojon's (2018) spread between NFC rates and domestic sovereigns. See appendix **??** for details.

	a) $s_t \equiv R_t - \underline{R}_t$			b) $s_t \equiv R^*_t - \underline{R}_t$		
	$\ln DF_t$	$\ln L_t$	LS_t	$\ln DF_t$	$\ln L_t$	LS_t
s_t	-0.481^{***} (0.134)	0.0221^{***} (0.002)	2.367 (1.758)	-0.931^{***} (0.144)	0.0084^{**} (0.0038)	-3.769^{**} (1.825)
R^*_t	-0.497^{***} (0.025)	-0.0028^{***} (0.0005)	1.649^{***} (0.257)	-0.294^{***} (0.041)	-0.0041^{***} (0.0011)	2.654^{***} (0.506)
Obs	141	141	47	141	141	47
Adj. R^2	0.855	0.894	0.893	0.879	0.845	0.899

Notes: Standard errors in parentheses. Significance levels: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 1: Estimation results testing the impact of the ECB corridor width (Main Refinancing Rate R_t minus Deposit Facility Rate $\underline{R}_t$) and the spread to the floor (Eonia R^*_t minus Deposit Facility Rate), both measured per 25 bps, on bank excess reserves (ECB deposit facility use), bank lending to NFCs, and lending standards (net percentage of banks tightening or easing credit standards for SME loans). Excess reserves and lending regressions use monthly observations 2008M1–2019M12; lending standards regressions use quarterly observations over the same time period. Source: ECB. Excess reserves is use of the ECB Deposit Facility, lending is MFI loans to NFCs. Lending standards is from the ECB Bank Lending Survey.

pointing to the role of the interest on reserves in shaping banks' lending incentives. Conditional on the corridor, a 25 basis point higher Eonia rate predicts 0.3% lower lending volumes and much lower reserve balances, consistent with tighter liquidity conditions driving higher interbank rates.

Using quarterly bank-level balance sheet data over the same time period, I re-estimate specification 2.1 with bank fixed effects.[13] Table 2 shows similar results: a 25 basis point wider corridor predicts 1.8% higher contemporaneous lending, and 5.5% lower cash and reserve balances.[14]

2.2 The Eonia-Floor Relationship

The policy corridor is defined as the spread between the main policy rate and the interest on reserves. However, when there is surplus liquidity in the banking sector, the marginal bank funding cost—the overnight market rate (Eonia)—moves below the main policy rate. In this

[13] Bank-level balance sheet data is from S&P Global Market Intelligence (SNL Financial Fundamentals). Loans is 'Total Loans' and reserves is 'Cash and Reserve Balances'. We use all available data for banks operating in Austria, Belgium, France, Germany, Ireland, Italy, Netherlands, Portugal, Slovenia and Spain. Bank-level lending is first normalised by reporting as a ratio with the bank's average lending volume over 2008Q1–2019Q4. In order to ensure larger banks play a more important role, we use the size of the bank's balance sheet as a sampling weight in the estimation. We include country and bank fixed effects and cluster standard errors at the bank level.

[14] Further information and regression results reported in Appendix A. The lower impact on reserves is due to a broader category which includes physical cash and required reserves. The relative increases in reserves are consequently much more muted.

	a) $s_t \equiv R_t - \underline{R}_t$		b) $s_t \equiv R_t^* - \underline{R}_t$	
	$\ln Reserves_t$	$\ln L_t$	$\ln Reserves_t$	$\ln L_t$
s_t	-0.055^{***} (0.011)	0.0179^{***} (0.005)	-0.042^{**} (0.019)	0.0099^{**} (0.0039)
R_t^*	-0.0732^{***} (0.020)	-0.0163^{**} (0.007)	-0.0347 (0.025)	-0.0251^{***} (0.0073)
Obs	5804	4206	5804	4206
Adj. R^2	0.385	0.053	0.381	0.042

Notes: Standard errors in parentheses. Significance levels: $^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

Table 2: Estimation results testing the impact of the ECB corridor width (Main Refinancing Rate R_t minus Deposit Facility Rate $\underline{R}_t$) and the spread to the floor (Eonia R_t^* minus Deposit Facility Rate), both measured per 25 bps, on bank balance sheet data: 'Cash and balances with Central Banks' and 'Total Loans'. Source: Capital IQ: SNL Financial Fundamentals.

context, the key factor in determining lending conditions may be the spread between Eonia and the floor rather than the official corridor.

Section (b) in Tables 1 and 2 reports results using this alternative measure. The central results remain unchanged: a wider spread predicts lower reserve balances and higher lending volumes. A 25 basis point widening predicts 0.8% higher lending volumes using the aggregate data , and 1.0% higher lending volumes using bank-level data. Conditional on this spread, a higher Eonia predicts lower lending volumes, consistent with tighter liquidity conditions.[15]

The lending response is also reflected in survey evidence on credit standards. In Table 1 panel (b), higher lending is accompanied by an easing of lending standards, which is consistent with a lending mechanism operating through screening and selection considerations. This supports modelling information frictions as central drivers of bank lending conditions.

2.3 Threshold Effects and Competing Channels

These results reveal an important tension. When Eonia falls, perhaps due to quantitative easing increasing market liquidity, bank lending may rise as funding costs decline. However, if policy

[15]There is a negative but insignificant relationship between Eonia and reserve balances using bank-level data. This reflects two offsetting drivers of reserve balances: changes in the deposit rate (which move Eonia in the same direction) and asset purchases (which increase reserves while lowering Eonia).

rates remain unchanged, the spread between Eonia and the policy floor contracts, which our results suggest reduces lending. The overall impact on lending is therefore ambiguous.

To investigate this further, I estimate how the effect of Eonia on lending varies depending on how close Eonia is to the floor:

$$\ln L_t = \alpha_L + \beta_{L,s<\mathcal{S}} i_t R_t^* + \beta_{L,s>\mathcal{S}} \left(1 - i_t\right) R_t^* + \boldsymbol{\gamma}_{\mathbf{L}}' \cdot \mathbf{z}_t + u_{L,t} \tag{2.2}$$

where $i = 1$ when the spread is below threshold $\mathcal{S}$, and zero otherwise.[16] The rationale is that when the spread is low and the economy operates as a floor system, variation in the spread becomes more important for lending incentives.

Figure 2 shows the results across different threshold values. When the spread between Eonia and the floor is small (blue points), versus when it is large (red points), the effects of Eonia on lending differ markedly. The key finding is striking: when Eonia is far above the floor, changes in Eonia have no significant effect on lending. However, when Eonia is close to the floor (10-30 basis points above), a higher Eonia actually predicts higher lending volumes—the opposite of what standard theory would predict.[17]

The empirical exercises reveal the following stylised facts. First, conditional on the market interest rate, a narrowing of either the policy corridor or the spread between the market rate and the floor predicts lower bank lending and higher bank reserve balances. Second, conditional on the corridor, a lower interbank market rate predicts higher lending volumes. Third, when the market rate is close to the floor, a fall in the market rate predicts lower lending, consistent with a dominant profitability outside-option channel. Fourth, changes in lending volumes are accompanied by systematic movements in lending standards, consistent with screening responding endogenously to banks' incentives.

These facts can be understood through the lens of the theoretical framework developed in the next section. With information frictions in small business lending, quantitative easing that drives

[16] The controls are as before, except with the inclusion of the main policy interest rate, R_t, and the floor, $\underline{R}_t$.

[17] An alternative explanation is the reversal interest rate, explained by the zero-lower bound on household deposit rates and the negative effects on bank profitability when the marginal funding rate goes negative (see Abadi et al., 2023).

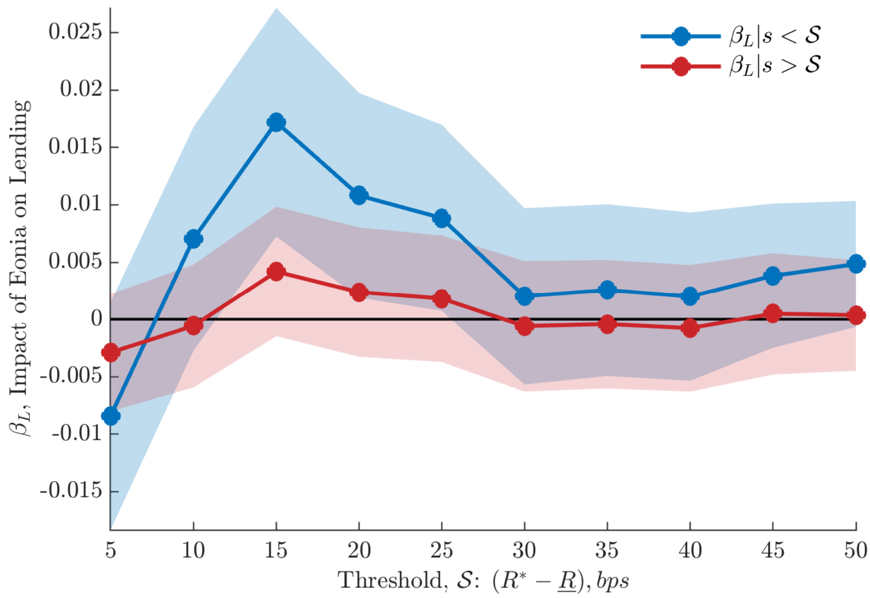

Figure 2: Estimated coefficients from specification (2.2) for a range of values of threshold, t. Shaded areas show the 95% confidence intervals.

a fall in Eonia generates two competing effects: the standard expansionary channel through lower bank funding costs, and a contractionary channel whereby reducing the spread to the floor disincentivises lending and can drive credit rationing. When Eonia is relatively close to the floor, this second channel becomes dominant.

3 A macroeconomic model of credit rationing

At the core of the model is a canonical New Keynesian (NK) closed economy model. In addition to the usual labour supply and consumption-savings decision, the representative household faces a portfolio choice problem. The household can choose to either deposit savings at a bank, S_t, purchase risk-free nominal bonds, B_t, or purchase firm equity, E_t, at price Q_t^E, to maximise

$$\mathbb{E}_t \sum_{s=0}^{\infty} \beta^s U(C_{t+s}, H_{t+s}),$$

subject to a nominal budget constraint

$$P_t C_t + S_t + B_t + Q_t^E E_t = R_{t-1} S_{t-1} + R_{t-1}^B B_{t-1} + W_t H_t + \text{profits},$$

where R_t and R_t^B are the nominal rates of interest earned on savings and bonds respectively, profits are nominal profits from the household-owned banks and payoffs from equity holdings. E_t is the new equity purchased and Q_t^E the nominal share price. The household consumption-savings decision and portfolio allocation is characterized by

$$1 = \mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \right] R_t, \tag{3.1}$$

where $\Lambda_{t,t+1} = \beta \frac{U'(C_{t+1})}{U'(C_t)}$, and where $R_t^B = R_t$ in equilibrium. Equity purchases will be characterized by zero-arbitrage condition which is outlined below. The labour supply condition equates the real wage with the marginal rate of substitution between consumption and leisure: $W_t/P_t = -U'(H_t)/U'(C_t)$.

A wholesale goods sector combines labour and purchases capital to produce a homogeneous intermediate good. This good is then sold to a retail sector under perfect competition. The retailers differentiate the intermediate good, selling their output under monopolistic competition subject to the Calvo (1983) price-setting friction.

Following Swarbrick (2023), the wholesale goods sector is characterised by information frictions in firm investment. This builds on two key assumptions. The first is that all investment projects require a single unit of productive capital for which firms need to raise a fixed quantity of external finance. This assumption ensures that firms rely on outside funding, but by treating all investment opportunities as a fixed size, we capture the inability of small firms being unable to diversify risk.

