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 and bank liquidity risk, rationalising evidence that lending conditions can remain tight despite liquidity injections. The model exhibits a policy trade-off whereby increasing banking sector liquidity can incentivize *more lending* by lowering the overnight rate and the marginal cost of funds, but can also incentivize *less lending* by compressing bank margins as interest rates approach the policy floor, raising the opportunity cost of lending and worsening credit rationing. It follows that quantitative easing (QE) can exert a *contractionary* effect by worsening credit rationing when the economy is away from the effective lower bound. The overall impact of QE depends on both the degree of firm risk and the size of the programme. However, by increasing inflation expectations, QE is always expansionary at the lower bound. During quantitative tightening away from the lower bound, the credit-rationing channel works in reverse, mitigating the contractionary effects.

1 Introduction

The toolkit of monetary policymakers has evolved considerably since the global financial crisis (GFC). Many central banks expanded their menu of policies to include forward guidance, as-

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set purchasing programmes, negative interest rates, and liquidity policies aimed at supporting lending to the real economy.[1] These developments were largely a response to the effective lower bound on nominal interest rates (ELB), which constrained conventional monetary policy. While balance sheet policies are generally considered to have, at least in part, substituted for interest rate policy, a key challenge faced by central banks was to translate these policy actions to improved lending conditions for small businesses. For example, despite rising 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. This is highlighted in Figure 1 which shows persistently sluggish loan growth following the crisis (panel a), despite much larger 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). Recent evidence suggests the opposite can be true. 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 where information frictions in small business lending interact with monetary policy implementation.[3] The lending friction prevents banks observing the risk characteristics of small firms in the economy, creating an adverse selection problem in credit markets. This generates a well-established effect, explored by Ikeda (2020) and Swarbrick (2023) in relation to the GFC, whereby banks may ration credit and build up excess reserves when firm risk is high. Crucially, the adverse selection introduces an additional channel of monetary policy whereby adjustments in the interest rate corridor can affect the opportunity cost of lending and therefore the incentive to ration credit to small business.

[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).

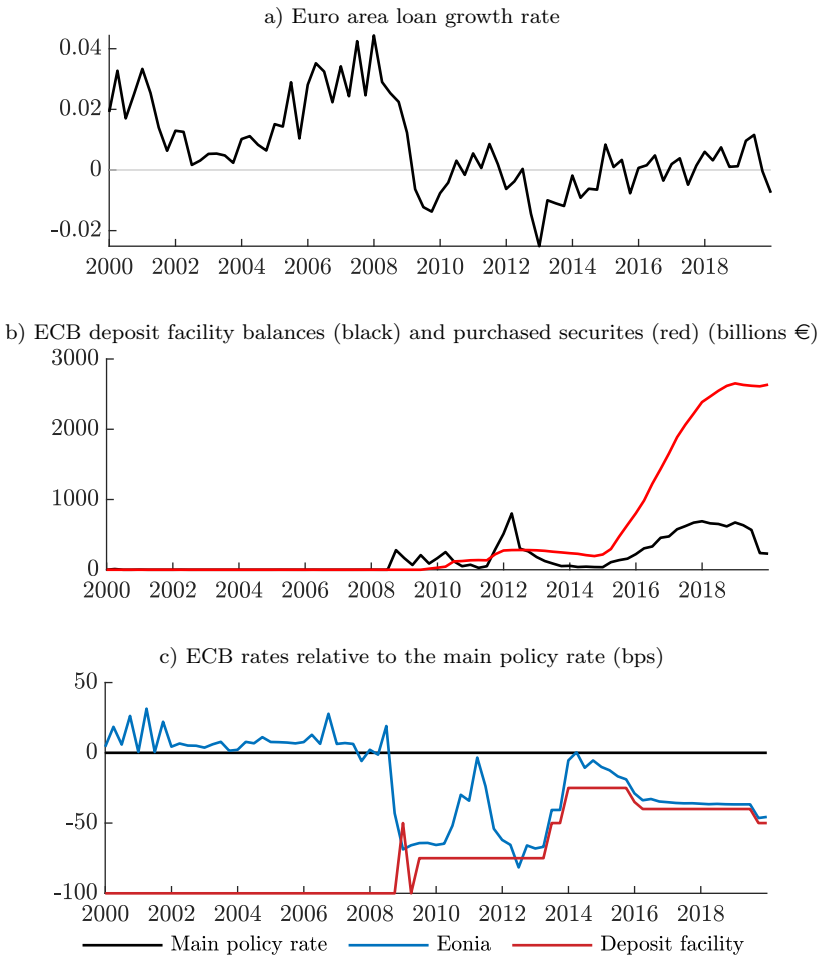


Figure 1: Source: ECB. Loans are those to euro area NFCs reported by MFIs. Purchases securities includes the stock of securities purchased as part of the various asset purchase programmes since 2009.

The key insight 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 the effects of shocks and policy actions, and generating a stabilizing role of liquidity easing policies.[4] From this perspective, lending contractions can stem from banks facing liquidity crises with different causes, including 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 the transmission mechanism of monetary policy to borrower balance sheets, introducing a financial accelerator whereby a monetary expansion increases asset prices and collateral values, permitting borrowers to take on additional debt. 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 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

[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).

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 policy 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 key 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 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

[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).

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 presents empirical evidence from the euro area on the links between the policy corridor and lending conditions. Section develops the theoretical model, and Section derives key analytical results.

2 Motivating evidence from the euro area

Focusing on the euro area is insightful here 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 U.S.[8]. There is also a heightened importance of small business for economic activity in Europe, where SMEs account for around two thirds of private-sector employment versus one half in the U.S. (see Carbo-Valverde and Rodríguez-Fernández, 2016). This highlights the systemic importance of banks in the euro area given the reliance of SMEs on bank lending.

