Essays on banking: opacity, stability, and monetary policy

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Abstract

The first chapter shows that a bank uses loan loss provision disclosures to smooth reported earnings in a non-linear fashion, so that the direction and size of earnings smoothing depends on where current earnings sit in the banks' distribution of earnings. This smoothing is estimated to have a positive effect on the market value of the bank, even when controlling for the variance in reported earnings which the smoothing is targeting. A supporting theoretical model shows that bank managers have an incentive to smooth reported earnings in this way when investors display risk aversion and demand a risk premium for volatile returns.

The second chapter studies how a conventional monetary loosening effects bank stability. I obtain a monetary policy shock from a Factor Augmented Vector Autoregression (FAVAR) for the US and project this shock onto stability measures for banks with different levels of deposits. The bank responses to the monetary policy shock provide evidence that when interest rates are far from zero, a cut in the policy rate is associated with an improvement in the stability of banks. However, when the policy rate is already close to zero, the stability of high deposit banks is shown to deteriorate, with the effect strongest for high deposit banks with low levels of capital.

The third chapter explores the role of bank transparency in the bank lending channel of monetary policy. An important proposition in the bank lending channel is that bank responses to policy changes depend on outsider perceptions of their balance sheet strength, which in turn are influenced by the level of bank transparency and information asymmetry between banks and depositors. Transparency about bank asset quality is introduced to the framework of Disyatat (2011) to demonstrate its role in the bank's response to changes in conventional monetary policy. Empirical tests using bank equity prices show that transparency can act to strengthen or attenuate a bank's response to a monetary policy surprise, depending on the quality of the bank's assets and broader macroeconomic and financial conditions.

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Declaration of authorship

I, Nicola Delf, declare that this thesis is a presentation of my own original work and I am the sole author. This work has not previously been presented for a degree or other qualification at this University or elsewhere. All sources are acknowledged as references.

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Introduction

This thesis comprises three essays on banking, tied together by the themes of bank opacity (equivalently, transparency), bank stability, and conventional monetary policy. Understanding the interaction between these themes is an important endeavour for financial stability and monetary policy makers, particularly in the context of the policy responses to the 2008 financial crisis. The crisis underscored the central role of banks in financial system stability and monetary policy transmission, leading to policy responses that included an increased emphasis on bank transparency and near-zero interest rates in the US. The implications of these responses have gained significant attention in the academic literature over the past two decades, and this thesis contributes to the ongoing debate.

The post-crisis emphasis on bank transparency sought to restore confidence in financial stability. The transparency with which banks disclose the risks associated with their balance sheets is a critical issue in bank regulation, with initiatives including Basel III and regular stress testing aimed at improving bank transparency. Banking firms tend to be considered more opaque than their non-financial counterparts due to the complexity of their assets.[1] Some level of opacity is necessary for risk sharing in financial intermediation, enabling banks to provide liquidity to depositors[2] while avoiding bank runs and maintaining stability.[3] Though banks make disclosures about the quality of their loan portfolios, the quality of information they provide depends on their accounting decisions.[4] Opacity might increase if banks choose to manipulate financial statements, for example using loan loss provisions to smooth earnings.

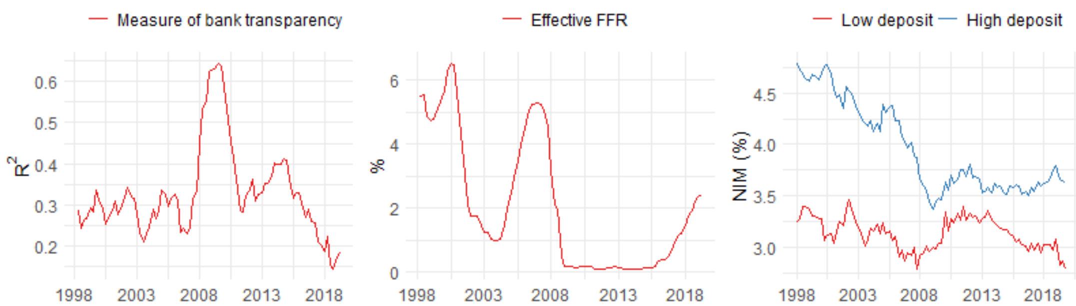
However, the beneficial effects of opacity rely on faith in the financial system and a stable economic environment. Too much opacity may be suboptimal if it enables inefficient investments and an increase in risk taking, as ‘bad’ banks can mimic ‘good’ banks.[5] This is evidenced by the role of opacity in masking the quality of bank assets

[1] Morgan (2002); Flannery et al. (2004); Iannotta (2006).
[2] Known as the Hirshleifer (1971) effect; see Kaplan (2006) and Dang et al. (2017).
[3] Diamond and Dybvig (1983); Jungherr (2018).
[4] Bushman (2014); Chen et al. (2022).
[5] Bouvard et al. (2015); Goldstein and Leitner (2018).

in the early 2000s, which supported a build up of systemic risk. The first chart in the Figure illustrates how greater bank transparency became optimal during the crisis, as it supported a restoration of faith in the financial system.

In parallel to efforts to increase bank transparency, policy makers responded to the crisis with aggressive monetary easing. The second chart in the Figure shows how the effective Federal Funds Rate (FFR) fell below 0.25% at the start of 2009. This easing was against a significant tightening of credit standards, and sought to limit deterioration in the real economy due to the financial disruption. While the policy was set with macroeconomic objectives in mind, it also had consequences for the pricing of bank deposits. The low policy rate exposed banks to an effective lower bound on deposit rates, disrupting this part of the transmission mechanism. Banks are able to fully pass-through changes in the policy rate to deposit rates when rates are at normal levels,[6] however this mechanism breaks down when rates are close to zero.[7] As a result, banks with a high dependence on deposits faced a relatively greater compression in net interest margins (NIMs) following the fall in the effective FFR in 2009, evidenced in the third chart of the Figure. This compression hindered internal capital generation, the effects of which could not be fully offset by returns on long-term assets with a persistently flat yield curve.

Figure: Effective Federal Funds Rate (FFR), measure of bank transparency, and NIMs for low and high deposit banks



Note: The first figure plots a measure of bank transparency that is estimated at the bank-quarter level as the adjusted R^2 from rolling regressions of current and future bank defaults on variables from bank financial statements that describe asset quality (see Chapter 3). The second figure plots the effective Federal Funds Rate (FFR). The third figure plots the median net interest margins (NIMs) for banks sorted into deposit-asset quintiles, where 'low' deposit refers to those in the first quintile, and 'high' deposit refers to those in the fifth quintile.

Against this landscape, this thesis contributes to the existing literature as follows. The first and third chapters provide new contributions to the literature by exploring the impact of bank opacity and transparency in financial reporting with respect to

[6] Neumark and Sharpe (1992); Drechsler et al. (2017).
[7] Altavilla et al. (2022); Wang et al. (2022).

two different themes: the impact of opacity on the market value of the bank, and the impact of transparency on the response of bank equity prices to a monetary policy announcement. The second chapter, along with the third, offer further new contributions to the literature by exploring heterogeneity in bank responses to monetary policy announcements. Specifically, the second chapter considers the role of deposit funding in the response of bank stability to a monetary policy shock. The remainder of this introduction outlines the findings of each chapter and their specific contributions.

The existing literature on bank opacity presents a duality whereby the benefits of opacity are conditional on the level of risk, be it bank specific or system wide. The beneficial role of opacity in supporting risk sharing in financial intermediation has been established theoretically, but there is very little empirical evidence on the positive value effect of opacity. Against this, the first chapter analyses how smoothing of reported earnings, which introduces opacity to financial disclosures, is interpreted by equity markets. The empirical analysis is motivated by a theoretical framework based on Trueman and Titman (1988), which shows that banks are incentivised to smooth reported earnings since doing so will maximise the equity holder's posterior probability that earnings variance is low. Dynamic panel regressions are used to show that bank earnings smoothing is non-linear around a positive threshold: when the bank's earnings are above the bank-specific mean level of earnings, it is estimated that loan loss provisions are around 13% higher than average. Comparatively, when the bank's earnings are below this threshold, provisions are around 27% lower than average. Moreover, using a bank-level time-varying proxy for earnings smoothing, this behaviour is shown to have a positive effect on the valuation of the bank. This result holds even when controlling for the earnings variability that the smoothing is targeting. The findings provide novel empirical support to the notion that opacity can be beneficial, as equity holders interpret earnings smoothing behaviour as the bank manager absorbing bad news rather than passing it to outsiders.

The second chapter explores conventional monetary policy following the financial crisis, specifically examining whether a conventional monetary loosening during the period of very low interest rates adversely affects bank stability. Drawing on evidence of a lower bound on deposit rates (e.g., Wang et al., 2022), the chapter offers new insights into the effects of a low rate policy on bank stability. The analysis uses a Factor Augmented Vector Autoregression (FAVAR) to estimate monetary policy shocks, which are projected onto measures of bank stability for banks with varying levels of deposit reliance. The projections reveal that, when interest rates are far away from zero, monetary loosening leads to improved bank stability across bank types. This improvement occurs for two reasons. First, bank funding costs may fully adjust to policy rates, while rates on long-term assets remain fixed in the short term, thus supporting internal capital generation and enhancing net worth. Second, consistent with the bank capital channel, an overall improvement in the macroeconomic environment raises asset values, which in turn strengthens bank capital and limits realisation of ex-ante risks. This finding contributes to the literature on the risk-taking channel of monetary policy, which highlights an increase in the risk of *marginal* lending following monetary easing (e.g., Dell'Ariccia et al., 2017; Paligorova and Santos, 2017). The results in this chapter show that higher ex-ante risk taking does not necessarily lead to greater bank riskiness, which also depends on the bank's operating environment. However, when interest rates are already very low, the same monetary loosening has contrasting effects: it decreases the stability of banks more reliant on deposits, while the stability of banks with lower dependence on deposits improves in the same way as when interest rates are at normal levels. This is due to the lower bound on deposits rates, which depresses the net interest margins of deposit-heavy banks, limiting their capacity to generate internal capital and compromising their stability. This finding lends new support to the 'reversal' rate of monetary policy proposed by Abadi et al. (2023), with important insights for the interaction between monetary policy and financial stability.

The insights obtained on the role of opacity in the first chapter and the channels of monetary policy transmission studied for the second chapter inspired the research question for the third chapter: If there are circumstances when opacity in financial disclosures can be valued positively by outsiders, does transparency play a role in the transmission of monetary policy through banks? The bank's external finance premium plays a critical role in the bank capital channel (Disyatat, 2011), and it depends on outsider perceptions of bank health. The third chapter incorporates transparency around bank asset quality into the framework of the bank lending channel of Disyatat (2011), to demonstrate how transparency affects the sensitivity of the bank's external finance premium to changes in monetary policy. The hypothesis is tested empirically by analysing the role of transparency in the responses of bank equity prices to high-frequency monetary policy surprises. Transparency is measured using the adjusted R^2 from rolling bank-level regressions of bank write-offs on loan loss provisions, non-performing assets, earnings and the capital-asset ratio, following the methodology of Chen et al. (2022). The appeal of this measure is that it captures the idea that outsider understanding of the bank's asset quality depends on information released by the bank itself. The analysis reveals that bank transparency significantly influences equity price responses to monetary policy surprises. However, the direction of this effect depends on the bank's reported share of non-performing assets and the prevailing macroeconomic environment. When the bank has higher quality assets and the environment is stable, transparency mitigates the fall in bank equity prices following a surprise monetary tightening. Conversely, when a bank reports lower quality assets and is operating during a crisis period, transparency strengthens the fall in equity prices. This occurs because the adverse operating environment, combined with perceptions of poor asset quality, heighten concerns about the bank's risk of default. There is limited empirical evidence on the role of information frictions in the transmission of monetary policy through banks, and these results constitute important new insights into how the quality of bank disclosures determine the bank's response to monetary policy announcements.