The second key assumption is that every period, each intermediate goods firm draws a project characterized by a production technology, productivity level and a risk profile. A proportion η of firms, denoted *corporates*, have a perfectly observable project and so are suitable for raising funds via a bond market. The remaining $1 - \eta$ firms have a privately observed project, a proportion λ

of which have no idiosyncratic risk (*safe*), whereas the remaining $1-\lambda$ have a risky project that will only succeed with probability p_t (*risky*).

Under a decentralized bond market, because all borrowers seek the same amount of finance, the only screening device to separate the risky and safe project holding firms is the interest rate. Either all firms would access funds at the same rate, or *safe* firms will be rationed when the interest rate is set higher than their expected return. The information asymmetry gives rise to a banking sector that can outperform bond markets by screening borrowers.[18]

Before turning to the problem facing the borrowers and lenders in the economy, we first outline details about monetary policy. We will differ from the standard NK model by giving the central bank three instruments. The first is the standard tool: the main policy target rate, R_t^{tr}, which the central bank charges for short-term liquidity operations. Second, the central bank can directly vary the amount of liquidity to influence the short-term market interest rate on household savings, R_t. This can be targeted through private sector bond purchases, or additional liquidity provision to the bank sector.[19] The third instrument is the interest rates on standing deposit ($\underline{R}_t$) and lending ($\overline{R}_t$) facilities.[20] Banks can hold excess reserve balances in the former and access additional liquidity as required via the latter.[21]

3.1 Banks

Bank assets consist of business loans and central bank reserves, while liabilities include central bank liquidity and household deposits. The composition of the liability side is addressed below. We begin by examining the asset side. To extend finance to firms, the banks can post the terms of a menu of loans that borrowers can choose on application.[22] Loans are single-period, with terms specifying both an interest rate and an approval probability. This flexibility allows banks to offer multiple loan options at different interest rates to separate borrowers. These options are designed

[18]Indeed, a major rationale for the existence of banks is to mitigate borrowers' financing frictions (see Flanagan, 2025).

[19]Either are equivalent as in equilibrium corporate bonds, household savings, and central bank loans to the banks will clear at the same interest rate.

[20]The first two instruments are implicitly the same, however to capture the policy tools used in practice, we model the implementation of the first via a Taylor rule, and the second to allow shifts of the market rate below the main policy rate towards the policy floor, $\underline{R}_t$.

[21]There is no regulatory reserve balance and so all bank reserve balances at the central bank are excess reserves.

[22]Because firm-type is drawn every period, it is not possible that banks learn the firm type over time and so credit terms are not a function of a firm's history.

as incentive-compatible, or self-selecting, contracts. For instance, a risky firm might accept a higher interest rate if it increases the probability of approval compared to a lower-interest loan.

Specifically, the lenders post contracts $c_t^i = \{\tau_t^i, x_t^i\}$ for $i \in \{s, r\}$, where τ_t^i is the nominal repayment rate, and x_t^i the financing, or approval probability. Letting R_t^i denote the gross nominal rate of return on capital for a type-i project and p_t the success probability of risky projects, lenders set contract terms subject to firms' individual rationality (IR) and incentive compatibility (IC) constraints. The relevant constraints can be written:

$$\mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\right]\tau_t^s \leq \mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}R_{t+1}^s\right] \tag{3.2}$$

$$\mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}p_{t+1}\right]\tau_t^r \leq \mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}p_{t+1}R_{t+1}^r\right] - \mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}p_{t+1}\left(R_{t+1}^r - \tau_t^s\right)\right]\frac{x_t^s}{x_t^r}. \tag{3.3}$$

The first constraint ensures the participation of safe firms by promising weakly positive surplus. The second provides an incentive for the risky firm to reveal their type, even choosing a higher interest rate loan. This is achieved through a higher probability of loan approval. When the lending contracts separate borrowers, therefore, safe loans have low repayment rates but a lower approval rate, while risky loans have a higher repayment rate but higher approval rate.[23]

The free entry of banks will imply a zero-arbitrage condition for the banking sector. Banks can enter, access liquidity at interest rate R_t in the form of nominal household deposits and one-period nominal loans from the central bank, and post loan contracts. Matching to firms is efficient and we assume to be proportional to the bank size, measured as the nominal size of the balance sheet.[24]

Denoting the volume of liquidity provision for bank j as S_t^j, the total volume of loans L_t^j, and the matched firms $f_t^j \equiv f_t S_t^j / \int S_t^j \mathrm{d}j$, the total *ex post* gross nominal rate of return to the representative bank is

$$\tilde{R}_{t-1}\left(S_{t-1}^j - L_{t-1}^j\right) + \left[\lambda x_{t-1}^s \tau_{t-1}^s + (1-\lambda)\, x_{t-1}^r p_t \tau_{t-1}^r\right](1-\eta)\, f_{t-1}^j Q_{t-1}^K, \tag{3.4}$$

[23] The implications of these contracts are discussed further in the next section.

[24] So a bank of twice the size of another will match with twice the number of firms. This is required in expectation, although matching could be risky. Match uncertainty would generate a role for the interbank market and is explored in a separate paper.

where $\tilde{R}_{t-1}$ is the marginal return on surplus liquidity, or cost of additional liquidity. When $S^j_{t-1} > L^j_{t-1}$, this is the interest on reserves, $\underline{R}_{t-1}$, and is otherwise the rate on the standing lending facility, $\overline{R}_{t-1}$. Without liquidity risk, if $\overline{R}_t > R_t$, banks will not use the lending facility in equilibrium, even if the banking sector is liquidity constrained. For this reason, we drop $\overline{R}_t$, focusing only on the reserves facility.

Each borrower will use the loan to purchase a single unit of capital at price Q^K_t. Therefore, total loans extended $L^j_t \equiv (1-\eta)\left(\lambda x^s_t + (1-\lambda)\, x^r_t\right) f^j_t Q^K_t$. Denoting the the loan supply-demand ratio $\phi^j_t \equiv \frac{S^j_t}{(1-\eta) f^j_t Q^K_t}$, the zero-profit condition will determine the equilibrium volume of banking sector liquidity:

$$1 = \mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \left(\underline{R}_t + \left[\lambda x^s_t \left(\tau^s_t - \underline{R}_t \right) + (1-\lambda)\, x^r_t \left(p_{t+1} \tau^r_t - \underline{R}_t \right) \right] \frac{1}{\phi_t} \right) \right] \tag{3.5}$$

where we drop the bank index j since it follows that ϕ_t must be equal for all banks. Given that bank liabilities are risk-free deposits but assets are risky loans, it is possible for there to be *ex post* profits or losses in equilibrium. When there are profits, the household will receive a dividend, recapitalising the banks when there are losses.

Given their current level of liquidity, the banks choose the loan contract terms to maximise the expected next-period real surplus by solving:

$$\begin{aligned}
&\max_{c^s_t, c^r_t} \mathbb{E}_t \left[\Lambda_{t,t+1} \left\{ \lambda x^s_t \left(\frac{\tau^s_t}{P_{t+1}} - \frac{\underline{R}_t}{P_{t+1}} \right) + (1-\lambda)\, x^r_t \left(p_{t+1} \frac{\tau^r_t}{P_{t+1}} - \frac{\underline{R}_t}{P_{t+1}} \right) \right\} \right] \\
&\text{s.t.} \quad 0 \le x^s_t \le x^r_t \le 1 \\
&\qquad\quad \lambda x^s_t + (1-\lambda)\, x^r_t \le \phi_t
\end{aligned} \tag{3.6}$$

and subject to constraints (3.2) and (3.3). The $x^r_t \ge x^s_t$ also follows from the IC constraints and the inequality constraint (3.6) is a liquidity constraint. ϕ_t is determined by equilibrium condition (3.5) and will be less than one if the demand for loans is greater than available bank liquidity. While there is no hard constraint on liquidity since banks can in principle always access additional liquidity, this stems from a profitability constraint whereby additional liquidity provision to finance lending comes at a higher interest rate.[25] This implies the possibility of effective liquidity constraints depending on macro-financial conditions and the monetary policy stance.

When constraint (3.6) is slack, then there is excess liquidity in the banking sector, banks hold excess reserves which are held in the central bank deposit facility. The solution to the bank's problem gives

$$\mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\left(p_{t+1}R^r_{t+1}-\underline{R}_t\right)\right]=\varrho_t-\psi_t\frac{1}{1-\lambda}+\varphi^r_t\frac{1}{1-\lambda} \tag{3.7}$$

$$\mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\left(\left(\lambda+\left(1-\lambda\right)p_{t+1}\right)R^s_{t+1}-\underline{R}_t\right)\right]=\varrho_t+\varphi^r_t-\varphi^s_t, \tag{3.8}$$

where ϱ_t is the Lagrange multiplier on the feasibility constraint, φ^s_t and φ^r_t those on x^s_t and $1-x^r_t$ respectively, and ψ_t is the Lagrange multiplier on $x^r_t-x^s_t$. These first-order conditions are also subject to complementary slackness conditions that include zero-lower bounds on the four Lagrange multipliers:[26]

$$\varphi^s_t,\varphi^r_t,\varrho_t,\psi_t\geq 0. \tag{3.9}$$

3.2 Intermediate goods firms

Intermediate goods firms draw their project type at the end of period t and seek external finance. If they draw an observable project, then they are characterised as a *corporate* and access funds in the bond market. Otherwise, as a *small firm*, they must apply for a bank loan. They may or may not be successful in securing funds; if firms are successful, they purchase the required unit of capital at nominal price Q^K_t, ready for production in the following period, otherwise, they must exit. New firms can enter but must pay fixed entry costs. Firm dynamics are illustrated in figure 3.

Of the funded risky projects, a proportion $1-p_{t+1}$ will fail in the next period before production

[25] In particular, this would be at the policy ceiling, $\overline{R}_t$. The profitability constraint ensures the lending facility is never used in equilibrium without a source of liquidity risk.

[26] This is the nominal version of the conditions derived using the real business cycle framework in Swarbrick (2023).

begins, with all capital lost. Success probability, $p_{t+1} \in [0, 1]$, is subject to aggregate risk. After production, the firm repays the loan, sells the depreciated capital back to the capital market at Q^K_{t+1}, and returns any surplus to the household.

We denote corporates, safe- and risky-project firms with superscript $i \in \{c, s, r\}$. A successfully funded project requires a single unit of capital that is converted into ω^i_t productive units where $\omega^r_t = 1/p_t > \omega^c_t = \omega^s_t = 1$.[27] The firm hires $h_t\left(\omega^i_t\right)$ units of labour and produces output using constant returns to scale technology,

$$y_t\left(\omega^i_t\right) = z_t\left[\omega^i_t\right]^{\alpha}\left[h_t\left(\omega^i_t\right)\right]^{1-\alpha}, \tag{3.10}$$

where aggregate total-factor productivity, z_t, follows a stationary stochastic process. Capital depreciates at rate δ, so the remaining capital after production will be $\omega^i_t(1-\delta)$. Denoting the final consumption good price P_t, the nominal market value of capital Q^K_t, and the wholesale good price P^W_t, we can write the real value of a successfully funded type-i firm as:

$$V^i_t = \max_{h_t\left(\omega^i_t\right)}\left\{\frac{P^W_t}{P_t}y_t\left(\omega^i_t\right) - \frac{W_t}{P_t}h_t\left(\omega^i_t\right) - \left(\tau^i_t\frac{Q^K_{t-1}}{P_t} - (1-\delta)\,\omega^i_t\frac{Q^K_t}{P_t}\right) + \bar{V}_t\right\}, \tag{3.11}$$

where τ^i_t is the aggregate-state indexed loan repayment rate and $\bar{V}_t$ represents the *ex-ante*, real continuation value of a firm, prior to drawing its type, given by:

$$\bar{V}_t \equiv \mathbb{E}_t\left[\Lambda_{t,t+1}\left(\eta V^c_{t+1} + (1-\eta)\left(\lambda x^s_t V^s_{t+1} + (1-\lambda)\,x^r_t p_{t+1} V^r_{t+1}\right)\right)\right], \tag{3.12}$$

which is a probability-weighted average of future values conditional on the next period project draw. The solution to (3.11) yields a labour demand condition that equates the real wage with the marginal product of labour,

$$\frac{W_t}{P_t} = (1-\alpha)\,\frac{P^W_t}{P_t}\frac{y_t\left(\omega^i_t\right)}{h_t\left(\omega^i_t\right)}, \tag{3.13}$$

where it follows that output per worker y^i_t/h^i_t and the efficiency capital-labour ratio ω^i_t/h^i_t will

[27] The assumption that $\omega^r_t = 1/p_t$ is not required but allows us to focus on the effects of risk, where a risk shock increases the default risk and the worsens the impact of the credit friction, but where there is no impact in the first-best economy.