Finally, the European Central Bank (ECB) provides rich empirical variation for analysis. On multiple occasions in recent years, the ECB adjusted the width of their interest rate corridor and shifted between corridor and floor systems, generating substantial policy variation that allows us to examine the relationship between corridor design and lending activity (see Figure 1, panel c). [9]

The ECB measures the corridor as the spread between the interest rates on their two standing

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

[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), essentially moving towards a floor system. Other central banks including the Bank of England and Bank of Canada operated a corridor system which moved to floor systems following the GFC. The corridor widths were also subject to adjustment.

facilities—the marginal lending facility (LF) and deposit facility (DF)—with the interest rate on their main refinancing operations (MRO) typically lying halfway between. Prior to the financial crisis, the ECB operated a corridor system but moved to a *de facto* floor system as excess liquidity in the banking sector built up.[10] As a result, the interest paid on reserve balances became the key link to the short-term rates rather than the cost of central bank liquidity (see Figure 1, panel c).

There was an important policy change during the financial crisis that played a critical role in this shift. Until October 2008, banks bid for a fixed volume of central bank liquidity at weekly MRO tenders. Due to the seizing up of the interbank market during the crisis, the ECB switched to a fixed rate, full allotment tender to provide whatever liquidity was requested. This partly led to the swelling of banks' reserve balances shown in Figure 1.

Following this shift in monetary policy implementation, the effective lower bound became a crucial factor in monetary policy strategy. The views of monetary policymakers on the specific level of the constraint have evolved over time. For example, former ECB governor Trichet initially ruled out any negative rates (see Trichet, 2013), while his successor Draghi stated categorically in September 2014 that they had reached the lower bound when cutting the MRO to 0.05% and the deposit facility to -0.20%.[11]. Subsequently, interest rates were cut further and by March 2016, the MRO had reached zero and the deposit rate -0.40%.

Whatever the particular level of the lower bound, when interest rates approach this region, the policy corridor becomes an important monetary policy tool. While one motivation for narrowing the corridor might be to reduce interest rate volatility,[12] the mechanism we focus on operates when banks are reluctant to lend and instead hoard excess liquidity. It was widely recognised during the post-crisis years that banks were reluctant to lend, and one tool to counteract this was to widen the corridor by lowering the deposit facility rate.[13] As Draghi observed, cuts in the

[10] See Kakes et al. (2022) Gravelle et al. (2023) for discussions.

[11] At the press conference following the cut Draghi claimed "... now we are at the lower bound, where technical adjustments are not going to be possible any longer" (Draghi, 2014)

[12] See e.g., Hartmann and Smets (2018), and as discussed by Trichet in 2008 (Trichet, 2008), and stated by Draghi: "... restricting the interest rate corridor will also dampen the volatility of the EONIA rate" (Draghi, 2013).

[13] This was discussed, for example, during the press conference of 2 October 2008, (Trichet, 2008). In 2009, Trichet claimed that pushing banks to lend the extra liquidity was the primary purpose of widening the corridor through lowering the DF rate (see Trichet, 2009).

deposit rate improve the monetary policy transmission by incentivizing lending at the expense of lower reserve balances, thereby strengthening the credit channel (see Draghi, 2015).

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.[14] $\mathbf{z}$ is a vector of controls including GDP, inflation, Eonia, credit risk, and ECB asset purchases.[15]

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.[16] This result is robust to the inclusion of a range of controls, including Eonia. Crucially, keeping the market interest rate unchanged, a wider policy corridor predicts higher lending volumes, pointing to the role that interest on reserves plays in affecting bank lending incentives.

The same analysis finds that a 25 basis point higher Eonia rate predicts 0.3% lower lending volumes and much lower reserve balances, given the policy corridor, consistent with tighter liquidity conditions driving higher interbank rates.

[14] 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).

[15] 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.

[16] 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.

	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^{***}	0.0221^{***}	2.367	-0.931^{***}	0.0084^{**}	-3.769^{**}
	(0.134)	(0.002)	(1.758)	(0.144)	(0.0038)	(1.825)
R_t^*	-0.497^{***}	-0.0028^{***}	1.649^{***}	-0.294^{***}	-0.0041^{***}	2.654^{***}
	(0.025)	(0.0005)	(0.257)	(0.041)	(0.0011)	(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.

Using quarterly bank-level balance sheet data over the same time period, I re-estimate specification 2.1 with bank fixed effects.[17] 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.[18]

To further explore the dynamic effects, I employ the local-projection method proposed by Jorda (2005) to compute forecasts of bank lending conditional on corridor adjustments. In particular, we estimate the following specification:

$$\ln X_{i,t+h} = \alpha_{X,h} + \gamma_{X,i,h} + \beta_{X,h}\Delta s_t + \boldsymbol{\gamma}'_{\mathbf{X},\mathbf{h}} \cdot \mathbf{z}_t + u_{X,i,t} \tag{2.2}$$

Figure 2 shows that a corridor widening predicts a temporary rise in bank lending and corresponding drop in reserve balances, confirming the baseline results.[19]

[17] 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.

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

[19] Note that while we compute a profile similar to an impulse response function, since we are not strictly

	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^{***}	0.0179^{***}	-0.042^{**}	0.0099^{**}
	(0.011)	(0.005)	(0.019)	(0.0039)
R_t^*	-0.0732^{***}	-0.0163^{**}	-0.0347	-0.0251^{***}
	(0.020)	(0.007)	(0.025)	(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.

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 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.[20]

In Table 1 section b), we see that the change in lending corresponds with an adjustment of bank lending standards. Banks increase lending activity, and this is largely thanks to an easing of

identifying the corridor change as an exogenous shock, it would be more accurately described as a conditional projection profile.

[20]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).