Chapter 1

Bank opacity, earnings smoothing and bank valuation

1.1 Introduction

Do reported loan loss provisions tell us anything about a bank beyond its approach to loan loss management? Loan loss provisions contribute to reserves to cover loan defaults, though managers have discretion in their reporting, creating the possibility that they contain additional information.[1] Such discretionary behaviour creates opacity, which ordinarily would be associated with a discount in the bank's market value as investors demand a risk premium due to the possibility of adverse selection. However, this study presents a theoretical model in which earnings smoothing is favoured by a risk averse equity holder since it increases their posterior probability that the bank's earnings variance is low. The theory is supported by empirical analysis, which shows that markets place positive value on opacity in the form of earnings smoothing, even when controlling for variance in the earnings profile.

The theoretical framework is a version of Trueman and Titman (1988), modified to suit the business of a bank. The bank is owned by a risk averse equity holder, and the bank manager obtains benefits by increasing the bank's equity value. Only the bank manager knows the bank's economic earnings and has discretion over how these are reported; they may choose to smooth earnings to maximise the equity holder's valuation. However, the equity holder does not know which banks have the ability to smooth reported earnings. The model proposes two hypotheses for empirical testing: first, do banks use loan loss provisions to smooth earnings over time? Second, does

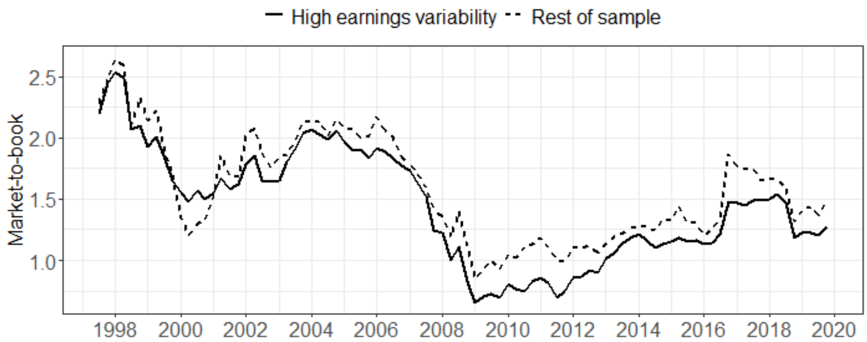
[1]Starting with Wahlen (1994) and Beaver and Engel (1996), research has sought to distinguish between the discretionary and non-discretionary components of reported loan loss provisions. Beatty and Liao (2014) provide a comprehensive review.

earnings smoothing through loan loss provisions enhance the bank's value?

The empirical analysis uses a sample of public US banks for the period 1995Q1 to 2019Q4 to address the theoretical questions. The findings show that banks use provisions to smooth their reported earnings in a non-linear fashion. A positive earnings threshold exists, beyond which the bank's provisioning approach changes. When earnings exceed the bank-specific mean, it is estimated that loan loss provisions are around 13% higher than average. Conversely, when earnings are below the bank-specific mean, provisions are 27% lower than average.

In response to the second theoretical question, the analysis shows that this behaviour positively impacts bank value. As expected, given the role of volatility in the risk averse preferences of equity holders, Figure 1.1.1 shows how banks with lower earnings variability are generally valued more positively than those with higher variability. While this is pattern is unsurprising, it overlooks the possibility that lower earnings variability may result from proactive smoothing of earnings disclosures, which would imply information opacity. A measure of reported earnings smoothing at the bank-quarter level is constructed to examine this relationship. The measure is a time-varying beta coefficient derived from rolling regressions of loan loss provisions on earnings, representing an extension of Bushman and Williams (2012). The measure is shown to be associated with reduced volatility in reported earnings, supporting its use.

Figure 1.1.1: Market-to-book ratio of banks with high and low earnings variability



Note: The chart presents the mean average market-to-book ratio for banks with a high variation in earnings before provisions versus the rest of the sample. Variation in earnings before provisions is estimated as a rolling standard deviation over 12 quarters, and 'high' variability is defined as above the 90th percentile for that quarter.

The reported earnings smoothing proxy has a positive effect on bank value, measured both by the market-to-book ratio and Tobin's Q. The effect is around two-thirds of the size of the impact of non-interest income on bank value, a key factor in bank value and future cash flow expectations. Importantly, given Figure 1.1.1, the positive effect of reported earnings smoothing on valuation is robust to controlling for volatility of earnings, on which the market values negatively. However, earnings smoothing can only offset around half of the negative impact of a volatile earnings profile. One reason for the value-enhancing effect of increased opacity is that equity holders may perceive the bank manager as absorbing some of the bad news, rather than passing it on to outsiders (Jin and Myers, 2006; Allayannis and Simko, 2022).

Importantly, this study focuses on the concept of smoothing in *reported earnings* and accounting disclosures, distinct from smoothing through *real decisions* that impact output and economic earnings. Real earnings smoothing could involve managers choosing alternate investment or production actions to produce a smoother earnings path (Lambert, 1984) or distorting production to meet expected earnings levels (Acharya and Lambrecht, 2015). To that end, 'reported earnings smoothing' may be shortened to 'earnings smoothing' throughout this paper.[2]

In addition to research already mentioned, this study contributes to three main areas of the literature. The first contribution is to research into discretionary loan loss provisions, which as well as earnings smoothing may be used for signalling or capital management (e.g., Ahmed et al., 1999; Fonseca and González, 2008; Bushman and Williams, 2012; Curcio and Hasan, 2015). This study extends the earnings smoothing hypothesis by showing that bank-level earnings smoothing behaviour is non-linear, supporting the work of Laeven and Majnoni (2003) and Balboa et al. (2013).

Second, the study contributes to research into the effect of reported earnings smoothing on firm value. For non-financial firms, existing evidence suggests that those exhibiting earnings smoothing tend to experience positive value effects (Gao and Zhang, 2015; Allayannis and Simko, 2022). The results here support Allayannis and Simko (2022), who argue that earnings smoothing is more likely to improve value when less information is available about the firm. This is particularly relevant for banks, which are generally more opaque than non-financial firms due to the opaque nature of loans as assets (Morgan, 2002; Dang et al., 2017). To my knowledge, this is the first study to directly link the use of loan loss provisions for earnings smoothing with its effect on bank value.

Third and finally, this study contributes to the literature on the role of opacity for US banks, given the popular use of discretionary loan loss provisions as a proxy for bank opacity. Several empirical studies have evidenced that banks with higher levels of discretionary loan loss provisions tend to face negative outcomes such as increased loss overhang, pressures on lending due to capital adequacy concerns, or stock market illiquidity (Beatty and Liao, 2011; Bushman and Williams, 2015; Zheng, 2020; Zhang and McIntyre, 2020). However, economic theory suggests that some opacity is required

[2]On the point of definitions, it should be noted that the term 'earnings' is used to describe pre-tax income, and 'income' describes money retained by a firm after the deduction of all expenses and taxes. This study abstracts from any role for taxation in smoothing behaviour to maintain focus on the role of loan loss provisions.

for effective risk sharing between liability holders (Kaplan, 2006; Dang et al., 2017). This research supports the view that some opacity is beneficial: equity holders reward bank managers for earnings smoothing, implicitly recognising their role in absorbing some of the risks associated with lending. In this context, earnings smoothing may signal managerial competence in respect of risk and accounting management. The topic therefore has importance for regulators of accounting standards and financial stability. Accounting regulators prioritize transparency to ensure compliance, accountability, and reduce fraud, while financial stability regulators focus on disclosure transparency to maintain confidence in financial intermediaries and system stability. Post-financial crisis initiatives aim to balance necessary opacity with sufficient transparency, enabling better risk monitoring and decision making by claimholders.

The chapter is structured as follows. First, Section 1.2 summarises the relevant literature, followed by the theoretical framework (Section 1.3), the empirical approach (Section 1.4) and the data (Section 1.5). The Section 1.6 presents the results on the tests for earnings smoothing, and Section 1.7 presents the results for the tests of the effect of earnings smoothing on bank value. Finally, Section 1.8 discusses the results, and Section 1.9 concludes.

1.2 Summary of relevant literature

1.2.1 Motivations for smoothing reported earnings

Fudenberg and Tirole (1995) describe earnings smoothing as 'the process of manipulating the time profile of earnings to make the reported income stream less variable'. Earnings smoothing theories rely on information asymmetries between the firm and outsiders, and generally present the insider as either acting to take advantage of the asymmetry to gain a private benefit (rent extraction), or acting to reduce the agency costs associated with the asymmetry by providing a signal to outsiders.

Fudenberg and Tirole's (1995) framework fits in the former category, where earnings smoothing arises as the manager acts to defend their own interests and retain the private benefits of being a manager. The manager, averse to income risk due to the threat of shutdown from owners in case of poor performance (measured by income), has an incentive to distort reported earnings to maximize their tenure and private benefits. In a similar vein, Graham and Harvey (2001) suggest that earnings smoothing arises as managers seek to minimise their corporate tax burden, which is inversely related with their private benefits. Comparatively, the framework of Trueman and Titman (1988) aligns with the latter category, where the manager smooths earnings to reduce the agency costs of asymmetry and increase the outsider claim-holder's valuation of the firm. Smoothing achieves this by reducing the perceived probability of default, as outsiders lack full knowledge of the firm's ability to inter-temporally shift earnings. Smoothing allows a lower quality firm to mimic a higher quality firm, ultimately reducing borrowing costs.

The motivations for earnings smoothing — rent extraction and agency cost reduction — can be interpreted as either reducing or improving outsider information. Rent extraction actions are information reducing: for example, Leuz et al. (2003) link earnings smoothing with reduced investor protection, where strong protections help discipline insiders. In contrast, earnings smoothing that addresses agency costs can be seen as information improving: for example, Sankar and Subramanyam (2001) show how a manager with value-relevant private information may communicate this through biased earnings reports, which are later corrected, to optimise their two-period compensation package. Similarly, Chaney and Lewis (1995) demonstrate how firms can signal their value by reducing the noise around their expected level of earnings.

1.2.2 Evidence of smoothing reported earnings by banks

Empirical evidence generally supports the notion that banks smooth earnings through accounting disclosures such as loan loss provisions (LLPs). LLPs serve to increase the bank's loan loss allowance (or reserves) in anticipation of future defaults.[3] Banks make provisions on the observation of non-performing assets, considering the current reserve level, and deduct them from gross earnings. Several studies have explored when banks are more likely to smooth reported earnings. Using cross-country samples, Laeven and Majnoni (2003), Fonseca and González (2008), Bushman and Williams (2012) and Bouvatier et al. (2014) all find evidence that loan loss provisions are used to smooth earnings. Fonseca and González (2008) show that measures limiting rent extraction, such as strong investor protections, accounting disclosure requirements, and supervisory power, reduce earnings smoothing for a sample of 40 countries. Bouvatier et al. (2014) similarly find that supervisory power and ownership concentration lowers earnings smoothing for European banks. Bushman and Williams (2012) show a positive association between earnings smoothing and risk shifting behaviour, especially for banks with lower levels of capital. Laeven and Majnoni (2003) confirm earnings smoothing but highlight an asymmetric relationship, with banks provisioning more when earnings are negative.