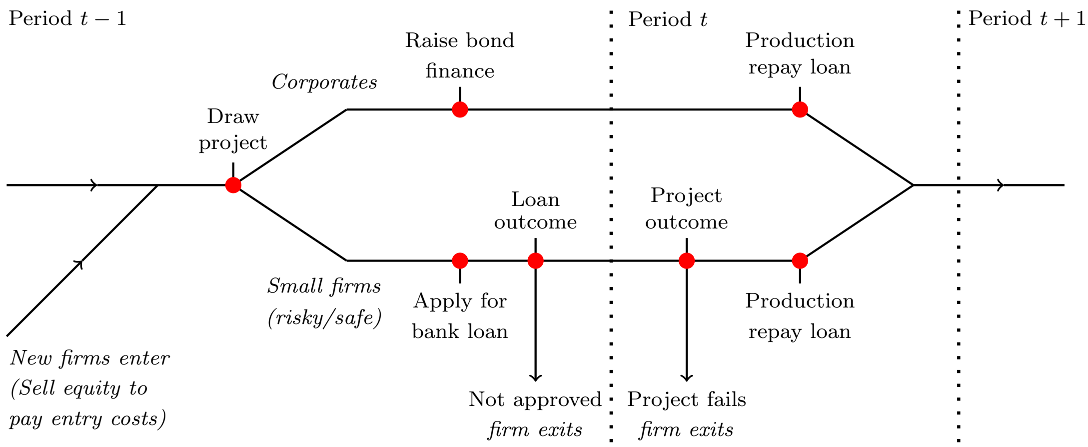

Figure 3: Firm dynamics.

be equal across all firms. We can then write the gross nominal return on capital used in the previous section as

$$R_t^i \equiv \frac{\alpha \frac{P_t^W}{P_t} y_t^i + (1-\delta)\, q_t^K \omega_t^i}{q_{t-1}^K} \Pi_{t-1,t}, \tag{3.14}$$

where $q_t^K \equiv Q_t^K / P_t$ is the real price of capital. Noting that the gross return on efficiency units of capital, $\alpha \frac{y_t(\omega_t^i)}{\omega_t^i} + (1-\delta)$, is equal for all firms, it follows that $R_t^r = \omega_t^r R_t^c = \omega_t^r R_t^s$.

3.2.1 Firm entry

Firms can earn positive profits due to the information asymmetry and because each firm is a fixed size, the number of firms in the economy will matter for aggregate outcomes. To model firm dynamics, we assume firms pay a small fixed cost equal to F units of the final good to enter. The entry cost is a fee paid to households (a rebate), so it does not absorb real resources and enters household income as a lump-sum transfer.

To pay the entry costs, firms sell equity to households at nominal price Q_t^E. Total equity purchases, E_t, corresponds to the number of new firms invested in, where each share is a claim on the future profit streams of an entering firm.

$$E_t = \left(f_t - \left(\eta + (1-\eta)\left(\lambda x_{t-1}^s + (1-\lambda)\, x_{t-1}^r\right)\right) f_{t-1}\right).$$

Under this assumption, new firms will enter until the expected discounted profits $\bar{V}_t$, given by equation (3.12), equals the entry cost F.

3.3 Retailers

Firms in the retail sector differentiate a homogeneous intermediate good purchased at price P_t^W into final retail goods which are sold under monopolistic competition. Following the standard approach, preferences for retail goods is characterized by constant elasticity of substitution between the differentiated goods indexed $j \in (0,1)$, for example for consumption goods:

$$C_t = \left(\int_0^1 [C_t(j)]^{\frac{\varepsilon-1}{\varepsilon}} \mathrm{d}j \right)^{\frac{\varepsilon}{\varepsilon-1}}. \tag{3.15}$$

For a given amount of total consumption, households choose the amount of each variety in order to minimize total expenditure, $P_t C_t = \int_0^1 P_t(j) C_t(j) \mathrm{d}j$. This leads to demand schedules $C_t(j) = (P_t(j)/P_t)^{-\varepsilon} C_t$ of which there are equivalent conditions for investment demand.

The retailers set their price to maximize the present value of future profits but do so subject to Calvo friction, whereby they face a fixed probability, ξ of being able to update each period. This leads to the usual conditions for the optimal price for price setters, P_t^*, and law of motion for inflation $\Pi_{t-1,t} \equiv P_t/P_{t-1}$, which are characterised by the usual NK Phillips curve. Price dispersion generates an output loss in aggregate, so that the total intermediate output is related to total retail output according to:

$$Y_t = \frac{1}{\Delta_t} \int_i y_t^i \mathrm{d}i \tag{3.16}$$

over intermediate goods firms indexed i.

3.4 Capital producers

To introduce capital adjustment costs, we assume that capital producers purchase final goods from the retailers, converting into investment goods, sold in perfect capital markets to firms. There is an open market for capital goods at the end of the period. Firms that secure funding seek to purchase enough capital to make up the required amount and exiting firms sell their remaining capital stock. Subject to the demand for capital and the market price, Q_t^K, capital producers purchase final retail goods, converting them into new capital goods to sell to firms under perfect competition. We assume that it is costly to adjust investment plans following Christiano et al. (2005), such that the representative capital producer seeks to maximise the stream of real profits:

$$\max_{I_t} \sum_{s=0}^{\infty} \mathbb{E}_t \left[\Lambda_{t,t+s} \left(q_{t+s}^k I_{t+s} \left[1 - s\left(\frac{I_{t+s}}{I_{t-1+s}} \right) \right] - I_{t+s} \right) \right] \tag{3.17}$$

We assume a quadratic form of the cost function, so

$$s\left(\frac{I_t}{I_{t-1}} \right) = \frac{\phi}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \tag{3.18}$$

from which we arrive at a first-order condition that determines investment in period t

$$1 = q_t^K \left(\left[1 - \frac{\phi}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right] - \phi \left(\frac{I_t}{I_{t-1}} \right) \frac{I_t}{I_{t-1}} \right) + \mathbb{E}_t \left[\Lambda_{t,t+1} q_{t+1}^k \phi \left(\frac{I_{t+1}}{I_t} - 1 \right) \left(\frac{I_{t+1}}{I_t} \right)^2 \right].$$

Because $\omega_t^r = 1/p_t$ and $\omega_t^c = \omega_t^s = 1$, in aggregate, the total units of capital sold is equal to the efficiency units in production, and therefore, the aggregate capital stock evolves according to:[28]

$$K_t = (1-\delta) K_{t-1} + I_t \left[1 - \frac{\phi}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right]. \tag{3.19}$$

3.5 Market clearing and aggregation

Labour market clearing implies that total labour demanded by the three types of firm will equal the labour supplied by households, H_t. The perfect labour market implies that all firms will choose the same efficiency-capital-labour ratio and so, giving the capital markets clearing condition as

$$K_t \equiv \left[\eta + (1-\eta) \left(\lambda x_t^s + (1-\lambda) x_t^r \right) \right] f_t, \tag{3.20}$$

[28] In principle, it could be that the supply of capital outstrips the firms' demand for capital, were a credit crunch to occur to such an extent that demand for capital drops dramatically and future supply is constrained sufficiently. In this case, the capital producer could stored the capital instead and would occur if $q_t^K < \mathbb{E}_t \left[\Lambda_{t,t+1} q_{t+1}^k \right]$, so the current real price of capital is less than the future discounted real price. This condition is not met in any simulations.

we can write the aggregate labour demand equation

$$\frac{W_t}{P_t} = (1-\alpha)\, MC_t z_t \left(\frac{K_{t-1}}{H_t}\right)^{\alpha}.$$

where $MC_t \equiv P_t^W / P_t$ is the real marginal cost in the retail sector. We can likewise give an aggregate intermediate good production function as

$$Y_t^W \equiv \int_i y_t^i \mathrm{d}i = z_t K_{t-1}^{\alpha} H_t^{1-\alpha} \tag{3.21}$$

Finally, the goods market clears, implying the aggregate resource constraint

$$Y_t = C_t + I_t. \tag{3.22}$$

3.6 Monetary policy

A central bank can adjust the supply of liquidity in the economy in order to target the short-term rate, R_t. Denoting the total supply of liquid assets in the economy S_t, the central bank is able to engage in open market operations to perfectly target the market clearing interest rate, R_t.

Unlike the standard New Keynesian economy on which we build, the amount of liquidity in circulation affects the market interest rate through bank balance sheet and profitability constraints.[29] Suppose that the central bank increases the supply of liquidity through the purchase of corporate bonds. In the standard model, swapping one type of riskless asset (corporate bonds) for another (central bank reserves) would make no difference. However, here the central bank is replacing a higher interest earning bonds with lower interest rate reserves. In this case, the bond market will only clear at a lower interest rate, shifting the market interest rate down. Any central bank profits are immediately paid out to households.[30]

[29] A link between money volumes and interest rates can exist in the textbook case can be introduced via money in the utility. See, e.g., Galí (2015).

[30] Exactly equivalently is providing liquidity through central bank refinance operations, providing short term loans to the banking sector. In equilibrium, the interest on this liquidity will equal the rate paid on corporate bonds and household savings. Increasing liquidity provision will change the balance sheet position of banks, increasing the share in very low return reserves and so will only clear the money markets at a lower market interest rate.

To distinguish between the central bank interest rates, we assume that the main policy interest rate set to satisfy a Taylor-type rule:

$$\log\left(R_t^{tr}\right) = \log\left(\frac{\Pi}{\beta}\right) + \gamma_\pi\left(\pi_{t-1,t} - \pi^*\right) + \gamma_y\left(y_t - y^*\right) \tag{3.23}$$

where $\pi_{t-1,t} \equiv \log\left(\Pi_{t-1,t}\right)$ and $y_t \equiv \log\left(Y_t\right)$, and the asterisks indicate a policy targets. In addition to the main policy interest rate, the central bank has two further tools. The first is the interest rate paid on the reserve facility. For now, we set this equal to the main policy interest rate minus a desired corridor.

$$\underline{R}_t = R_t^{tr} - c_t \tag{3.24}$$

The second additional policy are liquidity operations that separately move the market interest rate below the main policy interest rate. While this is essentially the same instrument as the main interest rate, we characterize the departure from the Taylor rule as a quantitative easing policy, whereby the market interest rate will move below the main policy rate towards the floor. This policy determines the spread between the main policy interest rate and the market interest rate:

$$R_t = R_t^{tr} - q_t \tag{3.25}$$

Having outlined the model, we turn to discussing the model's key implications and some analytical results.

4 Monetary Policy Transmission: Mechanisms and Quantitative Results

This section characterises how bank lending incentives depend jointly on macro-financial conditions and monetary policy. Theses incentives give rise to three equilibrium lending regimes, distinguished by whether banks finance all loan applications, face binding liquidity constraints, or actively ration credit.