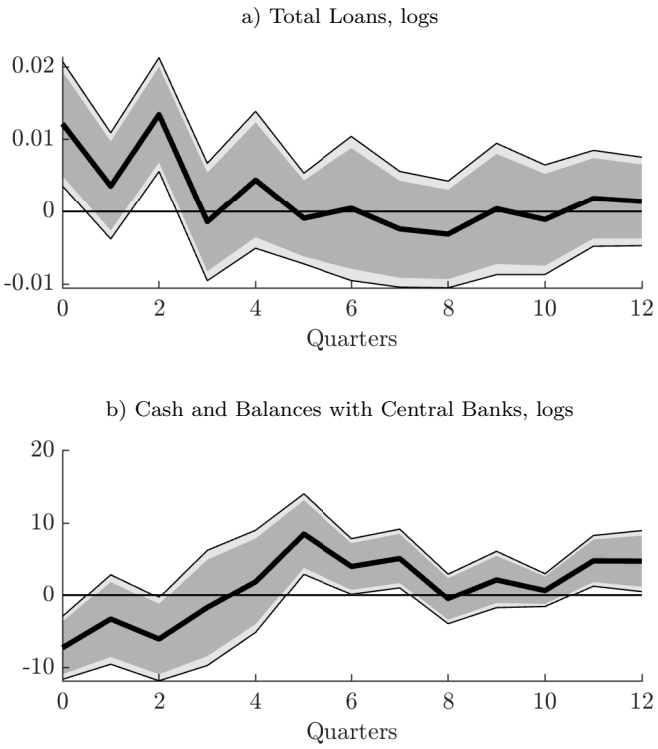


Figure 2: Local projections conditional on a period 0 ECB interest corridor widening of 25bps. Shaded bands show 90% and 95% confidence intervals. Bank level data from S&P Global Market Intelligence (SNL Financial Fundamentals) 2008Q1–2019Q4. Same controls used in the aggregate regressions with the addition of bank fixed effects. Standard errors clustered at the bank level.

lending standards. This points to the role of information frictions since lending standards are used to screen borrowers when these frictions worsen and lending rates are insufficient.

2.3 Threshold Effects and Competing Channels

These results reveal an important tension. When Eonia falls, perhaps due to quantitative easing increasing market liquidity, there is a corresponding increase in bank lending driven by a lower bank funding cost. However, if policy rates remain unchanged, the spread between Eonia and the policy floor contracts, which our results suggest should reduce 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:

$$\ln L_t = \alpha_L + \beta_{L,s<\mathcal{S}} i_t R_t^* + \beta_{L,s>\mathcal{S}} (1 - i_t) R_t^* + \boldsymbol{\gamma}_{\mathbf{L}}' \cdot \mathbf{z}_t + u_{L,t} \tag{2.3}$$

where $i = 1$ when the spread is below threshold $\mathcal{S}$, and zero otherwise.[21] The rationale is that when the spread is low and the economy operates as a floor system, the effect of the diminishing spread becomes more crucial for lending incentives.

Figure 3 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.[22]

The empirical exercises reveal the following stylised facts. First, controlling for the market interest rate, and shrinking of either the policy corridor or the spread between the market rate and the floor predicts lower bank lending and high bank reserve balances. Second, controlling for the corridor, a lower interbank market rate predicts higher lending volumes. Third, controlling for policy interest rates, we find a fall in the market rate predicts lower lending when it is close to the policy floor. Fourth, lending standards are an important tool for banks in varying the quantity of loans.

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

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

[22] 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).

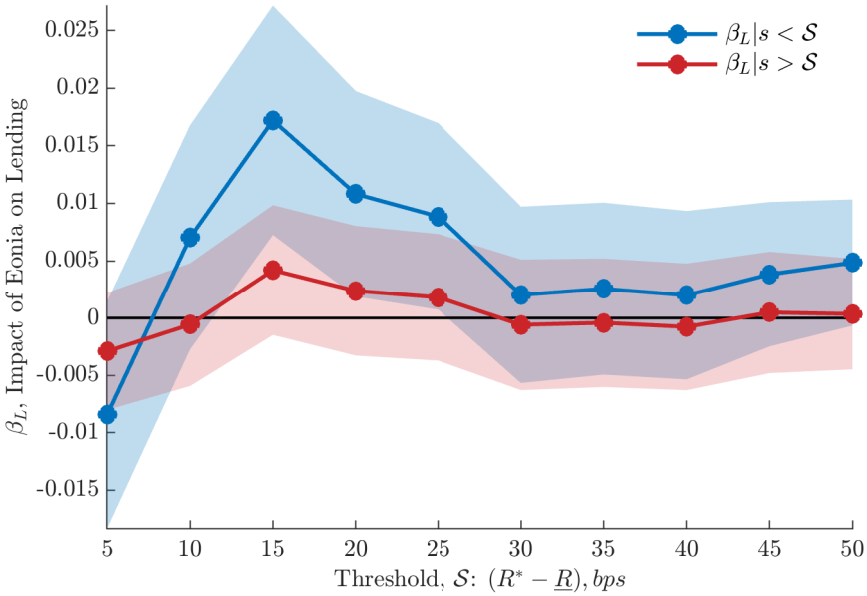


Figure 3: Estimated coefficients from specification (2.3) for a range of values of threshold, t. Shaded areas show the 95% confidence intervals.

3 A macroeconomic model of credit rationing

At the core of the model is a canonical New Keynesian (NK) closed economy model with investment adjustment costs. 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

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

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 $\Lambda_{t,t+1} = \beta \frac{U'(C_{t+1})}{U_t'(C_t)}$, and with $R_t^B = R_t$. The equity purchase condition will be outlined below. The labour supply condition equates the real wage with the marginal rate of substitution between consumption and leisure: $W_t/P_t = -U'(H_t)/U_t'(C_t)$.