Balboa et al. (2013) investigate this asymmetry in the relationship between provisions and reported earnings, finding that it depends on the *size* of earnings. For a panel of US banks, the disclosure strategy is to decrease earnings when they are negative ('big bath'), and smooth earnings when they are positive, with provisions inflated during periods of very high earnings. This non-linearity may reflect that banks tend to engage

[3] These are the expected loan losses that arise over the duration of the loan and were not anticipated at origination, and contrast with unexpected losses which are covered by regulatory capital.

in greater earnings smoothing during economic turmoil, which aligns with Fudenberg and Tirole (1995) and is shown empirically by Hamadi et al. (2016) following the 2008 financial crisis. Similarly, Danisman et al. (2021) finds that US banks are more likely to smooth earnings during periods of economic policy uncertainty.

1.2.3 Bank valuation and reported earnings smoothing

The market value of a bank may be interpreted as the present value of the cash flows that accrue to all funding providers, where the present value assessment by the market depends on the information that is available to outsiders. Earnings smoothing may influence this value assessment by signalling the bank's type and providing value-relevant information about its fundamentals, which includes the potential masking of those fundamentals. The value of a bank can be measured by the market-to-book ratio, which compares the market value of equity to its book value (e.g., Beaver et al., 1989; Calomiris and Nissim, 2014). A ratio greater than one suggests the market perceives the firm as worth more than reported, possibly due to expectations of future high performance. Another measure, Tobin's Q, approximates the value of future cash flows of a bank by comparing the market value of a bank's assets to their replacement value (e.g., Boyd and Runkle, 1993; Laeven and Levine, 2007; Huizinga and Laeven, 2012). The replacement value is unobserved, so is approximated for by book values, and the proxy for Tobin's Q may be interpreted as the value created per dollar of assets (Minton et al., 2019).

Although there is research on bank characteristics and valuation, few studies concentrate on earnings smoothing. Beaver et al. (1989) find a positive association between the market-to-book ratio and loan loss reserves, and hypothesise that this could be due to managers using reserves as a 'good' signal by managing earnings. Huizinga and Laeven (2012) find evidence to suggest that the understatement of losses permitted by discretionary accounting practices during the financial crisis contributed significantly to the decline in Tobin's Q. Adjacent to valuation, Kilic et al. (2013), Hamadi et al. (2016) and Hegde and Kozlowski (2021) study the effect of discretionary accounting practices (including earnings smoothing) on equity returns. Kilic et al. (2013) argue that regulatory changes in the accounting of derivatives which induced affected banks to use provisions to smooth earnings, reduced the informativeness of provisions. Hamadi et al. (2016) similarly use a regulatory change to show how a reduction in earnings smoothing improved the informativeness of loan loss provisions to the market. Hegde and Kozlowski (2021) estimate a positive abnormal market return when banks over-provision during good economic times, characteristic of earnings smoothing. However, none of these studies directly test the effect of earnings smoothing on market value.

1.3 Theoretical motivation for earnings smoothing

The theoretical motivation for earnings smoothing is based on the model of Trueman and Titman (1988, henceforth TT), who demonstrate how the manager of a firm with a variable flow of earnings is motived to smooth reported earnings. The framework is well suited to the analysis of a bank because it relies on two important assumptions:

1. Insiders have the discretion to move income inter-temporally (which is possible for a bank manager via loan loss provisions); and
2. Claim-holders cannot fully observe each firm's operations so are not certain of the flexibility to to shift earnings (which is supported by the inherent opacity of bank assets).

Consider a representative bank which makes a two period investment in a single unit of productive technology (e.g., a loan to an entrepreneur). The bank's investment is funded by a single insured depositor who requires zero return. The bank is owned by a single risk averse equity holder who holds claim to the cash flows which accrue from the investment. The characteristics of the bank and the equity holder are outlined first, followed by the decision to smooth earnings.

1.3.1 The bank

The bank is run by a manager, who is paid a fixed salary and does not respond to monetary incentives. Instead, the manager obtains non-pecuniary private benefits B which increase with equity holder's utility. In the case of a bank, this may reflect how the bank's cost of funding is decreasing in the equity holder's valuation, and lower funding costs allow the bank to maximize the spread from its intermediation activities. The investment in productive technology generates economic earnings each period by the following process:

$$\tilde{x}_t = \mu + \tilde{e}_t \tag{1.1}$$

Where μ are expected earnings and $\tilde{e}_t$ is the per-period variation from expected earnings. The distribution of $\tilde{e}_t$ is normal with mean zero, and the process is stationary over time. Expected earnings μ are known to all agents, though $\tilde{e}_t$ and its distribution are the bank manager's private information. The variance of $\tilde{e}_t$ may be high (h) or low (l), so that $\sigma_h^2 > \sigma_l^2$.

Only the bank knows whether it has the flexibility to smooth earnings. In reality, the bank might be unable to smooth earnings due to limited sophistication in accounting skills, a tight regulatory capital ratio,[4] or the realisation of a large credit risk. When

[4] Assuming that the regulatory capital ratio is binding, if the bank is very close to this ratio then it may not have the ability to smooth earnings at all since internally generated capital (profit) is instead required to maintain the required amount of capital. The interaction between earnings smoothing,

the manager is able to smooth earnings, it is assumed that they can move only a fixed proportion, g, of the difference $\mu - x_1$, from the second period to the first, where $0 < g < 1$. Then, smoothed earnings for the first period are:

$$x_1^s = (1-g)x_1 + g\mu \tag{1.2}$$

And for the second period:

$$x_2^s = x_2 - g(\mu - x_1) \tag{1.3}$$

Here, the superscript s denotes earnings which are smoothed between periods. In this sense, g may be interpreted as an earnings reporting parameter that changes the conditional variance of reported earnings relative to economic earnings, while preserving the unconditional mean. Further, g ensures the reversal of earlier smoothing practices and restricts the extent to which high-variance banks can mimic low-variance banks. The value of g is assumed to be known by all agents.

1.3.2 The equity holder

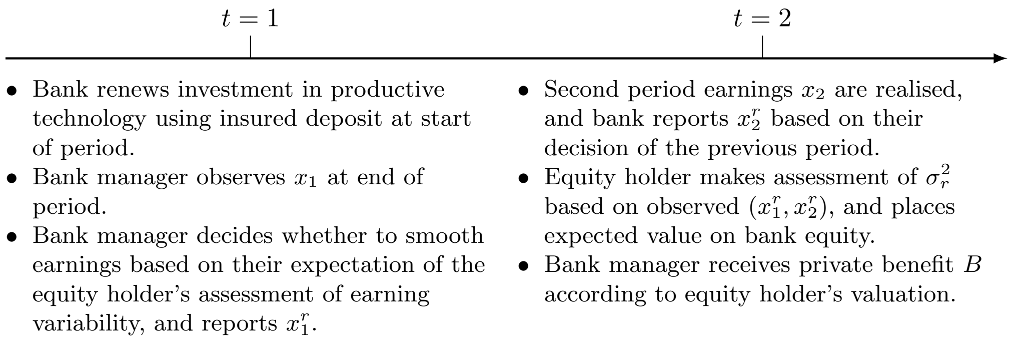
The equity holder is risk averse, and has a preference for low earnings variability as they interpret volatile earnings as a sign that the bank has unstable investments. Risk aversion means that *reported* earnings variance determines the value the equity holder places on the bank, since the equity holder is an outsider and does not know true economic earnings. The equity holder's preferences can be represented by a standard constant relative risk aversion (CRRA) utility function, so that the risk premium $\pi(x^r)$ demanded is an increasing function of reported earnings variance:

$$\pi(x^r) = \frac{\sigma_r^2 \theta}{2} \tag{1.4}$$

Where $\theta \neq 1$ is the coefficient of relative risk aversion, $x^r = x_1^r + x_2^r$ are total earnings over the two periods and σ_r^2 is variance in reported earnings. Since the equity holder does not know the bank's reporting strategy, x^r could feasibly represent economic earnings x or smoothed earnings x^s.

Though the equity holder can observe reported σ_r^2, they do not know the true earnings variance. Ex-ante, the equity holder assigns prior probabilities that the intertemporal variation from μ will be low with probability p_l, and high with $p_h = 1 - p_l$. The equity holder must also assign a belief that the bank has the flexibility to manage earnings: the equity holder believes this is the case $0 < q < 1$ percent of the time.

Figure 1.3.1: Timeline of events



1.3.3 Decision to smooth earnings

Following the intuition of TT, this section outlines why a bank manager with the objective of maximising the risk averse equity holder's valuation has an incentive to smooth income.[5] The timeline of events is presented in Figure 1.3.1.

Given the equity holder's observation of the bank's reported income over the two periods, their posterior probability of true economic earnings variance is defined as $\dot{p}_i$, where $i = (l, h)$. We can additionally define E_l (E_h) as the price the equity holder would pay if they knew for certain that the variance of economic earnings is low (high), where $E_l > E_h$. Then, with imperfect information about the true variance, the price the equity holder is willing to pay is based on the posterior expectations about the bank's underlying earnings variance:

$$E(\dot{p}_l) = \dot{p}_l E_l + \dot{p}_h E_h \tag{1.5}$$

Intuitively, the equity holder is willing to pay a higher price when their posterior probability of low earnings variance is higher, since this implies that the per period deviation from μ is minimised. To maximise the equity valuation, the bank manager therefore has an incentive to increase the equity holder's posterior probability that the variance of economic earnings is low.

Consider that the reported earnings $x^r = (x_1^r, x_2^r)$ over $t = 1, 2$ can have two possible interpretations by outsiders:

1. **The bank manager is unable to smooth reported earnings** so that reported earnings equal economic earnings, $x^r = (x_1^r, x_2^r) = (x_1, x_2) = x$, where x without superscript represents economic earnings.

internal capital generation and cost of equity effects is not explicitly addressed in this framework.

[5]This framework differs from TT in that the equity holder in this set-up is risk averse; TT instead model a risk neutral equity holder who is seeking to maximise the value of debt which will be sold at the end of $t = 2$. Then, the bank manager is seeking to maximise the future value of the debt which is higher when earnings variance is perceived to be low.

2. **The manager is able to smooth reported earnings**, so $x^r = (x_1^r, x_2^r) = (x_1^s, x_2^s) = x^s$. Then, by rearranging Equations 1.2 and 1.3 respectively and with knowledge of g and μ:

$$x_1 = \frac{x_1^r - g\mu}{1-g} \tag{1.6}$$

$$x_2 = x_2^r + g(\mu - x_1) \tag{1.7}$$

Only the bank manager knows for certain whether earnings were smoothed, and the equity holder does not know whether they are observing x or x^s. Given the observation of x^r, the best the equity holder can do is make an assessment of whether they have observed σ_l^2 to use in their valuation. Applying Bayes rule, this assessment equates to:

$$\begin{aligned} \dot{p}_l = p\left(\sigma_l^2 \mid x^r\right) &= \frac{p(x^r \mid \sigma_l^2) \cdot p(\sigma_l^2)}{p(x^r)} \\ &= \frac{p_l\left(qf_l^s(x^r) + (1-q)f_l(x^r)\right)}{p_l\left(qf_l^s(x^r) + (1-q)f_l(x^r)\right) + p_h\left(qf_h^s(x^r) + (1-q)f_h(x^r)\right)} \end{aligned} \tag{1.8}$$

Where $f_i(x^r)$ is the joint probability density function of reported earnings evaluated at $x^r = (x_1^r, x_2^r)$ if the manager *cannot* smooth income and variance is σ_i^2 $(i = l, h)$. Similarly, $f_i^s(x^r)$ is the equivalent density function when the bank manager *can* smooth earnings.