A key implication is that liquidity policies operate through two competing channels: a standard expansionary demand channel and a contractionary credit-rationing channel that works through banks' lending incentives. Which channel dominates depends on risk and profitability conditions, and policy can shift the economy across regimes.

We first characterise equilibrium loan contracts and identify the three regimes. We then illustrate the steady-state thresholds using comparative statics, and finally quantify the competing channels using impulse responses simulations.

4.1 Loan contracts and equilibrium regimes

The bank first-order conditions (3.7) and (3.8) together with the (binding) IC and IR constraints, (3.3) and (3.2) imply a menu of loan contract specifying the loan repayment, τ_t^i, and loan approval probability, x_t^i.

Proposition 1 *If $x_t^s > 0$ ($\varphi_t^s = 0$) then $x_t^r = 1$ ($\varphi_t^r > 0$) in equilibrium.*

Proof See online appendix ?.

Unless there is full rationing of safe firms, the approval rating on risky loans is 1 and all risky firms are funded. It follows that when banks wish to tighten lending standards due to changing macro-financial conditions, increased default risk for instance, they do so on price on risky loans and approval probability on safe loans.[31] This also implies that credit rationing will occur on safe loans (good types) rather than risky loans (bad types).

The bank first-order conditions, together with the firm and bank entry conditions, determine the equilibrium level of bank sector liquidity and potential mismatch in loan supply and demand.

Proposition 2 *Banks never use the central bank standing lending facility if $\overline{R}_t > R_t^{tr}$. However, banks will use the deposit (reserve) facility in equilibrium.*

Proof See online appendix ?.

[31] This is consistent with evidence presented in Swarbrick (2023). Probit regressions using UK SME lending data reveal that low and average risk loans experienced lower approval rates during periods of credit tightening, whereas above average risk loans did not.

Proposition 2 formally established that without a source of liquidity risk, the banks will never resort to using the central bank lending facility if this charges a higher interest rate than the main liquidity operation. So it truly is a last resort facility. However, despite coming at a cost of lowering bank profitability, surplus liquidity can routinely arise in equilibrium and banks can hold excess reserves. This stems from a free entry condition in the banking sector. Providing liquidity has positive expected value, more will be demanded until the zero-profit condition holds. The opportunity cost of funds $\tilde{R}_t$ is equal to the interest on reserves $\underline{R}_t$.

While the banking sector can hold excess liquidity and provide enough loans to fulfill all firm financing needs, there are two other possible equilibrium outcomes. Either banks can become liquidity constrained when the marginal cost of funds exceeds the marginal return on lending, or banks can ration credit when the marginal information rent to risky firms exceeds the marginal revenue from safe loans.

Proposition 3 *There is no credit rationing in equilibrium if*

$$\mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \left(\lambda \left(R^s_{t+1} - \underline{R}_t \right) - (1-\lambda)(1-p_{t+1}) R^s_{t+1} \right) \right] > 0 \tag{4.1}$$

Using this threshold, we can identify three distinct regimes:

1. ***Abundant liquidity****: there is full approval under a pooling equilibrium ($\tau^s_t = \tau^r_t$ and $x^s_t = x^r_t = 1$) in which all firm financing needs are met if 4.1 is satisfied and:*

$$\mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \left[1 - (1-\lambda)(1-p_{t+1}) \right] R^s_{t+1} \right] \geq 1 \tag{4.2}$$

2. ***Scarce liquidity****: there is restricted lending due to binding liquidity constraints under a separating equilibrium ($\tau^s_t < \tau^r_t$ and $x^s_t < x^r_t = 1$) in which not all firms are financed if 4.1 is satisfied and:*

$$\mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \left[1 - (1-\lambda)(1-p_{t+1}) \right] R^s_{t+1} \right] < 1 \tag{4.3}$$

3. ***Credit rationing****: there is restricted lending due to credit rationing if*

$$\mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\left(\lambda\left(R^s_{t+1}-\underline{R}_t\right)-(1-\lambda)\left(1-p_{t+1}\right)R^s_{t+1}\right)\right]=0 \tag{4.4}$$

Proof See online appendix ?.

Corollary 1 *The incentive to ration credit* ***rises*** *in: the share of risky firms, $1-\lambda$; the interest rate on reserves, $\underline{R}_t$; and the expected risky firm default rate, $1-p_t$. Given policy rates, the credit rationing incentive always* ***falls*** *in the return on capital, R^s_{t+1}, if $\lambda>(1-\lambda)(1-p_t)$.*[32]

Corollary 2 *Under non-rationing, the likelihood of liquidity constraints binding rises in the expected risky firm default rate, $1-p_t$, and the firm share of risky firms, $1-\lambda$*

In order to unpack proposition 3, first note from IC constraint (3.3), that the information rent earned by risky firms is equal to:

$$\mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\left(1-p_{t+1}\right)R^s_{t+1}\right]x^s_t, \tag{4.5}$$

which increases in the number of safe loans made. The credit rationing condition (4.4) is the difference between the marginal revenue from issuing a safe loan, $\lambda\left(R^s_{t+1}-\underline{R}_t\right)$, and the marginal cost from the resulting increase in the information rent. Once this cost outweighs the revenue, due to high default risk or high return on reserves, the banks will begin to ration credit until the marginal revenue and cost are equal.

The point at which rationing occurs depends both on how risky small business lending is but also on the interest on reserves since this determines the value of liquidity, or the opportunity cost of lending. As this rises, the incentive to ration credit increases and bank holdings of excess reserves rise.

Two features of this mechanism are worth emphasising. First, credit rationing emerges as a profit-maximising response, rather than as a consequence of insufficient funding. Banks are never mechanically constrained in their access to liquidity: they can always expand their balance

[32] This holds if the number of safe firms in the economy outnumber the number defaulting risky firms. This condition will be satisfied under any reasonable calibration.

sheets by holding additional reserves. Instead, lending is tightened because the opportunity cost of financing loans rises relative to holding reserves.

Second, this distinction clarifies the interpretation of "scarce liquidity" in the model. Scarcity arises for the real economy, not for banks. When lending margins are compressed, either by elevated borrower risk or a high policy floor, banks optimally reallocate their balance sheets away from loans and towards reserves. Aggregate bank liquidity may increase, yet the volume of credit extended to firms decline.[33]

Finally, Proposition 3 highlights a channel through which excess reserves can arise even in low-risk environments. When firm entry costs are high and default risk is low, information rents are small and a pooling equilibrium emerges. However, low firm profitability discourages entry, reducing aggregate loan demand. In this case, bank liquidity exceeds profitable lending opportunities, and banks optimally hold excess reserves despite the absence of severe informational frictions. Excess liquidity therefore reflects weak loan demand rather than impaired loan supply, and is associated with a larger investment wedge driven by subdued firm entry rather than by credit rationing.

These results establish that both liquidity constraints and credit rationing are equilibrium outcomes shaped jointly by macro-financial risk and monetary policy. The policy floor plays a central role by governing the opportunity cost of lending, but the allocation of liquidity between loans and reserves is ultimately determined by bank profitability and lending incentives, rather than the availability of funds.

4.2 Comparative statics

Figure 4 provides a steady-state illustration of the lending regimes characterised in Proposition 3. It shows how equilibrium outcomes vary with borrower risk and the width of the policy corridor, defined as the spread between the main policy rate and the interest on reserves. Movements along either dimension shift banks' lending incentives by altering the profitability of extending loans

[33]This departs from the standard banks-as-intermediaries view. A reduction in lending therefore does not translate one-for-one into an increase in reserves: because reserves yield a lower return than loans, substituting away from lending reduces bank profitability and limits balance-sheet expansion. A $1 fall in lending will therefore typically lead to an increase in reserves of less than $1.

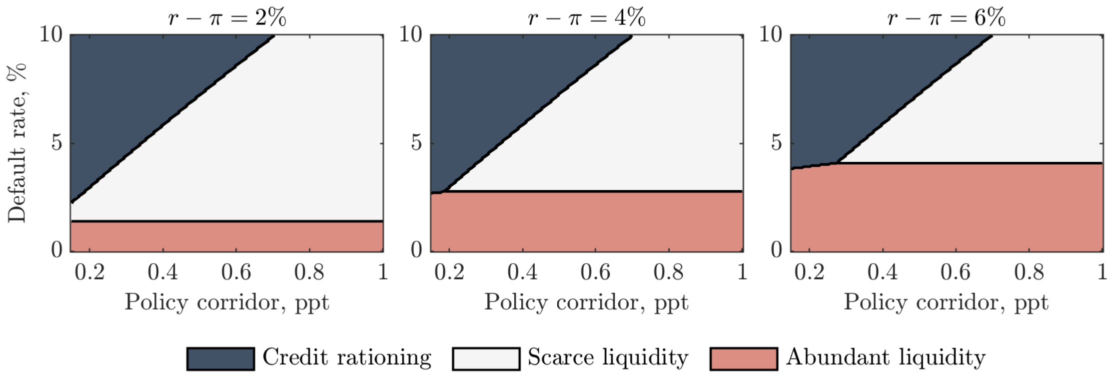

Figure 4: Comparative statics showing the role of risk (risky firm default rate), the policy corridor and the steady-state real interest rate. Other parameter values: $\eta = 0.5$, $\lambda = 0.775$, $F = 0.15$, $\beta = 0.9951, 0.9902, 0.9655$.

relative to holding reserves, generating transitions between abundant liquidity, scarce liquidity, and credit rationing.

In addition to borrower risk and the policy corridor, the three regions depend only on a small set of structural parameters. The overall share of small firms in the economy, $1 - \eta$, plays a minor role, whereas the composition of small firms between safe and risky types, $1 - \lambda$, is central. A higher share of risky firms worsens adverse selection, raising expected information rents and increasing the likelihood of credit rationing. The remaining parameters determining the steady-state regime are the discount factor, β, and firm entry costs, F, both of which govern the profitability of firm entry and therefore the demand for credit.

The effect of varying β is illustrated across the panels of figure 4. A higher discount factor raises the present value of future firm profits and encourages entry for a given entry cost, increasing the demand for external finance. As a result, higher β (or lower F) makes binding liquidity constraints and credit rationing more likely, shrinking the region in which a pooling equilibrium with abundant liquidity emerges. Secular declines in real interest rates therefore influence steady-state investment and output not only through standard intertemporal substitution, but also by affecting firm entry and lending conditions. When firm entry is low and liquidity abundant, lower real rates stimulate entry and investment. When risk is high and lending conditions are already tight, however, lower real rates can tighten effective liquidity constraints. Long-run growth effects

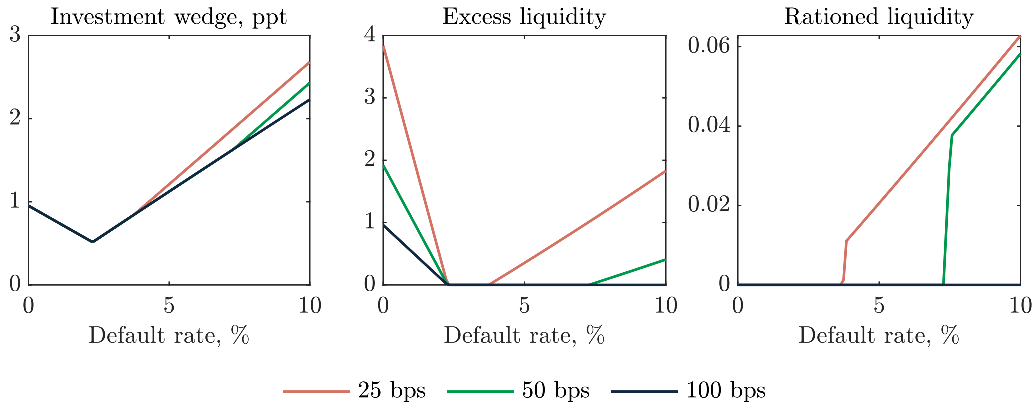

Figure 5: Comparative statics showing the role of risk (risky firm default rate) and the policy corridor on key macro-financial outcomes. Parameter values: $\eta = 0.5$, $\lambda = 0.775$, $F = 0.15$, $\beta = 0.992$.

therefore depend on prevailing macro-financial conditions.