The production sectors include an wholesale goods sector that combines labour and purchases capital to produce an intermediate good. This good is then sold to retailers under perfect competition. The retailers differentiate the intermediate goods which they sell 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, I capture the inability of small firms to be able to diversify risk. A central feature of many advanced economies, is that a large share of employment is at small to medium sized businesses. It is these businesses that suffered the most from drops in bank lending and so are the focus on this paper.

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.[23]

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 two instruments. The first is the short-term interest rate on household savings, R_t, which can be targeted through private sector bond purchases, or liquidity provision to the bank sector.[24] The second are interest rates on standing deposit ($\underline{R}_t$) and lending ($\overline{R}_t$) facilities. Banks can hold excess reserve balances in the former and access additional liquidity as required via the the latter.[25]

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.[26] 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 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 p_t^i and R_t^i denote the success probability and gross nominal rate of return on capital for a type-i project, lenders set contract terms subject to firms' individual rationality (IR) and incentive compatibility (IC) constraints. The relevant constraints are:

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

[23] See Flanagan (2025) who provides evidence that banks exist to mitigate borrowers' financing frictions.

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

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

[26] 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.

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

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.[27]

The free entry of banks will imply a zero-arbitrage condition for the banking sector. Banks can enter, access liquidity in the form of nominal household deposits and one-period nominal loans from the central bank, and post loan contracts. Matching to firms is in proportion to the bank size, measured as the nominal size of the balance sheet.[28]

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, the total *ex post* gross nominal rate of return to the representative bank is

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

where $\tilde{R}_{t-1}$ is the marginal return on surplus liquidity, or cost of additional liquidity. When $S_{t-1}^j > L_{t-1}^j$, this is the interest on reserves, $\underline{R}_{t-1}$, and is otherwise the rate on the standing lending facility, $\overline{R}_{t-1}$. Total loans extended $L_t^j \equiv (1-\eta)\left(\lambda x_{t-1}^s + (1-\lambda)\, x_{t-1}^r\right) f_{t-1}^j Q_{t-1}^K$. Then denoting the the loan supply-demand ratio $\phi_t \equiv \frac{S_t}{(1-\eta) f_t Q_t^K}$, the zero-profit condition will determine the equilibrium volume of banking sector liquidity:

$$1 = \mathbb{E}_t\left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}}\left(\tilde{R}_t + \left[\lambda x_t^s\left(\tau_t^s - \tilde{R}_t\right) + (1-\lambda)\, x_t^r\left(p_{t+1}\tau_t^r - \tilde{R}_t\right)\right]\frac{1}{\phi_t^j}\right)\right] \tag{3.5}$$

where $\phi_{t-1}^j = \phi_{t-1}$ will be the same 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, bailing out the banks when there

[27] The implications of these contracts are discussed further in the next section.
[28] It is this assumption that leads to surplus banking sector liquidity since.

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:

$$\begin{aligned}
&\max_{c_t^s, c_t^r} \mathbb{E}_t \left[\Lambda_{t,t+1} \left\{ \lambda x_t^s \left(\frac{\tau_t^s}{P_{t+1}} - \frac{R_t^{df}}{P_{t+1}} \right) + (1-\lambda) x_t^r \left(p_{t+1} \frac{\tau_t^r}{P_{t+1}} - \frac{R_t^{df}}{P_{t+1}} \right) \right\} \right] \\
&\text{s.t.} \quad 0 \leq x_t^s \leq x_t^r \leq 1 \\
&\qquad \lambda x_t^s + (1-\lambda) x_t^r \leq \phi_t
\end{aligned} \tag{3.6}$$

and subject to constraints (3.2) and (3.3). The $x_t^r \geq x_t^s$ 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.[29] This implies the possibility of effective liquidity constraints depending on macro-financial conditions and the monetary policy stance.[30]

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

$$\mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \left(p_{t+1} R_{t+1}^r - \tilde{R}_t \right) \right] = \varrho_t - \psi_t \frac{1}{1-\lambda} + \varphi_t^r \frac{1}{1-\lambda} \tag{3.7}$$

$$\mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} \left((\lambda + (1-\lambda) p_{t+1}) R_{t+1}^s - \tilde{R}_t \right) \right] = \varrho_t + \varphi_t^r - \varphi_t^s, \tag{3.8}$$

where ϱ_t is the Lagrange multiplier on the feasibility constraint, φ_t^s and φ_t^r those on x_t^s and $1 - x_t^r$ respectively, and ψ_t is the Lagrange multiplier on $x_t^r - x_t^s$. These first-order conditions are also subject to complementary slackness conditions that include zero-lower bounds on the four

[29] In particular, at the policy ceiling, $\overline{R}_t$.
[30] This will be explored later in section ?.

Lagrange multipliers:[31]

$$\varphi_t^s, \varphi_t^r, \varrho_t, \psi_t \geq 0. \tag{3.9}$$

Given the set of inequality constraints, it is possible to identify alternative equilibrium outcomes that depend on parametrization and macroeconomic conditions, and which include pooling and separating equilibria, zero or positive reserve balances, and either full lending or credit rationing. These will be discussed further in section ?.

3.2 Intermediate goods firms

Intermediate goods firms draw their project type at the end of period $t-1$ and seek external finance. If they draw an observable project, then they are a *corporate* and access funds in the bond market. Otherwise, the become a *small firm* and 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_{t-1}^k, ready for production in the following period, otherwise, they must exit. New firms can enter but must pay fixed entry costs. Firm dynamics are illusrated in figure 4.

Of the funded risky projects, a proportion $1-p_t$ will fail before production begins, with all capital lost. Success probability, $p_t \in [0,1]$, is subject to aggregate risk allowing us to consider the role of risk shocks. After production, the firm repays the loan, sells the capital back to the capital market at Q_t^K, 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_t^i productive units where $\omega_t^r = 1/p_t > \omega_t^c = \omega_t^s = 1$.[32] The firm hires $h_t\left(\omega_t^i\right)$ units of labour and produces output using

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

[32] The assumption that $\omega_t^r = 1/p_t$ 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.