The bank manager must make the decision to smooth earnings in $t = 1$, before they know the value of x_2. The manager can therefore only calculate their expected value of the equity holder's posterior probability of low income variance over all x_2 using the process $\tilde{x}_2$. Define the bank manager's expected value of the equity holder's posterior probability ($\dot{p}_l$) that the bank has low income variance and smoothed income as $E_i[\dot{p}_l(x_1^s, \tilde{x}_2^s)]$, and equivalently $E_i[\dot{p}_l(x_1, \tilde{x}_2)]$ when the bank does not smooth income, where $(i = l, h)$. This expectation is taken in $t = 1$, when the manager is making a decision about whether to smooth income. TT then assert the following lemma (p.132):

Lemma. *If economic earnings are normally distributed, then:*

$$E_i[\dot{p}_l(x_1^s, \tilde{x}_2^s)] > E_i[\dot{p}_l(x_1, \tilde{x}_2)]$$

In words, the bank manager expects that the equity holder is more likely to believe that the bank has low variability in earnings when earnings are smoothed. This expectation incentivises the bank manager to smooth earnings, as they believe that doing so will increase the equity holder's valuation of the bank. The proof is outlined in Appendix 1.A. This result means banks may use loan loss provisions to smooth earnings with the objective of reducing the agency costs inherent in financial intermediation. By reducing these agency costs, this could improve the bank's value by reducing the size of the associated risk premium.

This framework produces two hypotheses to test. The **first hypothesis** examines whether banks smooth earnings. This amounts to testing for the size of g in Equations 1.2 and 1.3, such that if $g = 0$ then we can conclude that banks do not smooth earnings. Comparatively, $g > 0$ would be associated with the size of bank earnings influencing their provisioning practices. The **second hypothesis** examines whether the existence of earnings smoothing leads to an improvement in the valuation of the bank. This result would support the Lemma by providing a motivation for the bank manager to smooth reported earnings.

1.4 Method: empirically assessing earnings smoothing

The empirical strategy addresses the two hypotheses in two stages. The first stage tests for the presence of earnings smoothing in a sample of publicly listed US banks through the use of discretionary loan loss provisions. The second stage tests whether earnings smoothing at the bank level is associated with proxies for higher valuation.

1.4.1 First stage: earnings smoothing using loan loss provisions

The empirical method to test whether banks smooth earnings over time using loan loss provisions closely follows models used to test similar hypotheses in the literature (e.g., Laeven and Majnoni, 2003; Fonseca and González, 2008; Hamadi et al., 2016) by using variations of the following regression:

$$\begin{aligned} llp_{it} = \alpha + \sum_{s=1}^{2} \zeta_s llp_{it-s} + \sum_{r=0}^{1} \eta_r nnpa_{it-r} + \vartheta nco_{it} + \\ \beta ebp_{it} + \delta_1 I_1(ebp_{it} < \Pi) + \delta_2 (I_1(ebp_{it} < \Pi) \times ebp_{it}) + \Omega X_{it} + \Gamma F_t + \varepsilon_{it} \end{aligned} \tag{1.9}$$

Where llp_{it} represents loan loss provisions, and ebp_{it} represents earnings before provisions and taxes and is the explanatory variable of interest. To account for the possibility of a non-linear relation between loan loss provisions and earnings, $I_1(ebp_{it} < \Pi)$ represents an interaction variable that is equal to 1 when ebp_{it} is below some threshold Π, and zero otherwise. Then, we would expect $\beta > 0$ and $\beta + \delta_2 < 0$ if loan loss provisions are being used to smooth earnings.

A lagged dependent variable is included to reflect the inter-temporal nature of the theoretical model, whilst accounting for an unobserved time varying co-founder that cannot be subsumed in a time-invariant variable such as a fixed effect. Equation 1.9 is estimated using the Arellano-Bond (AB) difference GMM estimator to account for endogeneity of the lagged dependent variable. In this set up, the bank-level financial accounting variables are also specified as endogenous and are instrumented using GMM-style instruments.

The variables $nnpa_{it}$ (new non-performing assets) and nco_{it} (net charge offs) control for bank-specific credit risks.[6] A lagged value of $nnpa_{it}$ is additionally included to account for any overlap between quarters that results from a shallow view of the timings between assets turning non-performing and being provisioned for. Only the contemporaneous value of nco_{it} is included since write-offs are more definitive in their nature.

The term X_{it} contains bank-level variables to control for other features that might influence provisions. The possibility of capital management via LLP is controlled for by $equity_{it-1}$. This is measured in terms of the balance sheet rather than in regulatory terms following Fonseca and González (2008), since the treatment of loan loss provisions in regulatory capital has varied by bank over the sample period. The possibility of size effects are controlled for by $size_{it-1}$; for instance, larger banks may benefit from greater diversification (Demsetz and Strahan, 1997) which could reduce their provisioning requirements. Finally, $loans_{it}$ represents loans net of the loan loss allowance and controls for changes in earnings that may be driven by the size of the loan book. Rapid growth in the loan book could be associated with greater default risk for the overall portfolio which would require greater provisioning requirements (Laeven and Majnoni, 2003; Bouvatier et al., 2014).

Finally, F_t contains macroeconomic variables to control for possible risks emerging from outside of the bank which could influence the level of reserves the bank might require. These are chosen according to the banker's information set at the time of making the provision, specifically: the level of unemployment, the house price index, the level of inflation, corporate credit spreads, the Federal Funds rate, retail sales and the industrial production index. The macroeconomic variables are included as orthogonal factors to reduce any effects of multicollinearity between the variables.

1.4.2 Second stage: earnings smoothing in bank valuations

The second hypothesis asks whether earnings smoothing improves the bank's valuation. This assessment takes two parts: first, I estimate a bank-level proxy for earnings-smoothing based on the sensitivity of loan loss provisions to changes in earnings. Second, I use this proxy of the degree of earnings smoothing to test whether it has any

[6] Often in the literature this is controlled for using the change in non-performing assets Δnpa_{it} (see Beatty and Liao, 2014) though this approach neglects the respective variation in net charge offs and new non-performing assets. It can be shown that $\Delta npa_{it} = nnpa_{it} - nco_{it}$, so that the sum of new non-performing assets and net charge offs can be used in place of Δnpa_{it}. In words, the change in non-performing assets depends on the arrival of *new* non-performing assets and the departure of existing non-performing assets in the form of net charge offs.

effect on bank valuation.

Part one: estimating a proxy for earnings smoothing

Earnings smoothing is approximated by a series of time-varying bank-specific measures. The first proxy uses a simple rolling window correlation between earnings before provisions and loan loss provisions, $\rho_{i\tau}(llp, ebp)$, following Rountree et al. (2008). Building on this approach, the remaining proxies use the coefficient from bank-level rolling window regressions of llp_{it} on ebp_{it}:

$$llp_{it} = \alpha_{i\tau} + \beta_{i\tau} ebp_{it} + \Gamma_{i\tau} X_{it} + \epsilon_{it} \tag{1.10}$$

Where llp_{it} and ebp_{it} are as defined previously, X_{it} represents a set of control variables, and $\beta_{i\tau}$ is the earnings smoothing proxy. The regression is estimated on τ windows of size $w = 12$ quarters, to balance between maximising the number and robustness of the $\beta_{i\tau}$ estimates. The β of Equation 1.10 is estimated twice: $\beta_{i\tau}(1)$ excludes control variables with $X_{it} = 0$, and $\beta_{i\tau}(2)$ uses X_{it} to control for non-discretionary components of provisions (specifically $nnpa_{it}$, nco_{it}, alw_{it}, ue_t, ind_t and ffr_t). The second beta estimate is closest to the time invariant equivalent proxy of Bushman and Williams (2012). Whilst the correlation coefficient tells us how much much earnings and provisions move together, the regression coefficients describes the sensitivity of provisions to the level of earnings and allow us to control for possible interference from other factors. The time-varying beta may further illustrate non-linearities between llp_{it} and ebp_{it} as earnings evolve over time.

Part two: testing the role of earnings smoothing in bank valuation

Using the earnings smoothing proxy, a second stage regression examines whether the propensity to smooth increases the bank's value as perceived by the market. The following panel regression is estimated:

$$value_{it} = \alpha_1 + \alpha_2 \beta_{i\tau} + \Gamma X_{it} + \epsilon_{it} \tag{1.11}$$

Where $value_{it}$ represents the value of bank i at time t, $\beta_{i\tau}$ is the measure of earnings smoothing (either the correlation coefficient $\rho_{i\tau}$ or $\beta_{i\tau}$ as estimated in Equation 1.10), and X_{it} represents a set of control variables. Following existing literature (e.g., Laeven and Levine, 2007; Huizinga and Laeven, 2012; Minton et al., 2019), bank value is measured by Tobin's Q and the market-to-book ratio. Tobin's Q (tq_{it}) is defined as the market value of assets divided by the book value of assets, where the book value proxies for the replacement value and the overall measure reflects value created per dollar of assets.[7] The market-to-book ratio (mb_{it}) is equal to the ratio of the market value of equity and the book value of equity.

Equation 1.11 is estimated without and with variables that might also influence the bank's value. Specifically, these are earnings volatility, the equity-to-asset ratio, bank size and the share of non-interest income. Earnings volatility is measured as the standard deviation of earnings before provisions over the same rolling window as the earnings smoothing proxies, following Rountree et al. (2008). Inclusion of earnings volatility seeks to control for the possibility that investors are more interested in a smooth earnings profile than the means taken to achieve it.

The selection of remaining control variables is guided by Minton et al. (2019), aiming to balance the bank's value-relevant characteristics while avoiding excessive variables that could exacerbate multicollinearity. Taking these control variables in turn:

- Literature on the value-relevance of **equity-to-assets** generally agrees that it could affect bank value, but disagrees on the direction of the effect.[8] Equity may be seen as value-positive if it exceeds regulatory requirements, signalling diligent monitoring and addressing informational frictions that lead to agency problems (Holmstrom and Tirole, 1997; Mehran and Thakor, 2011). Conversely, equity could negatively affect value by providing a cushion for incompetent managers, allowing them to reduce their exposure to market discipline (Hellmann et al., 2000).

- **Size** controls for valuation differences attributed to large banks. While large banks may be valued higher due to their claim on public resources (Ueda and Weder di Mauro, 2013), they may also face costs that outweigh this benefit (Minton et al., 2019). Additionally, size may account for unobserved characteristics, such as diversity, that contribute to value (Laeven and Levine, 2007).

- **Non-interest income** derived from activities like trading, venture capital, or securitisation, can be a significant earnings source for some banks (Calomiris and Nissim, 2014). When these income streams are persistent, they should enhance the market value beyond the book value.

[7] The market value of assets is obtained as the book value of assets plus the market value of equity, less the book value of equity. The market value of equity is obtained using the quarter-end stock price and number of common shares outstanding, and the book value of equity is obtained as the sum of stockholders equity, deferred taxes, envestment tax credit and preferred stock.

[8] Any effect assumes the Modigliani and Miller (1958) leverage indifference theorem does not hold for banks.