Figure 5 illustrates how the regimes map into macro-financial outcomes. Although average loan approval rates are lower when liquidity is scarce (the white region in Figure 4) than when liquidity is abundant (the red region), macroeconomic performance need not be worse. In the abundant liquidity region, low default risk and low information rents imply weak firm profitability and subdued entry. This reduces aggregate investment and capital accumulation, generating a positive investment wedge and lower steady-state output. In contrast, when liquidity constraints bind, higher firm entry raises investment and output potential, even though not all firms receive funding.

More generally, inefficiencies can arise on either side of the regime boundaries. When liquidity constraints bind, productive firms remain unfunded because the marginal cost of funds exceeds the marginal return on lending. When liquidity is abundant, banks optimally hold excess reserves because profitable lending opportunities are scarce, reflecting weak loan demand rather than impaired loan supply. The investment spread is minimised at the boundary where condition (4.1) is satisfied and the pooling condition (4.2) binds. Monetary policy can directly influence the former through the policy floor, but cannot affect the latter in steady state, as it is determined by secular features such as firm entry costs and the long-run real interest rate.

Monetary policy plays an asymmetric role across these margins. By lowering the policy floor or widening the corridor, policymakers can directly affect the credit rationing threshold by reducing the opportunity cost of lending. However, steady-state liquidity constraints are determined by secular factors such as the natural rate of interest and firm entry costs, and cannot be eliminated through interest rate policy alone. Figure 5 highlights this distinction by tracing the risk threshold implied by (4.1): a lower interest on reserves shifts this threshold outward, allowing the economy to sustain higher borrower risk without triggering credit rationing.

4.3 Liquidity policies: two channels

We now study the transmission of liquidity policies in the presence of the three lending regimes. We model a quantitative easing (QE) programme as an open-market operation that increases reserve balances and pushes the overnight market rate R_t below the main policy rate R_t^{tr}, towards the policy floor $\underline{R}_t$.[34] In the baseline simulations, the policy is implemented as an unexpected, temporary reduction in R_t of 25 basis points (annualised), corresponding to a move halfway from the policy rate to the floor, and following an AR(1) process with persistence of 0.75. Although this resembles a conventional rate cut from the perspective of households, because it lowers the market interest rate, it also alters banks' incentives by compressing the spread between the return on lending and the interest on reserves.

In the model, QE therefore operates through two competing channels. The first is the standard *expansionary* demand channel: a fall in R_t raises consumption and increases the incentive to invest. The second is a *contractionary* credit-rationing channel: by moving R_t closer to $\underline{R}_t$, the policy increases the opportunity cost of funding loans (relative to holding reserves), lowering banks' lending incentives and worsening the adverse-selection friction. When this channel dominates, banks ration credit, optimally reducing approval rates for safe loans. This causes credit spreads to rise, and investment falls even though household demand strengthens.

To evaluate the dynamic implication of the policy, we simulate the model under the King, Plosser

[34]This pattern is consistent with the empirical response of short-term market rates to asset purchase programmes; see Figure 1.

Parameter	Description	Value
β	Household discount factor	0.992
σ	Coefficient of relative risk aversion	1
χ	Consumption–leisure weight	$\bar{H} = 1/3$
α	Capital share in production	0.30
δ	Capital depreciation rate (quarterly)	0.023
ξ	Calvo price stickiness	0.75
ζ	Elasticity of substitution across goods	7
γ_π	Taylor rule inflation coefficient	1.5
γ_y	Taylor rule output gap coefficient	0.25
π^*	Inflation target (quarterly)	0.005
$\underline{R}$	Policy floor relative to policy rate (annualised)	-50 bps
η	Share of corporate firms	0.50
λ	Share of safe small firms	0.775
F	Firm entry cost	0.15
$\bar{p}$	Steady-state risky firm default rate (annual)	6%
ϕ_K	Investment adjustment cost parameter	0
h	Habits in consumption	0.5

Table 3: Baseline parameter values

and Rebelo (1988, KPR) class of utility with external habits in consumption:[35]

$$U(C_t, H_t) = \frac{\left(\left[C_t - h\bar{C}_{t-1}\right]^{1-\chi}(1-H_t)^{\chi}\right)^{1-\sigma}}{1-\sigma} \tag{4.6}$$

and a standard New Keynesian calibration (Table 3). For the new parameters, we set $\eta = 0.5$ so half of firms are corporates, set $\lambda = 0.775$ and $F = 0.15$, and unless otherwise stated, set the steady-state annual risky firm default rate to 6% ($\bar{p} = 0.985$). We focus on the role of borrower risk and the size of the liquidity programme, since these are the key determinants of whether the economy remains in the non-rationing region or crosses into the rationing regime.

Figure 6 compares impulse responses to the same QE shock in two economies that differ only in steady-state borrower risk. In the low-risk economy, the programme behaves like a conventional expansionary monetary policy shock. A lower R_t raises aggregate demand through the usual intertemporal-substitution channel, increasing consumption and investment. Lending standards remain unchanged because the economy stays away from the rationing threshold, so the demand

[35]Habits in consumption mainly affect the persistence of aggregate demand and have little impact on the transmission of liquidity policies away from the effective lower bound. When nominal rates are constrained, however, they become quantitatively relevant by generating more persistent declines in demand following adverse shocks.

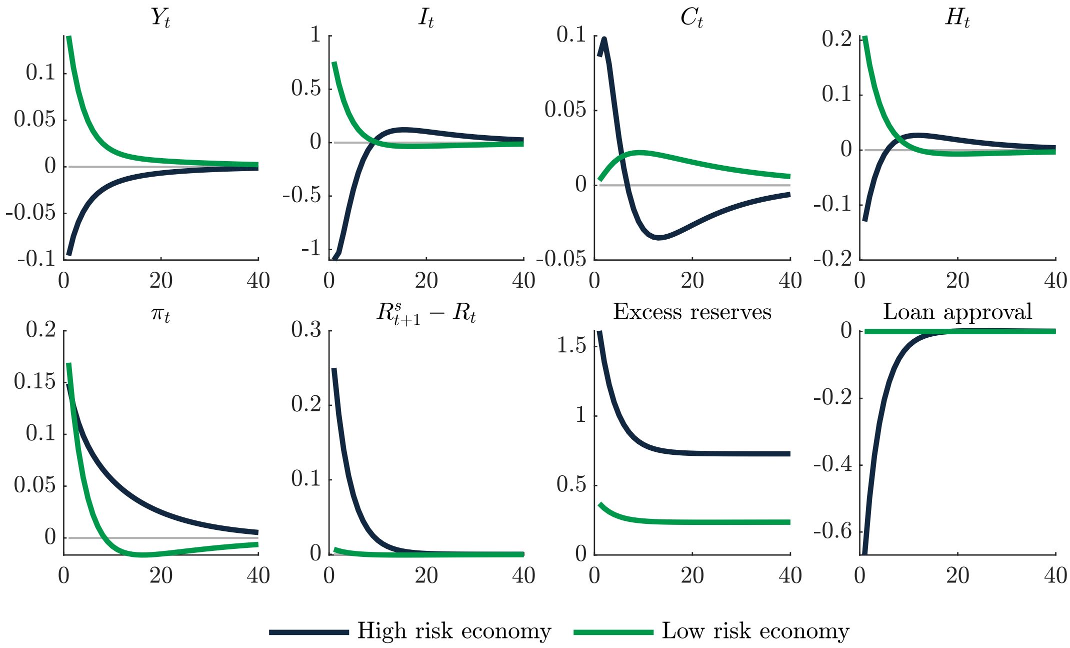

Figure 6: Impulse response functions to an unexpected temporary 'QE' programme. Plots in the top row show % deviation from steady state. The bottom row shows ppt deviation except for excess reserves with plots the level response. Excess reserves is given as the ratio of reserves to stock of loans. Per annum risky firm default rate is 12% (high risk) and 2% (low risk).

channel dominates.[36]

In the high-risk economy, the same policy produces the opposite short-run output response. Because banks are already close to, or within, the rationing region, compressing the spread between R_t and $\underline{R}_t$ strengthens the incentive to hold reserves rather than expand lending. Banks tighten lending standards by reducing safe-loan approval, credit spreads rise, and investment contracts. Reserves increase sharply at the same time, reflecting the endogenous reallocation of bank balance sheets towards low-return liquid assets. The economy therefore displays strongly state-dependent transmission: the same liquidity operation is expansionary when risk is low, but can be contractionary when risk is high because it pushes lending incentives into the rationing regime. The threshold separating these outcomes is given by condition (4.1). Providing this remains slack, the policy works through the demand channel. However, when the constraint

[36] A subtle point is that while the compressed spread moves the economy closer to the credit-rationing threshold, it simultaneously moves it away from the scarce-liquidity region. Reserves therefore rise endogenously as lending expands, reflecting higher bank liquidity rather than tighter lending incentives. This distinction underscores that liquidity scarcity in the model is driven by lending profitability rather than by funding availability.

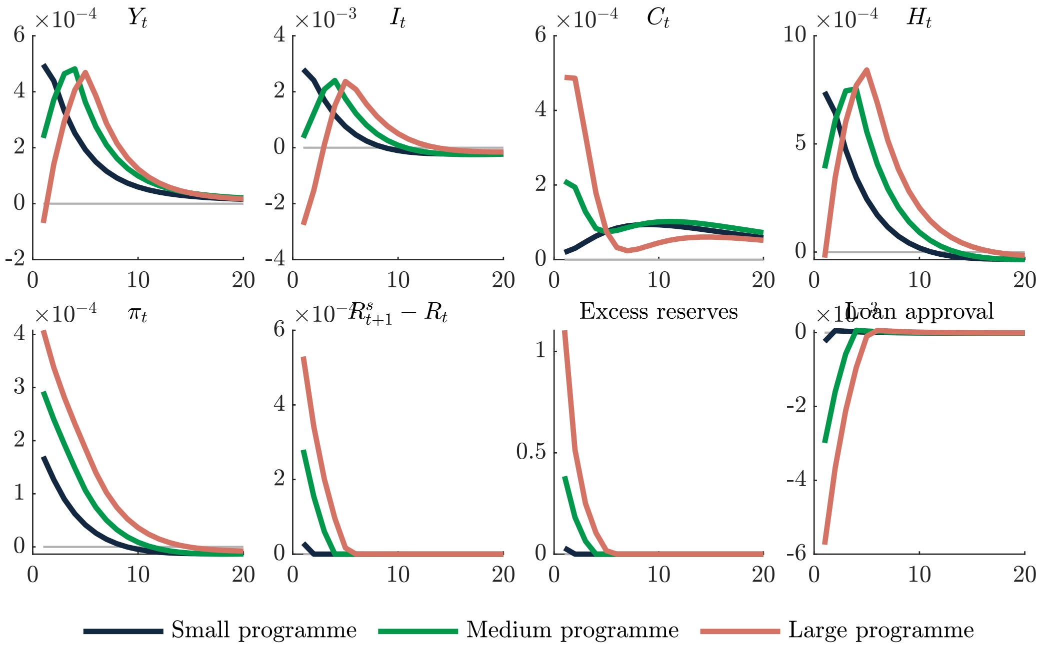

Figure 7: Impulse response functions to a temporary 'QE' programme. Plots in the top row show % deviation from steady state. The bottom row shows ppt deviation except for excess reserves which plots the ratio of reserves to stock of loans.

binds, banks will choose to tighten lending standards, and the negative investment effects offset (and can dominate) the expansionary effect from the intertemporal-substitution channel.