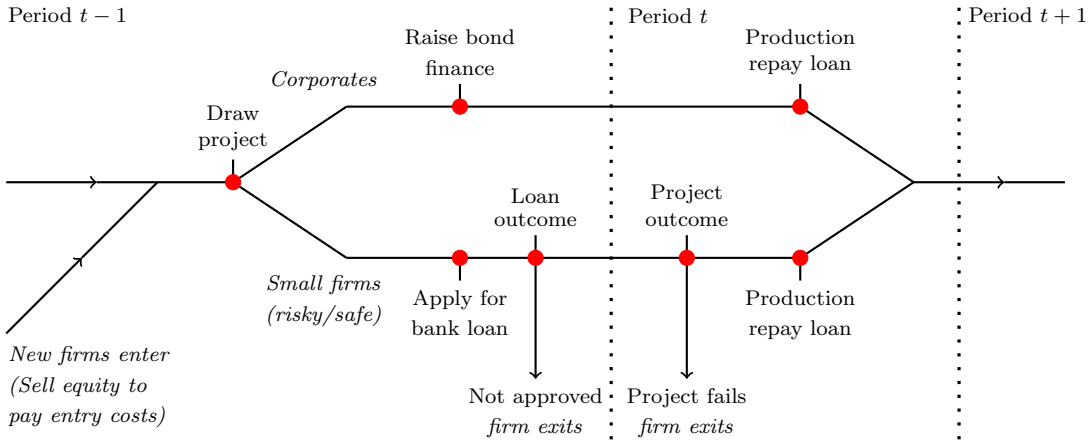


Figure 4: Firm dynamics.

constant returns to scale technology,

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

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 $\omega_t^i(1-\delta)$. Denoting the final consumption good price P_t, the nominal market value of capital Q_t^k, and the wholesale good price P_t^W, we can write the the real value of a successfully funded type-i firm as:

$$V_t^i = \max_{h_t\left(\omega_t^i\right)}\left\{\frac{P_t^W}{P_t}y_t\left(\omega_t^i\right) - \frac{W_t}{P_t}h_t\left(\omega_t^i\right) - \left(\tau_t^i\frac{Q_{t-1}^k}{P_t} - (1-\delta)\,\omega_t^i\frac{Q_t^k}{P_t}\right) + V_t\right\}, \tag{3.11}$$

where τ_t^i is the aggregate-state indexed loan repayment rate and V_t is the *ex-ante*, next-period, real value of a firm, prior to drawing its type, given by:

$$V_t = \mathbb{E}_t\left[\Lambda_{t,t+1}\left(\eta V_{t+1}^c + (1-\eta)\left(\lambda x_t^s V_{t+1}^s + (1-\lambda)\,x_t^r p_{t+1}^r V_{t+1}^r\right)\right)\right], \tag{3.12}$$

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 the real wage

with the marginal product of labour,

$$\frac{W_t}{P_t} = (1-\alpha)\frac{P_t^W}{P_t}\frac{y_t\left(\omega_t^i\right)}{h_t\left(\omega_t^i\right)}, \tag{3.13}$$

where it follows that output per worker y_t^i/h_t^i and the efficiency capital-labour ratio ω_t^i/h_t^i will be equal across all firms, using superscripts for convenience. 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, $\alpha\frac{y_t\left(\omega_t^i\right)}{\omega_t^i} + (1-\delta)$, 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

In this model, 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.

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 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 ap-

proach, 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:

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

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 $C_t(j) = \left(P_t(j)/P_t \right)^{-\varepsilon} C_t$ 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 $\Pi_{t-1,t} \equiv P_t / P_{t-1}$, and a law of motion for price dispersion, Δ_t.[33] 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

[33] The full derivation is detailed in the online appendix.

stream of real profits:

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

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

$$1 = q^k_t \left(\left[1 - \frac{\phi}{2} \left(\frac{I_t}{I_{t-1}} - 1 \right)^2 \right] - \phi \left(\frac{I_t}{I_{t-1}} \right) \frac{I_t}{I_{t-1}} \right) + \mathbb{E}_t \left[\Lambda_{t,t+1} q^k_{t+1} \phi \left(\frac{I_{t+1}}{I_t} - 1 \right) \left(\frac{I_{t+1}}{I_t} \right)^2 \right].$$

Because $\omega^r_t = 1/p_t$ and $\omega^c_t = \omega^s_t = 1$, 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:

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

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

$$K_t \equiv \left[\eta + (1-\eta) \left(\lambda x^s_t + (1-\lambda) x^r_t \right) \right] f_t, \tag{3.20}$$

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 affects the market interest rate through bank balance sheet and profitability constraints.[34] Suppose that the central bank increases the supply of liquidity through the purchase of corporate bonds from banks. 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.[35]

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

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

[34] 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).

[35] 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.

where $\pi_{t-1,t} \equiv \log(\Pi_{t-1,t})$ and $y_t \equiv \log(Y_t)$, 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 standing facilities (reserves and lending facility). For now, we set these equal to the main policy interest rate plus or minus a desired corridor.

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

$$\overline{R}_t = R_t^{tr} + c_t \tag{3.25}$$

The second additional policy are liquidity operations that separately move the market interest rate below the main policy interest rate. While essentially, this is 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:

$$R_t = R_t^{tr} - q_t \tag{3.26}$$

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

4 Analytical Results: Monetary Policy and Competing Channels

The bank first-order conditions (3.7) and (3.8) together with the (binding) IC and IR constraints, (3.3) and (3.2) imply menu of loan contracts. These contracts specify 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.*

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.[36] 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.*

Proposition 2 highlights 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.