1.5 Data

1.5.1 Bank-level data

Bank-level data is obtained from CRSP Compustat via WRDS, which is a merged database that allows access to both CRSP's US Stock Data and Compustat's fundamental data. The sample is quarterly and restricted to public banks. The chosen sample period is 1995Q1 to 2019Q4: a large number of banks report data from the early 1990s onwards, and starting the sample in the middle of the decade aims to exclude any adjustments to provisioning and lending practices that will have taken place following the Federal Deposit Insurance Corporation Improvement Act (FDICIA) in 1991, as well as the transition period to Basel I (initiated 1989).[9] The sample period ends before the start of 2020, Q1 and Q2 of which saw huge increases in loan loss provisioning due to the COVID-19 pandemic, which may have interfered with trends in earnings smoothing.

Observations are excluded when assets and gross loans are less than or equal to zero, the loan-to-asset ratio is greater than one, and when the capital asset ratio is greater than one. Non-depository institutions are excluded, as are banks with less than three years of consecutive observations available. Finally, all variables are Winsorised at the 1% level at the top and bottom of their distributions to limit the influence of outliers, following Chen et al. (2022) amongst others.[10] The final sample comprises 984 banks covering 41,825 bank quarters. For the CRSP stock price data used in estimating the market value of equity, the stock price of the last day of the quarter is used and where a closing price is not available, the CRSP convention is taken and the bid-ask average is used.

1.5.2 Macroeconomic data

The variables chosen to represent the bank's set of macroeconomic information are identified based on reporting frequency. The variables are the level of unemployment (ue_t, an indicator of future credit risk), inflation (cpi_t), the Case-Schiller real estate index (hpi_t), the effective Federal Funds rate (ffr_t), the BAA-AAA corporate bond yield spread ($corp_t$, credit spreads), advance retail sales estimate (rs_t) and the industrial production index (ind_t). Data is sourced from FRED Federal Reserve Bank of St Louis. To address multicollinearity, these variables are included as orthogonal factors derived from principal component analysis.

[9] Prior to the early 1990s, loan loss reserves were included in calculations of total capital so that a one dollar increase in LLP increased regulatory capital by the tax rate times one dollar, producing a direct incentive for capital management via LLP (Ahmed et al., 1999).

[10] For example, the CRSP Compustat data does not indicate M&A activity, which may influence extreme values.

1.5.3 Descriptive statistics

Table 1.5.1 presents the summary statistics of the variables. The average quarterly llp_{it} as a proportion of total lagged loans is 0.13%, which is reasonably close to the mean value of 0.17% reported by Beatty and Liao (2014) for a shorter sample (1993Q4 to 2012Q2). The median llp_{it} is 0.07%, with significant skewness and long tails in the distribution. Some of the other financial accounting variables, such as variations of npa_{it} and alw_{it}, also exhibit non-normal distributions. Despite this, the analysis retains untransformed values of llp_{it}, as transformations would eliminate negative values that capture revisions of historic provisions. Heteroscedasticity from excess skewness and kurtosis is addressed by using robust standard errors clustered at the bank level.

The estimated proxies of bank valuation are consistent with the literature. For example, Minton et al. (2019) reports mean Tobin's Q and market-to-book ratios of 1.065 and 1.757, respectively, while this study reports 1.0424 and 1.4670. The average capital-to-asset ratio ($equity_{it}$) is 9.95%, comparable to the 10.0% reported by Chen et al. (2022) for 1994 to 2019, and slightly higher than estimates from earlier periods, reflecting an overall upward trend in capital-to-asset ratios.

Table 1.5.2 shows a correlation matrix of the bank variables, with most correlations in the expected direction. Notably, the sign of nco_{it} is opposite to other credit risk variables, as a negative value indicates a write-off, signalling higher risk. The low correlation between llp_{it} and ebp_{it} may appear to contradict earnings smoothing theory, but this statistic does not control for other factors and assumes a linear relationship.

Table 1.5.1: Descriptive statistics

	Mean	Median	SD	Min	25th p.	75th p.	Max
llp_{it}	0.0013	0.0007	0.0026	-0.0042	0.0003	0.0013	0.0407
npa_{it}	0.0179	0.0097	0.0242	0.0000	0.0050	0.0203	0.2330
Δnpa_{it}	0.0002	-0.0002	0.0059	-0.0540	-0.0014	0.0011	0.0663
$nnpa_{it}$	0.0014	0.0003	0.0067	-0.0541	-0.0008	0.0021	0.0976
nco_{it}	-0.0011	-0.0004	0.0024	-0.0343	-0.0012	-0.0001	0.0035
$size_{it}$	7.4116	7.0924	1.5523	4.0191	6.3035	8.2413	13.1021
ebp_{it}	0.0063	0.0061	0.0045	-0.0552	0.0042	0.0082	0.0366
$loans_{it}$	0.6558	0.6693	0.1210	0.1339	0.5907	0.7402	0.9113
$equity_{it}$	0.0995	0.0943	0.0314	-0.0043	0.0794	0.1130	0.2903
tq_{it}	1.0424	1.0345	0.0634	0.8936	0.9998	1.0767	1.4297
mb_{it}	1.4670	1.3528	0.7012	0.0561	0.9984	1.8261	5.6721
nii_{it}	0.1596	0.1395	0.1110	-1.5778	0.0880	0.2102	1.8061

Notes: All bank level variables are presented as the ratio to total lagged loans, except: Δnpa_{it} which is the difference between npa_{it} (as a percent of total assets) at periods t and $t-1$; $size_{it}$ which the natural log of total assets; $loans_{it}$ and $equity_{it}$, which are the ratios of loans and capital to total assets respectively; nii, which is total non-interest income as a proportion of the sum of total non-interest income and total interest income; Tobin's Q and the market-to-book value ratio (tq_{it} and mb_{it} respectively) which are as defined in Section 1.4.2.

Table 1.5.2: Correlation matrix

	llp_{it}	Δnpa_{it}	$nnpa_{it}$	nco_{it}	ebp_{it}	$equity_{it}$	$size_{it}$	$loans_{it}$	tq_{it}	mb_{it}	nii_{it}
llp_{it}	1.0000										
Δnpa_{it}	0.3089	1.0000									
$nnpa_{it}$	0.5639	0.9327	1.0000								
nco_{it}	-0.7889	-0.1296	-0.4784	1.0000							
ebp_{it}	-0.1608	-0.1092	-0.1594	0.1588	1.0000						
$equity_{it}$	-0.1379	-0.0759	-0.1190	0.1290	0.0398	1.0000					
$size_{it}$	0.0645	-0.0042	0.0206	-0.0750	0.2383	-0.0050	1.0000				
$loans_{it}$	0.0246	0.0760	0.0582	0.0254	-0.3362	0.0165	-0.1625	1.0000			
tq_{it}	-0.2175	-0.0803	-0.1606	0.2330	0.4671	-0.0821	0.1864	-0.0866	1.0000		
mb_{it}	-0.2144	-0.0888	-0.1681	0.2325	0.4698	-0.1998	0.1960	-0.1087	0.9572	1.0000	
nii_{it}	0.0224	-0.0596	-0.0337	-0.0599	0.2573	-0.0091	0.3743	-0.2175	0.0809	0.0901	1.0000

1.6 Evidence for earnings smoothing

Table 1.6.1 presents the estimated coefficients for Equation 1.9. The number of lags of the dependent variable is set as $s = 2$.[11] The table presents two thresholds: $I_1(ebp_{it} < P_{10}(ebp_i))$ is equal to 1 when the earnings of bank i in period t are below the 10th percentile of bank i's earnings over the sample, and zero otherwise, whilst $I_1(ebp_{it} < \mu_{ebp_i})$ uses the mean average for bank i. Observations in these thresholds comprise 11% and 25% of the sample, respectively.

[11] When $s = 1$, the model is deemed misspecified by the Arellano-Bond test for autocorrelation in the first-differenced errors by identifying autocorrelation beyond the first lag, whilst the coefficient for $s = 3$ is generally insignificant.

The coefficients on ebp_{it} and its interaction variables are characteristic of earnings smoothing, supporting Hypothesis 1. Across all columns, the coefficient on ebp_{it} is positive and significant, while the interacted variables are negative, significant, and larger in absolute terms. This indicates that on average, banks make higher provisions when earnings are above a bank-specific threshold. However, when earnings fall below this threshold, provisions are significantly lower with $\beta + \delta_2$ respectively equal to -0.0821 and -0.0783 for Columns (3) and (4). It is estimated that when earnings are above the bank's sample average, a one standard deviation increase in earnings increases loan loss provisions by 0.0173pp (around 13% of mean loan loss provisions). Conversely, when earnings are below the bank's average, provisions are estimated to be 0.0353pp lower (around 27% of mean loan loss provisions). This asymmetry across the threshold possibly reflects some of the skew in earnings at the bank level.

The significance of the lagged dependent variables suggests that provisions are persistent, with a time-varying fixed effect. This implies that bank managers consider previous provisioning behaviour when setting current provisions. The effect is relatively small: on average, an increase of one standard deviation in provisions from the prior two quarters would cumulatively increase current provisions by around 0.0477pp, which is less than one fifth of a standard deviation of llp_t.

The coefficients for the remaining financial accounting variables align with expectations. A positive change in new non-performing assets significantly increases loan loss provisions. Interestingly, the coefficients on $nnpa_{it}$ and nco_{it} are in opposite directions, implying that not disaggregating Δnpa_{it} causes some misspecification. This result is important in the context of the literature on discretionary loan loss provisioning, where the definition of non-discretionary variables determines the model residual and thus the final measure of discretionary LLP (e.g., Beatty and Liao, 2014; Zheng, 2020).

The coefficient on equity is positive and significant. Changes to regulatory capital rules mean that the use of provisions for capital management is not a plausible reason.[12] The positive association likely reflects that well-capitalised banks may be more cautious in their provisioning approach. Similarly, the coefficient on loans is positive and significant, suggesting forward-looking behaviour. The coefficients on the macroeconomic factors is not commented on directly, though it is noted that sensitivity analysis (not reported) using the original variables of the macroeconomic environment generally produces signs in the expected direction.

[12]Since the introduction of Basel I in 1989, there has been no direct mechanical link between loan loss provisions and regulatory capital.