Figure 7 shows the same mechanism by varying the size of the QE programme: one lowering R_t by 10 bps relative to R_t^{tr}, one by 20 bps, and one by 30 bps. A small programme leaves the economy in the non-rationing region, so responses scale approximately proportionally with shock size. Larger programmes, however, move R_t sufficiently close to $\underline{R}_t$ that condition (4.1) binds and banks begin to ration credit. This raises the opportunity cost of lending, squeezing the marginal value of credit to safe firms. Once this regime shift occurs, loan approval falls and spreads rise endogenously; investment declines sharply and output can contract on impact, despite higher consumption demand. The programme size therefore matters nonlinearly: beyond threshold (4.1), additional easing disproportionately strengthens the credit-rationing channel.

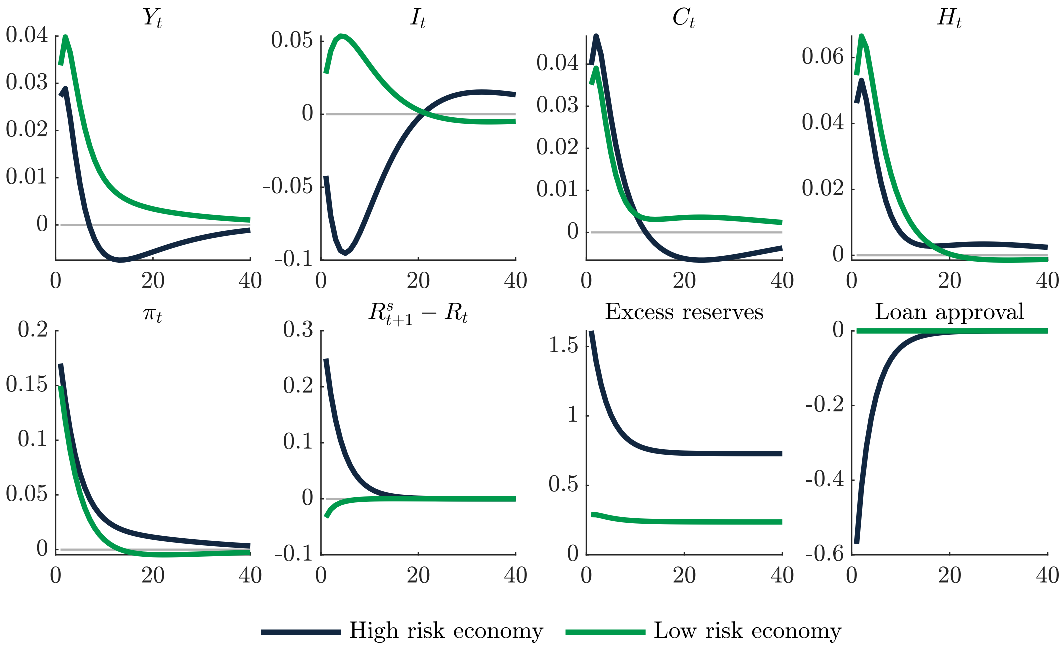

Figure 8: Impulse response functions to an unexpected temporary 'QE' programme in model with investment adjustment costs ($\phi_K = 4$). Plots in the top row show % deviation from steady state. The bottom row shows ppt deviation except for excess reserves which plots the ratio of reserves to stock of loans. Per annum risky firm default rate is 12% (high risk) and 2% (low risk).

4.4 Robustness: investment adjustment costs and preferences

The strength of the two competing transmission channels depends on how aggregate demand and investment respond to interest-rate movements. We therefore assess robustness along two dimensions: the presence of investment adjustment costs and alternative preference specifications that alter labour supply and consumption responses.

Liquidity policies affect the real economy through an expansionary demand channel and a contractionary credit-rationing channel that operates through investment. Introducing investment adjustment costs dampens the responsiveness of investment to changes in lending conditions. As a result, the contractionary credit-rationing channel is weakened, allowing the expansionary demand channel to dominate even in high-risk economies. This mechanism is illustrated in figure 8, which shows that with adjustment costs, the same QE programme generates a positive output response despite tighter lending standards.

We next consider preferences of the type proposed by Jaimovich and Rebelo (2009, JR), which

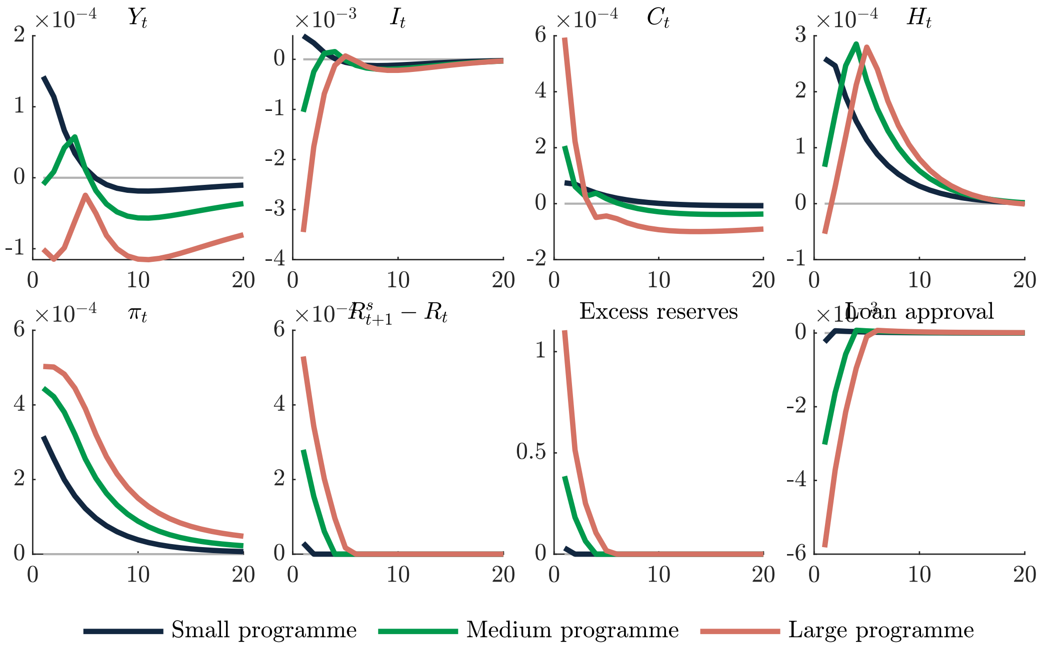

Figure 9: Impulse response functions to a temporary 'QE' programme with Jaimovich-Rebelo preferences, calibrated with a weak wealth effect on labour. Plots in the top row show % deviation from steady state. The bottom row shows ppt deviation except for excess reserves which plots the ratio of reserves to stock of loans.

allow for a weak short-run wealth effect on labour supply. These take the form:

$$U(C_t, H_t) = \frac{1}{1-\sigma}\left(C_t - \chi H_t^{\theta} X_t\right)^{1-\sigma} \tag{4.7}$$

where $X_t = C_t^{\gamma} X_{t-1}^{1-\gamma}$. When calibrated with ($\gamma = 0.2$) and an inverse Frisch elasticity $\theta = 2.5$, these preferences substantially dampen the consumption response to lower interest rates. As a result, the expansionary demand channel is weakened. In this case, a sufficiently large liquidity programme can generate a contraction, as the decline in investment driven by credit rationing is no longer offset by higher consumption.[37] Figure 9 illustrates this outcome.

Finally, combining Jaimovich–Rebelo preferences with investment adjustment costs reverses this result. Adjustment costs limit the contractionary investment response induced by tighter lending standards, while the weak wealth effect prevents excessive labour supply responses. To-

[37] Working in the same direction, increasing the degree of habit formation with the original KPR preferences will also dampen the offsetting effects of consumption demand. However, quantitatively, the effect is insufficiently strong to alter the key results.

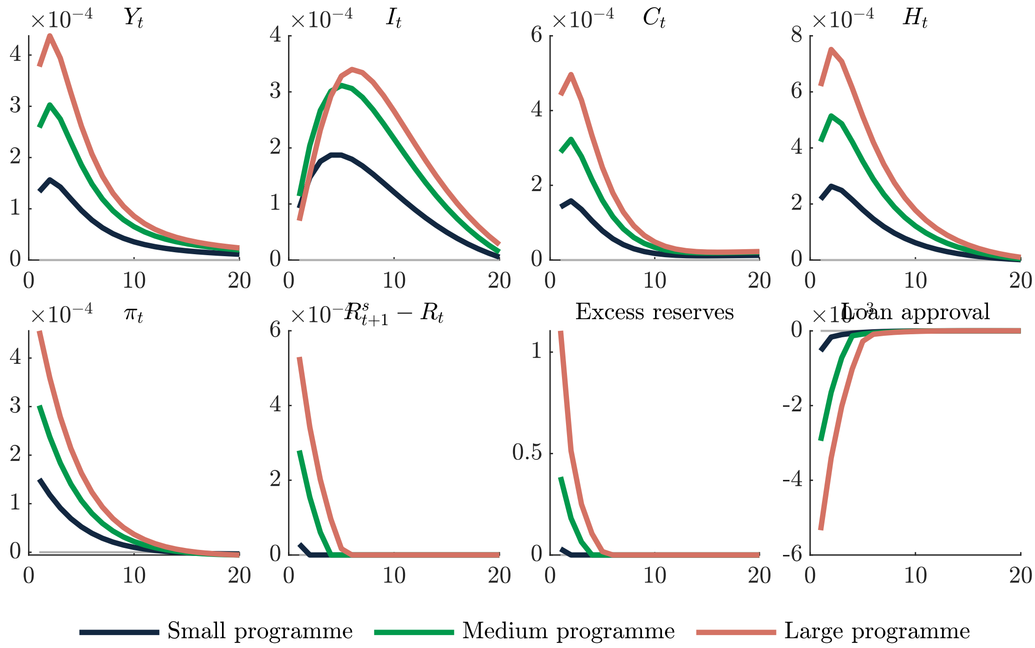

Figure 10: Impulse response functions to a temporary 'QE' programme with Jaimovich-Rebelo preferences, calibrated with a weak wealth effect on labour, and investment adjustment costs ($\phi_K = 4$). Plots in the top row show % deviation from steady state. The bottom row shows ppt deviation except for excess reserves which plots the ratio of reserves to stock of loans.

gether, these forces restore the dominance of the demand channel, so that even large liquidity programmes generate positive output responses despite increased credit rationing. Figure 10 illustrates this interaction.

4.5 Liquidity policies at the effective lower bound

In practice, liquidity policies are most often used when the main policy interest rate, R_t^{tr}, is constrained by the effective lower bound (ELB). This raises the question of how the ELB alters the balance between the expansionary demand channel and the contractionary credit-rationing channel. The key mechanism in this environment is the response of inflation expectations.

Figure 11 plots impulse response functions to a negative demand shock, with and without a QE response, in an economy with investment adjustment costs.[38] The demand shock is modelled as an unexpected increase in the household discount factor, followed by its gradual return to steady

[38]Investment adjustment costs are included to ensure that the shock generates a contraction in aggregate demand. Without adjustment costs, households would substitute away from consumption towards investment and labour, partially offsetting the decline in demand.