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

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

Under this condition, we can find two distinct 'regimes:'

1. *Pooling equilibrium* ($\tau_t^s = \tau_t^r$ *and* $x_t^s = x_t^r = 1$)*: all firm financing needs are met if*

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

[36] 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.

2. Separating equilibrium ($\tau_t^s < \tau_t^r$ and $x_t^s < x_t^r = 1$): not all firms are financed

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

There is credit rationing in equilibrium if

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

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, $1-p_t$. If safe firms outnumber risky firms ($\lambda > 1/2$), the credit rationing incentive always **falls** in the return on capital, R_{t+1}^s.*

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

$$\mathbb{E}_t \left[\frac{\Lambda_{t,t+1}}{\Pi_{t,t+1}} (1-p_{t+1}) R_{t+1}^s \right] x_t^s, \tag{4.5}$$

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, $\lambda \left(R_{t+1}^s - \underline{R}_t \right)$, and the marginal cost from the resulting increase in the information rent. Once this cost outweighs the revenue, the banks will begin to ration credit until the marginal revenue and cost are equal.

The point at which rationing occurs depends on how risky small business lending is but also on the interest on reserves since this sets 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. This reallocation of assets from small business loans to reserves does not simply reflect a story of banks as intermediaries of funds. That is, it does not follow that banks have a fixed amount of funds, allocating them either to reserves or loans. The amount of liquidity in the banking sector and the composition of bank balance sheets depends crucially on bank profitability. If banks substitute loans for central bank deposits, bank profitability takes a hit since reserves offer a lower return than lending. It follows therefore that a $1 fall in lending leads to a an increase in reserve balances of less than $1.

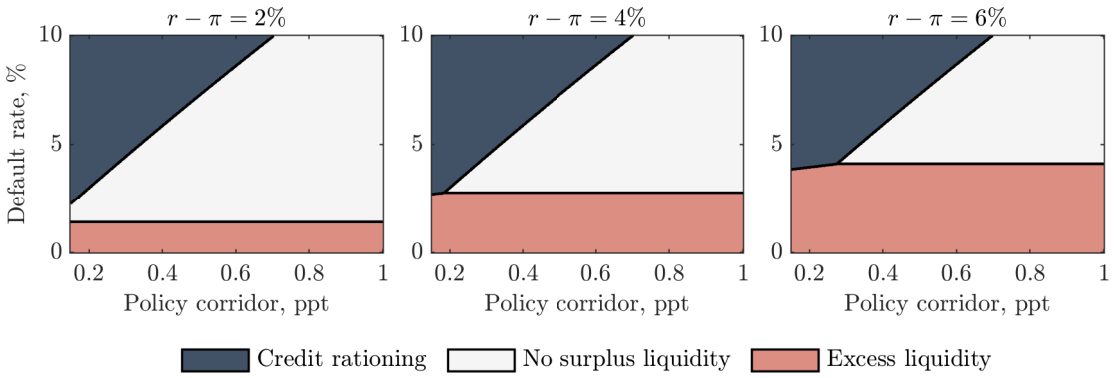


Figure 5: Comparative statics showing the role of risk (risky firm default rate), the policy corridor and the steady-state real interest rate. Other parameter values: $\eta = 0.5$, $\lambda = 0.775$, $F = 0.15$, $\beta = 0.9655, 0.9902, 0.9951$.

Proposition 3 highlights another scenerio under which excess reserves can emerge, due to firm entry costs. This friction introduces another source of economic efficiency, occurring in a low-risk economy in which a pooling equilibrium will emerge. The information rents are relatively low and so the return from lending to safe borrowers dominates any additional revenue that could be earned by separating the firms. Because information rents are low, firm profitability is relatively low, leading to a low firm entry rate. The abundant bank liquidity outstripping the number of firms seeking funds results in a rise in excess reserves, or the holding of low return assets. Even though the adverse selection problem is limited, the combination of low interest assets and a small number of firms (due to firm entry costs), and hence capital investment, is a larger credit spread.

The alternative equilibria outlined in proposition 3 are illustrated in figure 5. In addition to the plotted default rate and corridor, the regions depend only on a small set of parameters: The share of small firms in the economy, $1 - \eta$, plays a minor role with the composition of SMBs between risky and safe, $1 - \lambda$, more critical. The greater the number of risky firms, the greater the risk of credit rationing. The only other parameters affecting the equilibrium outcome are the discount factor, β, and firm entry costs, F. The effect of lowering β is shown moving left to right across the panels in figure 3. This differences are due only to how discounting affects firm entry, and therefore has an identical effect to increasing F. A higher β increases the value of future firm profits and encourages more firm entry for a given entry cost. Because a higher

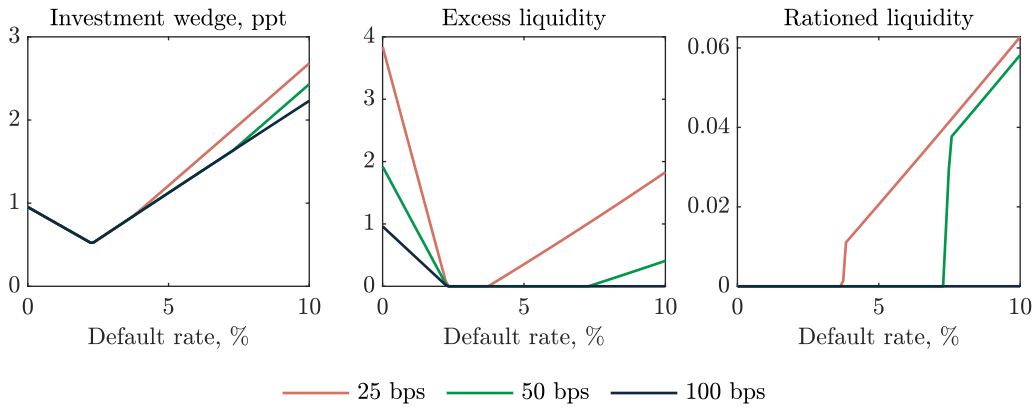


Figure 6: Comparative statics showing the role of risk (risky firm default rate) and the policy corridor on key macro-financial outcomes. Parameter values: $\eta = 0.5$, $\lambda = 0.775$, $F = 0.15$, $\beta = 0.992$.