Table 1.6.1: Test of earnings smoothing

	(1)	(2)	(3)	(4)
llp_{it-1}	0.0884***	0.0891***	0.0957***	0.0965***
	(0.0157)	(0.0158)	(0.0162)	(0.0163)
llp_{it-2}	0.0791***	0.0782***	0.0879***	0.0870***
	(0.0118)	(0.0118)	(0.0119)	(0.0119)
$nnpa_{it}$	0.0538***	0.0545***	0.0523***	0.0530***
	(0.0059)	(0.0060)	(0.0059)	(0.0060)
$nnpa_{it-1}$	0.0100*	0.0102*	0.0091	0.0094*
	(0.0047)	(0.0048)	(0.0047)	(0.0048)
nco_{it}	-0.6450***	-0.6462***	-0.6533***	-0.6546***
	(0.0290)	(0.0290)	(0.0295)	(0.0295)
ebp_{it}	0.0358***	0.0318**	0.0409***	0.0385***
	(0.0100)	(0.0111)	(0.0100)	(0.0111)
$I_1(ebp_{it} < P_{10}(ebp_i))$	0.0007***		0.0007***	
	(0.0001)		(0.0001)	
$I_1(ebp_{it} < P_{10}(ebp_i)) \times ebp_{it}$	-0.1232***		-0.1230***	
	(0.0161)		(0.0160)	
$I_1(ebp_{it} < \mu_{ebp_i})$		0.0006***		0.0007***
		(0.0001)		(0.0001)
$I_1(ebp_{it} < \mu_{ebp_i}) \times ebp_{it}$		-0.1148***		-0.1168***
		(0.0131)		(0.0130)
$equity_{it-1}$			0.0127***	0.0131***
			(0.0024)	(0.0024)
$size_{it-1}$			0.0003**	0.0003**
			(0.0001)	(0.0001)
$loans_{it}$			0.0023***	0.0022***
			(0.0006)	(0.0006)
Constant	0.0000	0.0001	-0.0050***	-0.0048***
	(0.0001)	(0.0001)	(0.0008)	(0.0008)
N	37843	37843	37841	37841
Banks	968	968	968	968
Chi^2	4038	4081	4131	4112
AB(1)	-11.0264	-11.0657	-11.0664	-11.1025
AB(2)	-0.6729	-0.6102	-0.9316	-0.8735

Standard errors in parentheses

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Note: Dependent variable is the ratio of loan loss provisions to lagged total loans. The regressions are estimated using the Arellano-Bond difference GMM estimator to address endogeneity of the lagged dependent variable. Reported standard errors are robust.

1.6.1 Interpretation of results

The analysis so far supports the first hypothesis of the theoretical model, showing that banks use loan loss provisions to smooth their earnings inter-temporally. The effect of earnings on loan loss provisions is non-linear, in that there is some positive earnings threshold around which banks will decide to draw on loan loss provisions to smooth their profile of earnings. This non-linearity is consistent with the evidence presented by Balboa et al. (2013), and provides reasoning as to why some research rejects the hypothesis of earnings smoothing when tested in a linear framework (e.g., Ahmed et al., 1999). In terms of the theory, this threshold may be interpreted as μ, and the combined coefficient $\beta + \delta_2$ may be interpreted as g. Between periods 1 and 2, amount $g(x_1 - \mu)$ is smoothed, which is equivalent to the deduction (or addition) made to loan loss provisions in the period. Indeed, the true size of $\tilde{e_1} = \tilde{x}_t - \mu$ is unknown, as it is the bank manager's private information.

This result implies a degree of discretionary loan loss provisioning behaviour, which could have two separate effects. First, it implies that bank accounting disclosures are less transparent than is intended by accounting standard setters. This may have financial stability implications to the extent that loan loss provisions are a true representation of the quality of the bank's assets. Second, discretionary behaviour could act to offset the procyclicality of loan loss provisions (Pool et al., 2015). If banks provision more when earnings are above some threshold, then this may put downward pressure on lending during the 'good times', limiting credit expansion.

Finally, it is worth commenting on how to interpret the results when earnings are negative, which is the case for a relatively small proportion of the sample (around 3.7% of observations). Since $\beta + \delta_2 < 0$, this means that if $ebp < 0$ then the effect on loan loss provisions will be overall positive, which is suggestive of 'big bath' behaviour (Balboa et al., 2013; Bornemann et al., 2015).[13] An alternative interpretation could be that negative earnings point to a riskier operating environment with high levels of losses; if these losses are driven by defaults, then this necessitates higher provisions. However, this type of external riskiness is controlled for by the inclusion of the macroeconomic factors.

1.7 Earnings smoothing and bank value

Given this evidence of earnings smoothing, this section tests hypothesis two on whether the sensitivity of loan loss provisions to earnings before provisions has a positive effect on the bank's value.

[13]'Big bath' behaviour means that the size of losses is increased so that provisions may be used in subsequent accounting periods, hence increasing the opportunities to improve remuneration or job security.

1.7.1 Summary of data used in testing the effect of earnings smoothing on bank valuation

Table 1.7.1 summarises the measures of earnings smoothing and bank characteristics. The sample of banks is reduced relative to the first stage of the analysis, since a bank is only included in the analysis if the propensity measure is available continuously for at least fifteen years. For the smoothing propensity proxy estimates that are based on correlation and a univariate regression, $\rho_{i\mathcal{T}}(llp, ebp)$ and $\beta_{i\mathcal{T}}(1)$, the sample comprises 655 banks, whilst for $\beta_{i\mathcal{T}}(2)$ the sample comprises 369 banks. The measures of earnings smoothing propensity are Winsorised at the the 1% level at the top and bottom of their distributions to mirror the treatment of the other variables. Despite the smaller samples, the characteristics of the remaining banks do not differ significantly; importantly, the measures of valuation tq_{it} and mb_{it} are still very close to the main sample averages.

Table 1.7.1: Descriptive statistics for earnings smoothing propensity

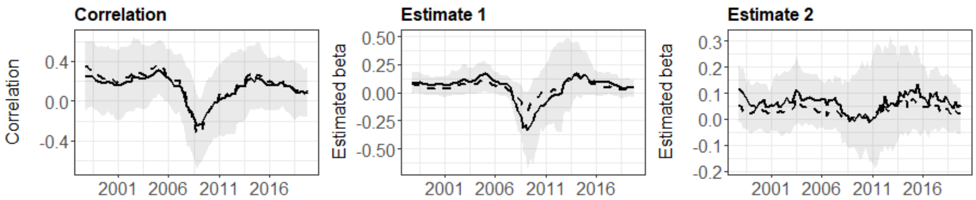
	Mean	Median	SD	Min	25th p.	75th p.	Max
$\rho_{it}(llp, ebp)$	0.1274	0.1635	0.4524	-0.9793	-0.2027	0.4874	0.9830
$\beta_{it}(1)$	0.0368	0.0404	0.4953	-3.6543	-0.0681	0.2054	3.2665
$\beta_{it}(2)$	0.0568	0.0331	0.3916	-3.3716	-0.0637	0.1862	2.4749
$\sigma(ebp)$	0.0011	0.0007	0.0013	0.0001	0.0005	0.0013	0.0118
mb_{it}	1.4705	1.3509	0.7262	0.0561	0.9882	1.8492	5.6721
tq_{it}	1.0429	1.0350	0.0652	0.8936	0.9988	1.0787	1.4297
llp_{it}	0.0014	0.0007	0.0027	-0.0042	0.0003	0.0014	0.0407
ebp_{it}	0.0063	0.0060	0.0045	-0.0552	0.0043	0.0081	0.0366
$size_{it}$	7.6299	7.2946	1.5532	4.4566	6.4997	8.4796	13.1021
$equity_{it}$	0.0989	0.0946	0.0299	-0.0043	0.0797	0.1126	0.2903
nii_{it}	0.1712	0.1526	0.1143	-1.5778	0.0986	0.2245	1.8061

Note: For $\rho_{it}(llp, ebp)$ and $\beta_{i\mathcal{T}}(1)$, the descriptive statistics cover 655 banks. For $\beta_{i\mathcal{T}}(2)$ (which is estimated using additional control variables), the descriptive statistics cover 369 banks. $\sigma(ebp)$ is earnings volatility, estimated over the same rolling window as the earnings smoothing proxies.

The mean value of $\rho_{it}(llp, ebp)$ is 0.1274, which is fairly modest though reflects the wide dispersion of the measure across banks and over time (i.e., the minimum and maximum values are each close to one in absolute terms). The mean of the bank-level beta estimates are positive, lending further support to the hypothesis of inter-temporal earnings smoothing. The averages of $\beta_{i\mathcal{T}}$ are fairly close to the coefficients on ebp_{it} in Table 1.6.1, and notably the distribution includes negative estimates which is supportive of the evidence of a non-linear association between provisions and earnings.

The shape of the $\beta_{i\mathcal{T}}$ distribution does change on the inclusion of control variables. The standard deviation is smallest for $\beta_{i\mathcal{T}}(2)$ after controlling for bank heterogeneity, suggesting a more precise estimate of earnings smoothing. Figure 1.7.1 shows $\rho_{i\mathcal{T}}(llp, ebp)$ and $\beta_{i\mathcal{T}}(1)$ each follow a similar trend, particularly around the financial crisis period. This is muted once variables associated with credit risk are included ($\beta_{i\mathcal{T}}(2)$).

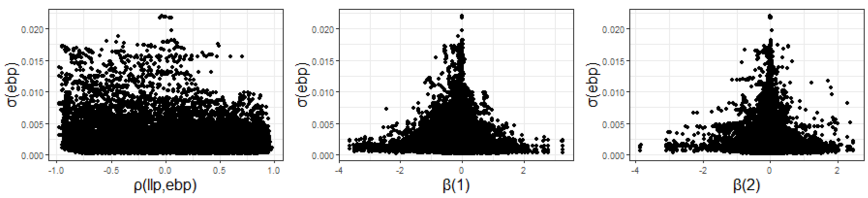
Figure 1.7.1: Degree of earnings smoothing: estimated proxies



Note: The charts present the cross-sample mean (solid line) and median (dashed line) of the earnings smoothing propensity measures. The grey shaded area covers the observations falling within 25th and 75th percentiles. Correlation refers to $\rho_{i\tau}(llp, ebp)$ (the rolling correlation between llp_{it} and ebp_{it}), and Estimate X refers to $\beta_{i\tau}(X)$ as defined in Section 1.4.2.

As a proxy for earnings smoothing behaviour, the estimated betas should be associated with a less volatile earnings profile. To examine whether this is the case, Figure 1.7.2 plots the proxies against the standard deviation of earnings, $\sigma(ebp)$, which is estimated on a rolling basis at the bank level on the same three year window. With the exception of the correlation coefficient, the shape of the plotted observations implies that the estimated proxies do capture earnings smoothing behaviour: the highest values of earnings volatility occur when $\beta_{i\tau}$ is close to zero (i.e., provisions are not being used to manage earnings). Comparatively, $\sigma(ebp)$ is generally low when the $\beta_{i\tau}$'s are large in absolute terms. In contrast, the same pattern is not observed for $\rho_{i\tau}(llp, ebp)$. This suggests that the use of provisions to manage earnings is a marginal concept which is better captured by a regression coefficient, rather than the overall strength of linear association.

Figure 1.7.2: Proxies for earnings smoothing plotted against earnings volatility



Note: On the y-axis, $\sigma(ebp)$ represents the standard deviation of earnings, estimated on the same 12 quarter rolling window as the earnings smoothing proxies) at the bank level. On the x-axis, $\rho(llp, ebp)$ represents the correlation between provisions and earnings before provisions, whilst $\beta(X)$ represents the estimated propensity for the bank to smooth earnings as defined in Section 1.4.2.

1.7.2 Evidence for the effect of earnings smoothing on bank valuation

Table 1.7.2 presents the results of Equation 1.11 without control variables. The dependent variables are Tobin's Q (tq_{it}) for the first three columns, and the market-to-book ratio (mb_{it}) for the last three columns. The regressions are all estimated with both quarter and bank fixed effects: quarter fixed effects control for common business cycle effects across banks (including the financial crisis), and inclusion of bank fixed effects means that the estimates are informative about whether banks with a higher propensity to smooth earnings are valued more than other banks in the cross-section. Reported standard errors are clustered at the bank level.

The different measures of earnings smoothing show fairly consistent estimates, with positive and significant coefficients at at least the 5% level of confidence indicating the positive effect of earnings smoothing on value. For the univariate measures of smoothing propensity ($\rho_{i\tau}(llp, ebp)$ and $\beta_{i\tau}(1)$), the size of the coefficients are not too dissimilar. For $\beta_{i\tau}(2)$, the smaller coefficients and larger standard errors reflect the fact that this is the strictest measure of earnings smoothing having controlled for any collinear effects.