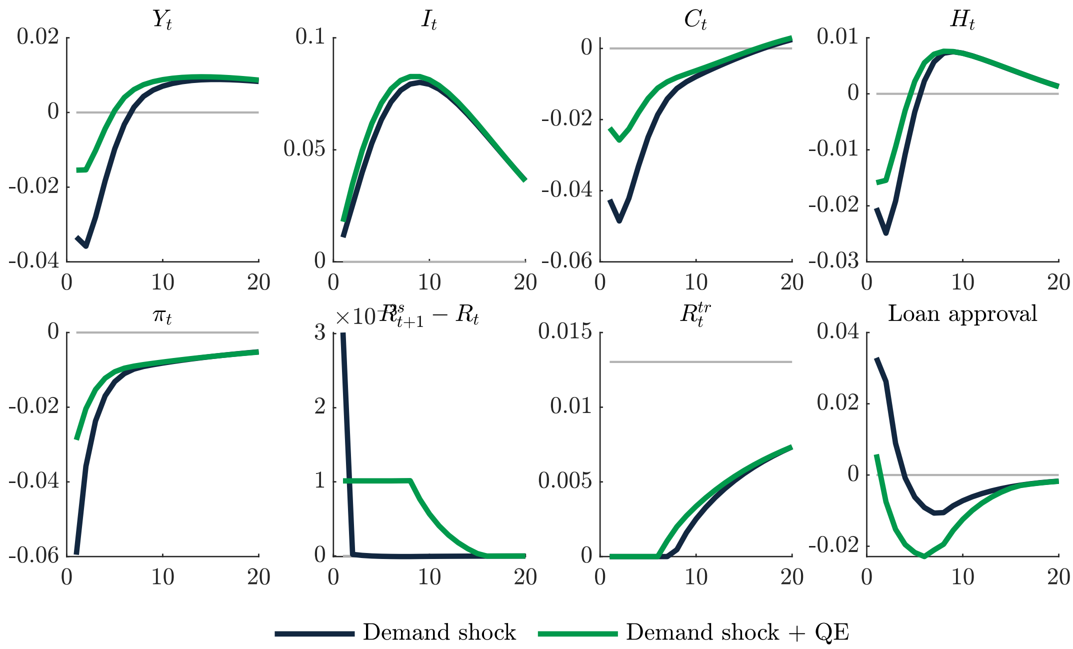

Figure 11: Impulse response functions to a demand shock with and without a 'QE' response and an economy with investment adjustment costs ($\phi_K = 4$). Plots in the top row show % deviation from steady state. The bottom row shows ppt deviation except for excess reserves which plots the ratio of reserves to stock of loans.

state.[39]

The shock pushes the policy rate to the ELB, where it remains for several periods. In the absence of QE, the inability of monetary policy to offset the decline in demand leads to a sharp fall in inflation. Higher household saving increases bank liquidity and results in a temporary easing of lending standards, but this effect is insufficient to stabilise aggregate activity.

When QE is implemented alongside the demand shock, the central bank expands reserve balances, lowering the overnight market rate below the policy rate and all the way to the policy floor.[40] As in the previous section, this activates two competing channels: an expansionary demand channel and a contractionary credit-rationing channel. Crucially, however, both channels are inflationary.

As shown analytically in the next section, tighter lending conditions raise firms' marginal costs, introducing a cost-push effect. Even when credit standards tighten and investment is partially

[39]The shock increases β by 0.01, and follows an AR(1) process with persistence 0.9.
[40]As before, the policy is implemented as a direct reduction in the market interest rate, here falling by 50 basis points relative to the policy rate, with persistence 0.8.

restrained, inflation expectations rise. At the ELB, this increase in expected inflation reduces real interest rates and brings forward policy lift-off, providing additional stimulus over the horizon of the shock. As a result, QE remains expansionary on net, despite a tightening in lending standards.

5 Implications for optimal policy

Incomplete section. This section studies the implications of credit frictions for welfare and optimal monetary policy in a simplified environment. We derive the log-linear New Keynesian representation in which endogenous lending distortions enter as a credit wedge, and obtain the associated quadratic welfare loss function. Building on this structure, we study optimal monetary policy through targeting rules under discretion and commitment, and examine the role of liquidity policy when nominal interest rates are constrained by the effective lower bound. The analysis highlights how credit frictions act as endogenous cost-push shocks and alter the inflation–output trade-off faced by the central bank.

5.1 Restricted environment and the efficient allocation

Assumption 1 (Restricted version) *We consider a restricted version without physical capital and with a fixed number of firms, f. Firms require external finance to operate, but we abstract from entry dynamics in order to focus on the allocation and policy implications of credit distortions. Preferences are additive-separable in consumption and labour:*

$$U\left(C_t, H_t\right) = \ln\left(C_t\right) - \varphi_H \frac{H_t^{1+\varphi}}{1+\varphi} \tag{5.1}$$

Additionally, the following parameter restrictions are imposed: $\eta = \pi^* = 0$.

The social planer's problem is to choose allocations C_t, H_t and A_t to maximise household utility $\sum_t \beta^t U\left(C_t, H_t\right)$ subject to the resource constraint $C_t = Y_t$ and technology $Y_t = A_t H_t^{1-\alpha}$, where $A_t = \exp\left(z_t\right)\left[f x_{t-1}\right]^{\alpha}$, and where $x_t \equiv \lambda x_t^s + (1-\lambda)\, x_t^r$ is the total share of projects that are funded.[41]

[41] Since there are many projects and each has the same expected return, a pool of risky projects has the same

The solution to the social planner problem yields $x_t = 1$ and $U_{H,t}/U_{C,t} = -(1-\alpha)A_t H_t^{-\alpha}$. This is equal to a full-lending (first-best), flexible-price economy where labour subsidies are imposed to remove the steady-state distortion stemming from monopolistic competition. In the optimal policy exercises that follow, we include constant labour subsidies and lending subsidies to impose the efficient steady-state allocation.

5.2 The New Keynesian model with a credit wedge

Taking a first-order approximation around the efficient allocation yields the New Keynesian IS relationship and Philips curve:

$$\pi_t = \beta \mathbb{E}_t [\pi_{t+1}] + \kappa \tilde{y}_t^* - \kappa \alpha \ln(x_t) \tag{5.2}$$

$$\tilde{y}_t = \mathbb{E}_t [\tilde{y}_{t+1}] - (r_t - \mathbb{E}_t [\pi_{t+1}] - r_t^n) \tag{5.3}$$

where

$$r_t^n = \rho + \mathbb{E}_t [\Delta z_{t+1}] \tag{5.4}$$

$$\kappa = \frac{(1-\xi)(1-\xi\beta)}{\xi} \frac{1+\varphi}{1-\alpha} \tag{5.5}$$

where $\tilde{y}_t$ is efficient output gap, π_t the log of inflation, r_t the log nominal interest rate.

The key difference relative to the textbook New Keynesian model (e.g. Clarida et al., 1999) is that marginal cost depends endogenously on credit allocation. When lending is constrained, effective productivity falls, generating a cost-push term in the Phillips curve. This mechanism mirrors the regime structure analysed earlier. Liquidity constraints and credit rationing reduce the funded share of projects, generating a supply-side distortion that feeds directly into inflation dynamics. $\ln(x_t)$ is given in the following piecewise-linear equation:

$$\ln(x_t) = \min \begin{Bmatrix} \Lambda_0 - \Lambda_r (r_t - \rho) + \Lambda_y \mathbb{E}_t [\tilde{y}_{t+1}] + \Lambda_\pi \mathbb{E}_t [\pi_{t+1}] + u_{r,t}, \\ \Upsilon_0 - \Upsilon_r (r_t - \rho) + \Upsilon_y \mathbb{E}_t [\tilde{y}_{t+1}] + \Upsilon_\pi \mathbb{E}_t [\pi_{t+1}] + u_{l,t}, \\ 0 \end{Bmatrix} \tag{5.6}$$

net present value as a pool of safe projects. Therefore, we do not discriminate and can focus only on x_t.

where $u_{r,t}$ and $u_{l,t}$ are linear combinations of exogenous shocks, and Λ_i and Υ_i composite parameters.

5.3 Welfare loss function and optimal targeting rules

Taking a second-order approximation to household utility around the efficient undistorted steady yields the loss function:[42]

$$\mathcal{L} = \mathbb{E}_0 \sum_{t=0}^{\infty} \beta^t \left(-\lambda_x \frac{1-\alpha}{1+\varphi} \alpha \ln(x_{t-1}) + \frac{1}{2} \left[\pi_t^2 + \lambda_x \tilde{y}_t^2 + \lambda_x \alpha^2 \ln(x_{t-1}^2) - 2\lambda_x \alpha \tilde{y}_t \ln(x_{t-1}) \right] \right)$$

where

$$\lambda_x = \frac{1+\varphi}{1-\alpha} \frac{(1-\beta\xi)(1-\xi)}{\varepsilon\xi} \tag{5.7}$$

Without the credit friction, $\ln(x_{t-1}) = 0$ and the loss function collapses to the standard case, which is linear-quadratic in inflation and the output gap. The possibility of credit rationing and liquidity constraints introduce additional sources of welfare loss.

First, reduced lending lowers effective productivity and output. This appears as a linear welfare loss through the term in $\ln(x_{t-1})$, capturing the direct cost of financing distortions. Second, the cross-product term reflects an amplification mechanism: movements in the credit wedge interact with the output gap, magnifying the welfare cost of downturns when lending tightens endogenously. Third, fluctuations in the credit wedge are themselves costly. Real marginal cost can be written as

$$\widehat{mc}_t = \frac{1+\varphi}{1-\alpha} \left(\tilde{y}_t - \alpha \ln(x_{t-1}) \right) \tag{5.8}$$

so marginal cost depends jointly on the output gap and the lending wedge. While stabilising marginal cost stabilises inflation, under credit rationing it is no longer possible to do so by stabilising the output gap alone. The policymaker must instead engineer an offsetting output gap, implying a trade-off between inflation stabilisation and output stabilisation. The quadratic

[42] Derivations in Appendix C.6.

term in $\ln(x_{t-1})$ captures the welfare cost of volatility in the lending wedge, which policy cannot eliminate while simultaneously stabilising both inflation and the output gap.

5.4 Optimal policy under discretion

To evaluate the optimal policy, we choose a path for the nominal interest rate r_t to minimise period welfare loss subject to the zero-lower bound, the Phillips curve (5.2), and the condition for the credit margin (5.6).

Proposition 4 *Under full-lending in both t and $t-1$, away from the zero-lower bound, $\mu_{y,t} = \xi_{r,t} = \xi_{l,t} = 0$ and these conditions imply the targeting rule:*

$$\pi_t = -\frac{\lambda_x}{\kappa}\tilde{y}_t. \tag{5.9}$$

Proposition 5 *If the lending is constrained either due to liquidity constraints or credit rationing, so $\hat{x}_{t-1} < 0$ but $\hat{x}_t = 0$, so $\xi_{r,t} = \xi_{l,t} = 0$, and the zero-lower bound is not binding ($\mu_{y,t} = 0$), then:*

$$\pi_t = -\frac{\lambda_x}{\kappa}\left(\tilde{y}_t - \alpha\hat{x}_{t-1}\right). \tag{5.10}$$

Equation (5.9) reproduces the standard discretionary targeting rule. When lending is constrained, however, equation (5.10) shows that the credit wedge enters directly into the policy trade-off. A decline in $t-1$ lending raises period t marginal costs and shifts the Phillips curve upward, acting as an endogenous cost-push shock through the channel highlighted in equation (5.8). For a given inflation rate, the central bank must therefore tolerate a larger negative output gap to stabilise inflation.

Under discretion, the policymaker cannot commit to offsetting the lending wedge in future periods. As a result, stabilising inflation today requires a stronger contraction in activity when credit conditions deteriorate. Because the credit friction operates as a supply-side distortion, it can in some states mitigate deflationary cost-push pressures, but more generally it worsens the inflation–output trade-off by amplifying the output cost of disinflation.

Section incomplete.

6 Concluding remarks

This paper makes three broad contributions. First, it provides empirical evidence that the transmission of asset purchase programmes depends on banks' lending incentives rather than on funding availability alone. Using cross-sectional and time-series variation, the empirical analysis shows that interest-rate compression following asset purchases can be associated with both expansions and contractions in credit, mediated by changes in lending standards. As a result, bank liquidity expansions need not translate into higher lending.