β (lower F) encourages a higher firm entry rate, the more likely there will insufficient liquidity to fund all businesses, and we see the red area representing the pooling equilibrium smaller in the left panel. This points to an important potential source of growth from the secular fall in interest rates observed in advanced economies over the last 50 years.

Although the average loan approval rate in the white area is lower than in the red area in figure 5, and despite the higher default risk, the macroeconomic outcomes can be better. The reason is that the lower firm entry fostered in the red area leads to lower output potential. Through the lens of the model, this manifests through a higher investment wedge, since the lower firm entry leads to less investment and less capital in production, implying a higher steady-state capital return. This high return on lending is offset by higher bank reserve balances. This is shown in figure 6. When risk is lower, the low firm entry introduces and inefficiency that shows up as a positive investment wedge The figure also clearly a risk threshold beyond which banks ration credit. The lower in the interest on reserves or policy floor, or the wider the corridor, the higher this risk threshold becomes.

4.1 Liquidity policies: two channels

Not only can the central bank target the main policy interest rate and set the interest rates on the reserve facility, we allow them to conduct open market operations. By injecting additional liquidity into the economy via asset purchases (e.g., corporate bonds), the financial markets will

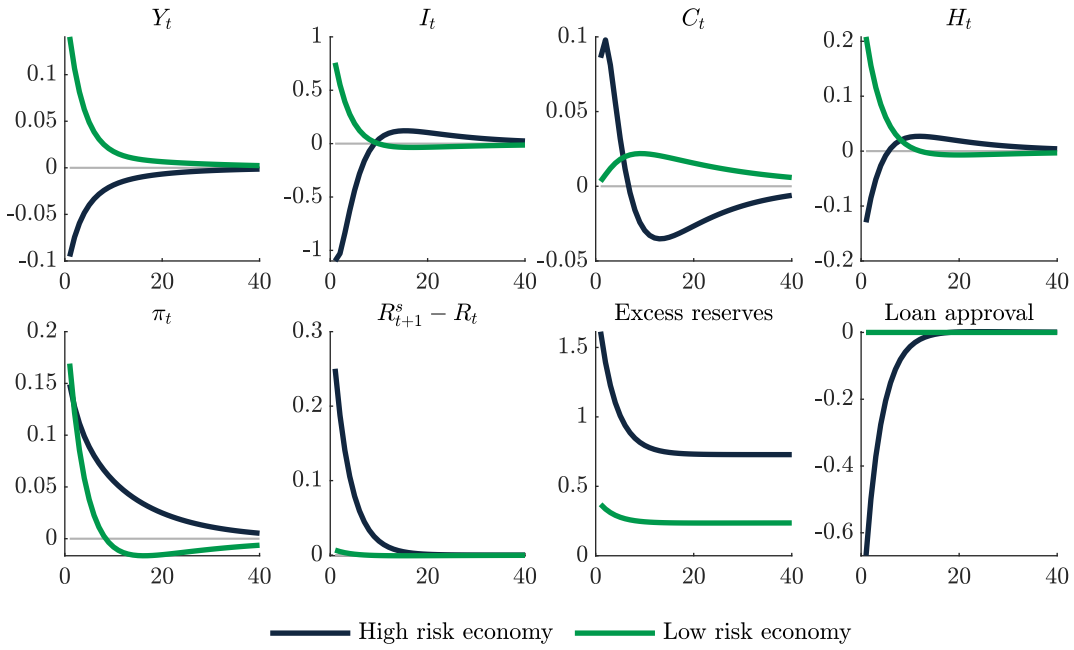


Figure 7: Impulse response functions to an unexpected temporary 'QE' programme. Plots in the top row show % deviation from steady state. The bottom row shows ppt deviation except for excess reserves with plots the level response. Excess reserves is given as the ratio of reserves to stock of loans. Parameter values: $\beta = 0.992$, $\alpha = 0.3$, $\delta = 0.023$, $\sigma_c = 1$, $\xi = 0.75$, $\zeta = 7$, $\gamma_\pi = 1.5$, $\gamma_y = 0.25$, $\pi^* = 0.005$, $\eta = 0.5$, $\lambda = 0.775$ and $F = 0.15$. The policy floor is 50 bps below R^{tr}_t, and (per annum) risky firm default rate is 12% (high risk) and 2% (low risk).

only clear at a lower interest rate. The reason is that the central bank is effectively swapping one type of asset paying R_t, with another (reserves) paying $\underline{R}_t < R_t$. This lowers the market short-term rate below R^{tr}_t and towards the floor, reflecting the observed response of short term rates to asset purchase programmes (see figure 1).

Figure 7 plots the impact of a liquidity easing programme in two alternative model economies: a high risk economy, and a low risk economy. The policy is modelled as an unexpected, temporary drop in the market interest rate below the main policy interest rate by 25 basis points (annualised), half the way towards the policy floor, $\underline{R}_t - R^{tr}_t = 50$ bps.