Table 1.7.2: Regression estimates of the relation between bank valuation and the propensity to smooth earnings

	$tq_{it}(\rho)$	$tq_{it}(1)$	$tq_{it}(2)$	$mb_{it}(\rho)$	$mb_{it}(1)$	$mb_{it}(2)$
Smoothing propensity	0.0049***	0.0061***	0.0036**	0.0630***	0.0692***	0.0538***
	(0.0015)	(0.0011)	(0.0014)	(0.0165)	(0.0122)	(0.0176)
Constant	1.0726***	1.0730***	1.0691***	1.8009***	1.8071***	1.7972***
	(0.0050)	(0.0049)	(0.0076)	(0.0590)	(0.0589)	(0.0981)
N	28736	28917	17873	28736	28917	17873
Banks	653	655	369	653	655	369
Adj R^2	0.5404	0.5401	0.5559	0.5389	0.5385	0.5561
F-stat	71.38	71.14	51.99	65.94	65.81	47.23

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variables are the natural logs of Tobin's q (tq_{it}) and the market-to-book ratio (mb_{it}). The column headers (ρ) and (X) to the measure of earnings smoothing included as a dependent variable ($\rho_{i\tau}(llp, ebp)$ and $\beta_{i\tau}(X)$) respectively. Reported standard errors are clustered at the bank level. Bank and quarter fixed effects are included for all specifications.

Table 1.7.3 reports the estimation results of Equation 1.11 when controlling for earnings volatility, equity, bank size and non-interest income. The magnitude of the coefficients on smoothing propensity remain significant and their size is generally unchanged. As in Table 1.7.2, the size of the earnings smoothing propensity coefficients are much larger for the market-to-book regressions compared to those of Tobin's Q, by around ten times. This difference can be attributed to the fact that Tobin's Q scales the difference in the market value of assets and the book value of assets by total assets.[14]

[14] A similar phenomenon is reported by Minton et al. (2019).

Table 1.7.3: Regression estimates of the relation between bank valuation and the propensity to smooth earnings, including bank-level control variables

	$tq_{it}(\rho)$	$tq_{it}(1)$	$tq_{it}(2)$	$mb_{it}(\rho)$	$mb_{it}(1)$	$mb_{it}(2)$
Smoothing propensity	0.0031**	0.0054***	0.0027*	0.0377**	0.0618***	0.0401**
	(0.0014)	(0.0011)	(0.0015)	(0.0157)	(0.0118)	(0.0181)
Earnings volatility	-3.1478***	-3.2417***	-3.5527***	-46.2560***	-47.5665***	-54.0748***
	(0.6765)	(0.6720)	(0.9002)	(7.5964)	(7.5519)	(9.7050)
$equity_{it}$	-0.1704***	-0.1726***	-0.2631***	-4.1669***	-4.2191***	-5.0962***
	(0.0532)	(0.0529)	(0.0695)	(0.5347)	(0.5345)	(0.7238)
$size_{it}$	-0.0055	-0.0058	-0.0085*	-0.0809**	-0.0849**	-0.1049*
	(0.0035)	(0.0036)	(0.0048)	(0.0402)	(0.0415)	(0.0562)
nii_{it}	0.0391***	0.0388***	0.0577***	0.3895***	0.3865***	0.5795***
	(0.0128)	(0.0127)	(0.0175)	(0.1411)	(0.1398)	(0.1916)
Constant	1.1278***	1.1305***	1.1540***	2.8178***	2.8556***	3.0712***
	(0.0252)	(0.0259)	(0.0354)	(0.2869)	(0.2967)	(0.4155)
N	28425	28599	17708	28425	28599	17708
Banks	650	652	369	650	652	369
Adj R^2	0.5505	0.5506	0.5764	0.5637	0.5643	0.5922
F-stat	70.72	71.36	57.12	67.38	68.02	49.26

Standard errors in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Note: Dependent variables are the natural logs of Tobin's q (tq_{it}) and the market-to-book ratio (mb_{it}). The column headers (ρ) and (X) to the measure of earnings smoothing included as a dependent variable ($\rho_{i\tau}(llp, ebp)$ and $\beta_{i\tau}(X)$) respectively. Reported standard errors are clustered at the bank level. Bank and quarter fixed effects are included for all specifications.

Though the effect of earnings smoothing on valuation is consistently significant, prima facie the size of the effect appears to be small: a one standard deviation increase in the propensity to smooth earnings as measured by $\beta_{i\tau}(1)$ is estimated to increase in Tobin's Q by 0.0027 (4.10% of a Tobin's Q standard deviation) and an increase in the market-to-book ratio of 0.0306 (4.22% of a market-to-book ratio standard deviation). However, these effects should be considered against the definitions of both Tobin's Q and the market-to-book ratio. That is, by construction the mean average of these value measures is always going to be very close to one, and the marginal dynamics around this mean average will be fairly small and slow. This can similarly be seen in the estimated effect of NII, for which there is consensus on its importance to bank valuation. The equivalent effect of a one standard deviation increase in NII is 6.80% of a Tobin's Q standard deviation and 6.08% of a market-to-book standard deviation. In which case, we can see that the effect of earnings smoothing is around two-thirds as important as the size of the effect of NII.

The coefficient on earnings volatility is negative and significant. The direction of the coefficient is as expected for a risk averse equity holder, meaning that the market does not like a volatile earnings profile. This result provides motivation for the bank manager to use provisions to smooth earnings to meet investor (owner) preferences.

The size of the effect in terms of the mean Tobin's Q or mean market-to-book ratio of a one standard deviation increase in earnings volatility is around -0.4% or -4.2% respectively. This means that the size of the effect of earnings volatility is greater than that of earnings smoothing. However, in practice the relative impacts of earnings volatility versus earnings smoothing on market value will depend on the extent to which smoothing is able to reduce the volatility it is targeting.

In respect of the control variables, size is estimated to have a negative though insignificant effect on Tobin's Q and the market-to-book ratio. The negative direction of the coefficient supports the idea that the costs associated with being a larger bank outweigh the benefits, whilst the weaker significance may be due to non-linear effects in the role of size.[15] Equity is estimated to have a negative effect on bank value, and the coefficient is larger when the effects of credit risk and other bank characteristics are removed from the measure of earnings smoothing propensity (columns 3 and 6). The downward effect conforms with the idea that high levels of equity may not be productive (Hellmann et al., 2000). Finally, a higher share of non-interest income is estimated to have a positive and significant effect on bank value, which is supportive of the results of Calomiris and Nissim (2014) and Minton et al. (2019).

1.7.3 Robustness: altering the smoothing window

The propensity to smooth earnings is shown to have a significant effect on bank valuation when controlling for a selection of bank characteristics and bank and year fixed effects, though the analysis thus far has maintained a fixed earnings smoothing window of three years. It is possible that the results are sensitive to this choice, depending on the memory of investors. The proxy for earnings smoothing propensity is re-estimated with smaller ($w = 8$) and larger ($w = 16$) window sizes, to test whether the propensity to smooth earnings is sensitive to the time period. The results are reported in Tables 1.B.1 and 1.B.2 in Appendix 1.B, where the coefficients in Table 1.B.1 are comparable to those in Table 1.7.2 of the main results, and those in Table 1.B.2 are comparable to Table 1.7.3.

The level of significance and approximate size of the estimates are generally consistent across the different sized windows, which demonstrates robustness of the propensity measures. Comparing the time trends of the average smoothing propensity proxies shows that they are consistent with the main results (not reported). There is some exception in significance for the strongest earnings smoothing proxy $\beta_{it}(2)$ for the longest window. At the same time, the size of the coefficients tends to increase with

[15] Minton et al. (2019) separates size into banks with assets above and below $50 billion, and finds assets above this threshold to have a negative and significant effect on Tobin's Q and market-to-book. In this study, size is measured as the natural log of total assets which does not capture any threshold effects.

window size, suggesting that markets place higher value on a longer term association between earnings and provisions. By implication, smoothing over a shorter window might not display the same degree of commitment to earnings management.

1.7.4 Interpretation of results

The results consistently show that the market valuation of banks is improved via earnings management using loan loss provisions. Whilst the absolute size of the effect appears small, this should be considered against the context of the construction of market-to-book and Tobin's Q. This supports the second hypothesis of the framework in Section 1.3, that bank managers are incentivised to smooth earnings as a less volatile earnings profile is preferred by equity holders. The positive response to earnings smoothing holds even when controlling for earnings volatility, which is a direct component of the risk averse equity holder's utility function. As well as the theoretical framework, this empirical evidence supports the finding of Hegde and Kozlowski (2021) that the market responds positively to over-provisioning by banks during good economic times, which are associated with periods of higher earnings.

One interpretation of the finding that earnings smoothing behaviour enhances the value of banks is that, by implication, discretionary loan loss provisions have some positive value. This implication counters the idea that more opaque accounting disclosures, which may be proxied for by discretionary loan loss provisions, are detrimental to the value of bank equity. Instead, it suggests that discretionary loan loss provisions contain valuable information; this point is discussed further in Section 1.8.

1.8 Discussion

This study presents empirical evidence that supports the theoretical model of earnings smoothing put forward in Section 1.3, which posits that the equity holder's preferences for a smoother earnings profile incentivises the bank manager to smooth earnings. Section 1.6 exhibits results showing that banks smooth reported earnings using loan loss provisions around some earnings threshold. Then, Section 1.7 shows that this smoothing behaviour has a positive effect on bank valuation, even when controlling for the level of earnings volatility which the smoothing is targeting. As noted at the end of Section 1.7, one implication of these findings is regards the market interpretation of discretionary loan loss provisions when these are motivated by earnings smoothing. A second implication exists for the role of reported loan loss provisions in financial stability and macroprudential regulation. Each of these are discussed in turn.

Value of information contained in discretionary loan loss provisions. 'Discretionary' loan loss provisions (DLLP) are the component of provisions that are not directly associated with the credit risk or macroeconomic environment facing the bank. To that end, DLLP can capture strategic behaviour by banks and estimations of DLLP are commonly used as a proxy for bank opacity.[16] Intuitively, discretionary earnings smoothing behaviour may increase the opacity of banks by masking the size of the provisions being made relative to the size of non-performing loans for the same period. We would typically consider a more opaque firm to have a higher risk premium, thus leading to a reduction in the firm's value. Greater opacity about the firm's true fundamentals increases adverse selection, and hence the size of the wedge between the valuations of insiders and outsiders. In the case of banks, markets are seen to respond positively to the additional information provided by stress tests since these provide certainty about the bank's underlying balance sheet (Morgan et al., 2014).

However, the idea that earnings smoothing is value-improving contradicts this conventional theory. The rationale for this may be seen in the work of Jin and Myers (2006), where the drivers of variance in firm cash flows are separated into firm-specific and macroeconomic. When the overall information environment is not completely transparent, earnings smoothing can make the firm appear more systematic (that is, less idiosyncratic) to investors. As a result, the manager absorbs some of the firm-specific bad news, rather than passing this on to outsiders. Allayannis and Simko (2022) find evidence for non-financial firms in support of this idea, in that investors view earnings smoothing more positively when the information environment for a firm is relatively low. Notably, the information environment for a bank is generally thought to be lower than for non-financial firms, due to the opaque nature of a bank's assets (Morgan, 2002; Kaplan, 2006; Dang et al., 2017). More opacity between insiders and outsiders is required for stable risk sharing and the ability of the bank to produce money like claims; in this sense, smoothing of reported earnings may be interpreted as the bank manager taking on some risk at the benefit of their equity holders.