Second, the paper develops a structural model that rationalises these findings. By embedding adverse selection into a New Keynesian framework with bank balance sheets and a policy corridor, the model delivers endogenous lending regimes and state-dependent transmission of liquidity policies. Liquidity injections operate through two opposing channels: a conventional demand channel and a credit-rationing channel that works through banks' lending incentives. Which channel dominates depends on risk, entry conditions, and the opportunity cost of lending, rather than on banks' access to funding. As a result, credit scarcity can arise for the real economy even as bank liquidity increases.

Third, the paper draws implications for monetary policy design. Endogenous lending distortions enter the New Keynesian model as a credit wedge that reshapes inflation dynamics, welfare trade-offs, and optimal targeting rules. Liquidity policies can remain expansionary at the effective lower bound by raising inflation expectations, even when they tighten lending standards, but their effectiveness is inherently state-dependent.

Section incomplete.

References

Abadi, J., Brunnermeier, M. and Koby, Y. (2023), 'The reversal interest rate', *American Economic Review* **113**(8), 2084–2120.

Acharya, V. V., Eisert, T., Eufinger, C. and Hirsch, C. W. (2019), 'Whatever it takes: The real effects of unconventional monetary policy', *The Review of Financial Studies* **32**(9), 3366–3411.

Adrian, T. and Shin, H. S. (2010), 'Liquidity and leverage', *Journal of Financial Intermediation* **19**(3), 418–437.

Akerlof, G. A. (1970), 'The market for "Lemons": Quality Uncertainty and the Market Mechanism', *The Quarterly Journal of Economics* **84**(3), 488–500.

Albertazzi, U., Nobili, A. and Signoretti, F. M. (2021), 'The bank lending channel of conventional and unconventional monetary policy', *Journal of Money, Credit and Banking* **53**(2-3), 261–299.

Allen, F. and Gale, D. (1998), 'Optimal financial crises', *The Journal of Finance* **53**(4), 1245–1284.

Allen, F. and Gale, D. (2000), 'Financial contagion', *Journal of Political Economy* **108**(1), 1–33.

Bech, M. and Monnet, C. (2016), 'A search-based model of the interbank money market and monetary policy implementation', *Journal of Economic Theory* **164**, 32–67. Symposium Issue on Money and Liquidity.

Belongia, M. T. and Ireland, P. N. (2022), 'A reconsideration of money growth rules', *Journal of Economic Dynamics and Control* **135**, 104312.

Berger, A. N. and Bouwman, C. H. S. (2009), 'Bank Liquidity Creation', *The Review of Financial Studies* **22**(9), 3779–3837.

Bernanke, B. S. and Gertler, M. (1989), 'Agency costs, net worth, and business fluctuations', *The American Economic Review* **79**(1), 14–31.

Bernanke, B. S., Gertler, M. and Gilchrist, S. (1999), Chapter 21 the financial accelerator in a quantitative business cycle framework, Vol. 1 of *Handbook of Macroeconomics*, Elsevier, pp. 1341–1393.

Besanko, D. and Thakor, A. V. (1987), 'Collateral and Rationing: Sorting Equilibria in Monopolistic and Competitive Credit Markets', *International Economic Review* **28**(3), 671–689.

Bester, H. (1985), 'Screening vs Rationing in Credit Markets with Imperfect Information', *The American Economic Review* **75**(4), 850–855.

Bhattacharya, S. and Thakor, A. V. (1993), 'Contemporary banking theory', *Journal of Financial Intermediation* **3**(1), 2–50.

Bindseil, U. (2000), 'Towards a theory of central bank liquidity management', *Kredit und Kapital* **3/2000**, 346–376.

Bindseil, U. and Jabłecki, J. (2011), The optimal width of the central bank standing facilities corridor and banks' day-to-day liquidity management, Working Paper Series 1350, European Central Bank.

Brunnermeier, M. K. and Sannikov, Y. (2014), 'A macroeconomic model with a financial sector', *The American Economic Review* **104**(2), 379–421.

Calvo, G. (1983), 'Staggered Prices in a Utility Maximizing Framework', *Journal of Monetary Economics* **12**(1978), 383–398.

Carbo-Valverde, S. and Rodríguez-Fernández, F. (2016), Small Business Lending, *in* T. Beck and B. Casu, eds, 'The Palgrave Handbook of European Banking', Palgrave Macmillan UK, London, pp. 231–255.

Carpenter, S. B., Demiralp, S. and Eisenschmidt, J. (2014), 'The effectiveness of the non-standard policy measures during the financial crises: The experiences of the federal reserve and the european central bank', *Journal of Economic Dynamics and Control* **43**, 107–129.

Christiano, L. J., Eichenbaum, M. and Charles, L. E. (2005), 'Nominal rigidities and the dynamic effects of a shock to monetary policy', *Journal of Political Economy* **113**(1), 1–45.

Clarida, R., Gali, J. and Gertler, M. (1999), 'The science of monetary policy: A new keynesian perspective', *Journal of Economic Literature* **37**(4), 1661–1707.

Cornett, M. M., McNutt, J. J., Strahan, P. E. and Tehranian, H. (2011), 'Liquidity risk management and credit supply in the financial crisis', *Journal of Financial Economics* **101**(2), 297–312.

De Meza, D. and Webb, D. C. (1987), 'Too Much Investment: A Problem of Asymmetric Information', *The Quarterly Journal of Economics* **102**(2), 281–292.

Diamond, D. W. and Dybvig, P. H. (1983), 'Bank runs, deposit insurance, and liquidity', *Journal of Political Economy* **91**(3), 401–419.

Diamond, D. W. and Rajan, R. G. (2001), 'Liquidity risk, liquidity creation, and financial fragility: A theory of banking', *Journal of Political Economy* **109**(2), 287–327.

Diamond, W., Jiang, Z. and Ma, Y. (2024), 'The reserve supply channel of unconventional monetary policy', *Journal of Financial Economics* **159**.

Disyatat, P. (2011), 'The bank lending channel revisited', *Journal of Money, Credit and Banking* **43**(4), 711–734.

Eggertsson, G. B., Juelsrud, R. E., Summers, L. H. and Wold, E. G. (2023), 'Negative nominal interest rates and the bank lending channel', *The Review of Economic Studies* **91**(4), 2201–2275.

Elliott, M., Golub, B. and Jackson, M. O. (2014), 'Financial networks and contagion', *The American Economic Review* **104**(10), 3115–3153.

Farhi, E. and Tirole, J. (2012), 'Collective moral hazard, maturity mismatch, and systemic bailouts', *American Economic Review* **102**(1), 60–93.

Flanagan, T. (2025), 'The value of bank lending', *The Journal of Finance* (forthcoming).

Galí, J. (2015), *Monetary Policy, Inflation, and the Business Cycle: An Introduction to the New Keynesian Framework and Its Applications*, 2nd edn, MIT Press, Cambridge, MA.

Gambacorta, L. and Marques-Ibanez, D. (2011), 'The bank lending channel: Lessons from the crisis', *Economic Policy* **26**(66), 135–182.

Gambacorta, L., Yang, J. and Tsatsaronis, K. (2014), Financial structure and growth, BIS Quarterly Review. Bank for International Settlements, March.

Gertler, M. and Karadi, P. (2011), 'A model of unconventional monetary policy', *Journal of Monetary Economics* **58**, 17–34.

Gilchrist, S. and Mojon, B. (2018), 'Credit risk in the euro area', *The Economic Journal* **128**(1), 118–158.

Glasserman, P. and Young, H. P. (2016), 'Contagion in financial networks', *Journal of Economic Literature* **54**(3), 779–831.

Gründler, D. and Scharler, J. (2025), 'Bank lending standards and monetary transmission in the euro area', *Economics Letters* **254**, 112413.

He, Z. and Krishnamurthy, A. (2013), 'Intermediary asset pricing', *American Economic Review* **103**(2), 732–70.

Holden, T. D., Levine, P. and Swarbrick, J. M. (2020), 'Credit crunches from occasionally binding bank borrowing constraints', *Journal of Money, Credit and Banking* **52**(2-3), 549–582.

Holm-Hadulla, F., Musso, A., Nicoletti, G. and Tujula, M. (2022), Firm debt financing structures and the transmission of shocks in the euro area, Article. *in* Economic Bulletin, Issue 4/2022, European Central Bank.
URL: *https://www.ecb.europa.eu/press/economic-bulletin/articles/2022/html/ecb.ebart202204_02 b35a8321b7.en.h*

Holmström, B. and Tirole, J. (1997), 'Financial intermediation, loanable funds, and the real sector', *The Quarterly Journal of Economics* **112**(3), 663–691.

Holmström, B. and Tirole, J. (1998), 'Private and public supply of liquidity', *Journal of Political Economy* **106**(1), 1–40.

House, C. L. (2006), 'Adverse Selection and the Financial Accelerator', *Journal of Monetary Economics* **53**(6), 1117–1134.

Ikeda, D. (2020), 'Adverse selection, lemons shocks and business cycles', *Journal of Monetary Economics* **115**, 94–112.
URL: *https://www.sciencedirect.com/science/article/pii/S0304393219300947*

Iyer, R., Peydró, J.-L., da Rocha-Lopes, S. and Schoar, A. (2014), 'Interbank Liquidity Crunch and the Firm Credit Crunch: Evidence from the 2007–2009 Crisis', *The Review of Financial Studies* **27**(1), 347–372.

Jaimovich, N. and Rebelo, S. (2009), 'Can news about the future drive the business cycle?', *American Economic Review* **99**(4), 1097–1118.

Joyce, M. A. S., Tong, M. and Woods, R. (2011), 'The united kingdom's quantitative easing policy: design, operation and impact', *Bank of England Quarterly Bulletin* **51**(3), 200–212.

Kashyap, A. K., Rajan, R. and Stein, J. C. (2002), 'Banks as liquidity providers: An explanation for the coexistence of lending and deposit-taking', *Journal of Finance* **57**(1), 33–73.

King, R. G., Plosser, C. I. and Rebelo, S. T. (1988), 'Production, Growth and Business Cycles', *Journal of Monetary Economics* **21**(2-3), 309–341.

Kiyotaki, N. and Moore, J. (1997), 'Credit cycles', *Journal of Political Economy* **105**(2), 211–248.

Loutskina, E. (2011), 'The role of securitization in bank liquidity and funding management', *Journal of Financial Economics* **100**(3), 663–684.

Mankiw, N. G. (1986), 'The Allocation of Credit and Financial Collapse', *Quarterly Journal of Economics* **101**(3), 455–470.

Martin, A., McAndrews, J. and Skeie, D. (2016), 'Bank Lending in Times of Large Bank Reserves', *International Journal of Central Banking* **12**(4), 193–222.

Nicoloso, P. and Tsonchev, V. (2019), Goodbye EONIA, welcome €STR!, Box 1. *in* Economic Bulletin, Issue 7/2019, European Central Bank.
URL: *https://www.ecb.europa.eu/pub/economic-bulletin/html/eb201907.en.html*

Ramakrishnan, R. T. S. and Thakor, A. V. (1984), 'Information Reliability and a Theory of Financial Intermediation', *The Review of Economic Studies* **51**(3), 415–432.

Stiglitz, J. E. and Weiss, A. (1981), 'Credit Rationing in Markets with Imperfect Information', *American Economic Review* **71**(3), 393–410.

Swarbrick, J. (2023), 'Lending standards, productivity, and credit crunches', *Macroeconomic Dynamics* **27**(2), 456–481.

Whitesell, W. (2006), 'Interest rate corridors and reserves', *Journal of Monetary Economics* **53**(6), 1177–1195.

Williamson, S. D. (1986), 'Costly Monitoring, Financial Intermediation, and Equilibrium Credit Rationing', *Journal of Monetary Economics* **18**(2), 159–179.