The policy shock follows an AR(1) process with persistence 0.75, so this can be considered a large asset purchase calibrated to target a spread $R^{tr}_t - R_t$ of 25 bps, followed by a gradual tightening. Figure 7 shows that the impact of the policy depends critically on the level of risk in the economy, and points to two primary channels by which quantitative easing programmes

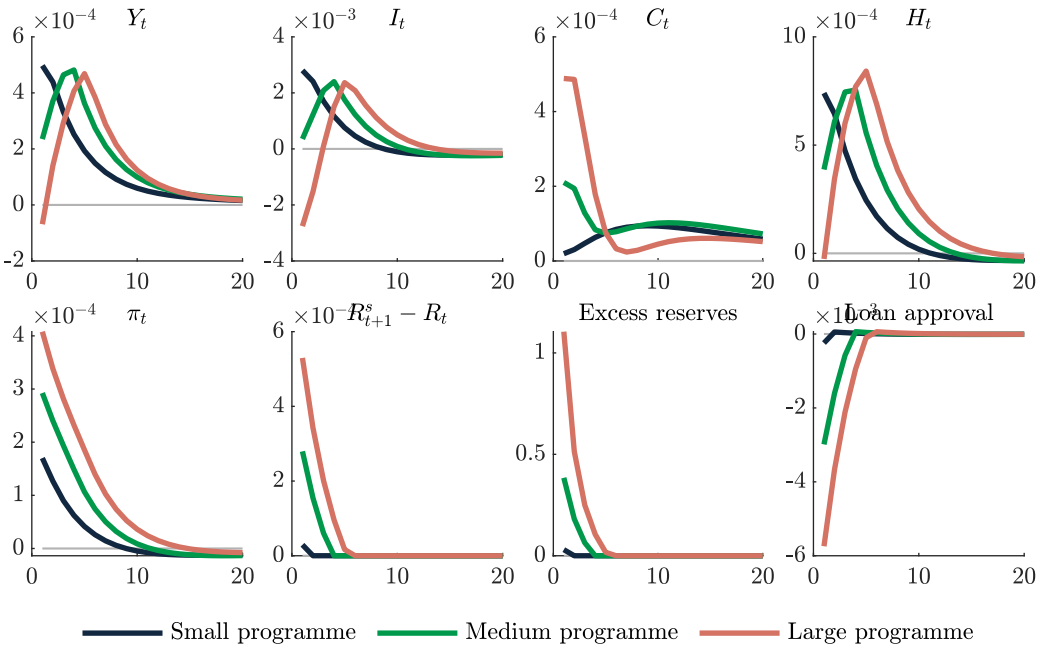


Figure 8: Impulse response functions to a temporary 'QE' programme. Plots in the top row show % deviation from steady state. The bottom row shows ppt deviation except for excess reserves with plots the level response. Excess reserves is given as the ratio of reserves to stock of loans. Parameter values: $\beta = 0.992$, $\alpha = 0.3$, $\delta = 0.023$, $\sigma_c = 1$, $\xi = 0.75$, $\zeta = 7$, $\gamma_\pi = 1.5$, $\gamma_y = 0.25$, $\pi^* = 0.005$, $\eta = 0.5$, $\lambda = 0.775$ and $F = 0.15$

impact the real economy away from the zero-lower bound. The first is the standard demand channel, which is in action in the low-risk economy. The fall in the market interest is exactly equivalent to an unexpected, persistent negative monetary policy shock, leading to an expansion through intertemporal substitution.

If the policy shock occurs in a high-risk economy, where banks are already rationing credit, the primary impact is to worsen lending conditions in the economy and lower investment. On one hand, the lower interest rate increases consumption demand, but because constraint (4.4) is already binding, lowering the interest rate towards the floor increases the opportunity cost of lending, and further increases the incentive to ration credit. Banks tighten lending standards, approving fewer loans and credit spreads rise. At the same time, reserve balances rise sharply. The inequality constraint (4.1) gives the threshold for these two scenario. Providing the constraint never binds, the programme will always have expansionary effects. The two economies plotted in figure 7 remain either side of this threshold.

If a policy action causes (4.1) to bind, then banks can start to ration credit. The overall effect of the policy, whether it is expansionary or contractionary, will then depend on macro-financial conditions (i.e., firm risk) and the size of the programme. Figure 8 shows responses to three asset programmes of different sizes: one lowering R_t by 10 bps relative to R_t^{tr}, one by 20 bps, and one by 30 bps. In all cases, the annual risky firm default rate is 6%. The response to a 10 bps relative fall in R_t is identical to the equivalent response in the low-risk economy in figure 7, scaled by the shock size. The policy is insufficient to cause the rationing condition (4.1) to bind, whereas under both larger programmes, the drop in the interest rate relative to the interest on reserves is enough to generate credit rationing. As the interest on reserve balances rises, the opportunity cost of lending increases, squeezing the marginal value of safe loans. This contractionary effect offsets the expansionary effects from the standard channel, and under the larger programme this is enough to cause a sharp decline in investment and an overall contraction on impact.

4.1.1 Robustness: investment adjustment costs and preferences

The results here a sensitive to the utility function and the inclusion of investment adjustment costs. The effects of the QE policy affects the real economy through the two conflicting channels: the expansionary demand channel working primarily through consumption effects, and the contractionary credit rationing channel working through investment. By reducing investment volatility, investment adjustment costs dampens the credit rationing channel and can allow the expansionary channel to dominate the contractionary channel, even in the high-risk economy.

Employing the preferences proposed by Jaimovich and Rebelo (2009), calibrated with a weak short-run wealth effect on labour supply, can see the large policy generate a substantial recession as the consumption effect dampens and no longer offsets the drop in investment. Habits in consumption will also dampen the offsetting effects of consumption demand, although not sufficiently to alter the key results.

4.2 Liquidity policies at the effective-lower bound

Liquidity policies are usually used as an additional tool when the main policy interest rate, R_t^{tr} is constrained by the effective-lower bound (ELB). This poses a questions as to how the ELB

effects the expansionary and contractionary channels. The key insight is the role of inflation expectations.

Section incomplete.

5 Optimal Policy in a Tractable Credit-Rationing Model

In this section we focus on a restricted version of the model to derive further analytical results and optimal targeting rules.

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6 Concluding remarks

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