Reported loan loss provisions, financial stability, and macroprudential regulation. The positive association between earnings smoothing and equity valuation does not in turn mean that discretionary accounting disclosures are not detrimental in the context of financial stability. Importantly, one purpose of LLP reporting is to signal prudent credit risk management and the accumulation of sufficient reserves; to that end, excessive use of discretionary loan loss provisions may raise concerns about financial stability.

Notably, consistent under-provisioning to produce a smoother profile of earnings could increase the bank's vulnerability to downside risks by producing a risk overhang (Bushman and Williams, 2015). Indeed, Hegde and Kozlowski (2021) show that banks with higher DLLP tend to have negative abnormal equity returns during economic down-

[16] See Beatty and Liao (2014) for a review of DLLP estimation approaches.

turns, motivated by greater concerns of default. Additionally, the procyclicality of loan loss provisions means that under-provisioning during good periods may attenuate lending pressures during bad periods (Pool et al., 2015). On the other hand, earnings smoothing may counter some of the procyclicality of loan loss provisioning, if it means that additional provisions are made when earnings are high (which is often the case during 'good' periods). This study does not aim to test the role of earnings smoothing in the bank's risk profile, though future work might consider the extent to which any positive benefits from earnings smoothing are offset by the negative impacts of under- or over-provisioning.

1.9 Conclusions

Discretionary accounting disclosures play an important role in the research and regulation of banks. However, there is limited empirical evidence on how outsiders interpret discretionary behaviour. The use of loan loss provisions to smooth reported earnings implies a degree of bank opacity, which one might generally associate with a lower valuation due to information frictions. However, the results presented by this paper suggests that this type of opacity can be value improving.

Using a sample of US banks from 1995 to 2019, this study finds that banks do tend to smooth earnings around some threshold level of earnings, and that this behaviour is looked upon favourably by equity holders. This is the case even when controlling the variability in the profile of reported earnings, which suggests that equity holders place value on the bank withholding some of its riskiness, evidencing the role of risk sharing in financial intermediation. This has implications financial stability and accounting regulators, as this behaviour may blur the understanding of reserves held for future losses.

Appendix

1.A Proof of the lemma

Recall $f_i(x^r) = f_i(x_1^r, x_2^r)$ is the joint probability density function of reported earnings evaluated at $x^r = (x_1^r, x_2^r)$ if the manager cannot smooth earnings, with earnings variance of σ_i^2 $(i = l, h)$. Using the marginal density functions we can write:

$$f_i(x_1^r, x_2^r) = h_i(x_1^r)h_i(x_2^r)$$

Similarly, for the manager that can smooth earnings we can write:

$$f_i^s(x_1^r, x_2^r) = h_i^s(x_1^r)h_i^s(x_2^r \mid x_1^r)$$

Then define the following expressions. First, for the bank that smooths earnings, the likelihood that variance is low given observed returns:

$$y(x_1, x_2) = \frac{h_l(x_1^s)h_l(x_2^s)p_l}{h_l(x_1^s)h_l(x_2^s)p_l + h_h(x_1^s)h_h(x_2^s)p_h} \tag{1.12}$$

Second, for the bank that does not smooth earnings, the likelihood that the variance is low given observed returns:

$$z(x_1, x_2) = \frac{h_l(x_1)h_l(x_2)p_l}{h_l(x_1)h_l(x_2)p_l + h_h(x_1)h_h(x_2)p_h} \tag{1.13}$$

Then, to show that $E_i[\dot{p}_l(x_1^s, \tilde{x}_2^s)] > E_i[\dot{p}_l(x_1, \tilde{x}_2)]$, it is sufficient to show $E_i[y(x_1, \tilde{x}_2)] > E_i[z(x_1, \tilde{x}_2)]$. That is, investors perceive earnings variance to be lower when the bank smooths earnings. This is simplifying Equation 1.8 for the likelihood of being able to smooth earnings, which possible due to its independence of bank earnings variability. Using $\tilde{x}_t = \mu + \tilde{e}_t$, then $E_i[y(x_1, \tilde{x}_2)]$ is given by:

$$\int_0^\infty [y(x_1, \mu - e_2)]h_i(\mu - e_2)de_2 + \int_0^\infty [y(x_1, \mu + e_2)]h_i(\mu + e_2)de_2 \tag{1.14}$$

Further, for the bank that does not smooth earnings and since we have assumed that the earnings distribution is normal and symmetric, $z(x_1, \mu - e_2) = z(x_1, \mu + e_2)$. Then, it is sufficient to show that:

$$y(x_1, \mu + e_2) + y(x_1, \mu - e_2) > 2z(x_1, \mu + e_2) \; \forall \; e_2 > 0 \tag{1.15}$$

Which holds for normally distributed random variables, concluding the proof.

1.B Robustness: altering the smoothing window

Table 1.B.1: Earnings smoothing impact on value using different estimation windows; no control variables

		tq_{it}			mb_{it}	
	$w = 8$	$w = 12$	$w = 16$	$w = 8$	$w = 12$	$w = 16$
$\rho_{i\tau}(llp, ebp)$	0.0034***	0.0049***	0.0063**	0.0512***	0.0630***	0.0735**
	(0.0010)	(0.0015)	(0.0020)	(0.0113)	(0.0165)	(0.0224)
$\beta_{i\tau}(1)$	0.0044***	0.0061***	0.0079***	0.0538***	0.0692***	0.0896***
	(0.0007)	(0.0011)	(0.0015)	(0.0081)	(0.0122)	(0.0168)
$\beta_{i\tau}(2)$	-	0.0036*	0.0061*	-	0.0538**	0.0701*
	-	(0.0014)	(0.0026)	-	(0.0176)	(0.0289)

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

Table 1.B.2: Earnings smoothing impact on value using different estimation windows; with control variables

		tq_{it}			mb_{it}	
	$w = 8$	$w = 12$	$w = 16$	$w = 8$	$w = 12$	$w = 16$
$\rho_{i\tau}(llp, ebp)$	0.0021**	0.0031**	0.0038**	0.0344***	0.0377**	0.0403*
	(0.0010)	(0.0014)	(0.0019)	(0.0106)	(0.0157)	(0.0217)
$\beta_{i\tau}(1)$	0.0040***	0.0054***	0.0068***	0.0492***	0.0618***	0.0762***
	(0.0007)	(0.0011)	(0.0015)	(0.0080)	(0.0118)	(0.0163)
$\beta_{i\tau}(2)$	-	0.0027*	0.0044	-	0.0401**	0.0432
	-	(0.0015)	(0.0028)	-	(0.0181)	(0.0329)

Standard errors in parentheses
* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

The rows of each table represent the different proxies for earning smoothing and the columns represent different window sizes for their estimation, where w is the number of quarters in a window. The main results use $w = 12$. When $w = 8$, there are insufficient degrees of freedom to estimate $\beta_{it}(2)$. Table 1.B.1 excludes control variables, and Table 1.B.2 controls for earnings volatility, bank equity, size and the share of non-interest income. All estimates include bank and quarter fixed effects.

Chapter 2

Monetary loosening and bank stability in a low interest rate environment

2.1 Introduction

What effect does a cut in the monetary policy interest rate have on bank stability? Since the global financial crisis, this question has gained prominence in the debate on monetary policy transmission. The credit view of monetary policy posits that channels of transmission exist as a result of financial frictions,[1] including altering bank riskiness.[2] However, the advent of a low interest rate environment following the financial crisis disrupted some of these mechanisms,[3] with the effects dependent on the bank's balance sheet structure. Research has suggested that a 'reversal' rate of interest exists due to an effective lower bound on deposit rates,[4] whereby the transmission of monetary policy via banks diverges from established theory. This paper contributes to the discussion by studying how the stability of banks with different shares of deposits responds to cuts to the policy rate, when the policy rate is away from and close to zero.

Specifically, the paper estimates monetary policy shocks identified using high-frequency monetary policy surprises in a factor-augmented vector autoregression (FAVAR), and projects these onto different measures of bank stability. Previewing the results, I find that when interest rates are away from ultra-low levels, a monetary loosening improves

[1] Starting with Bernanke and Gertler (1995), with work specific to banks including Meh and Moran (2010), Disyatat (2011) and Drechsler et al. (2017), amongst many others.

[2] For example Dell'Ariccia et al. (2014), Jiménez et al. (2014) and Paligorova and Santos (2017).

[3] In the US, the Federal Reserve maintained an average effective rate of 0.13% between 2009 and 2015, compared to an average of around 6% for the last half of the twentieth century.

[4] Abadi et al. (2023)

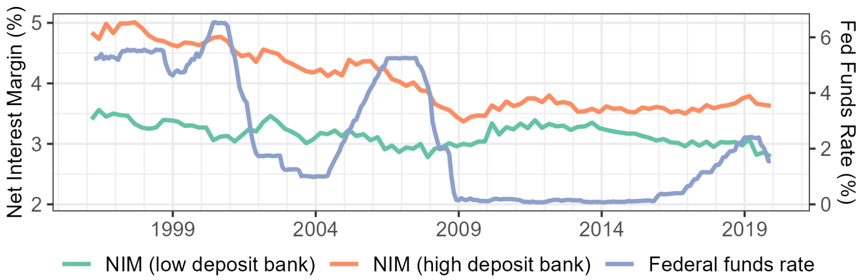
bank stability due to an overall improvement in the macroeconomic environment. However, when interest rates are already very low, the same monetary loosening decreases the stability of banks that are more dependent on deposits, while the stability of banks with lower deposit-dependence increases in the same way as when interest rates are at normal levels.

The result for when rates are at normal levels conforms with the standard way of thinking about monetary policy transmission via the bank capital channel (Bernanke, 2007; Disyatat, 2011). Importantly, there is no role for the *volume* of deposits. The monetary loosening reduces bank funding costs, while the rate on long-term assets remains fixed in the short term, supporting internal capital generation and an improvement in net worth. Higher net worth loosens the external financing constraint of the bank along the lines of Disyatat (2011), permitting higher lending, increased monitoring, and improved overall stability.

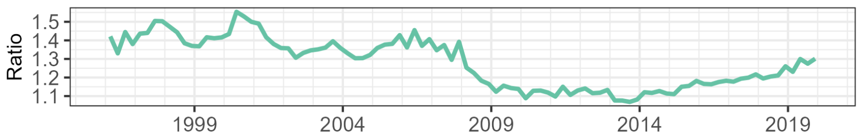
This mechanism is impeded when rates are very low. In this case, an effective lower bound on deposit rates exists such that when the policy rate reaches a certain level, a change in monetary policy cannot be fully passed on to depositors (e.g., due to the zero nominal value of cash, see Wang et al., 2022). Therefore, banks are unable to maintain the spread usually earned on deposits and their cost of funding cannot decrease by the same relative amount. This effect is particularly acute for banks that are more reliant on deposit funding, so the policy rate cut does not have the usual effect of improving their net worth. Figure 2.1.1 shows how, when the effective Federal Funds rate falls below 0.25% at the start of 2009, the net interest margin (NIM) of high deposit banks (measured using the deposit-asset ratio) falls by relatively more than that of low deposit banks. Subsequently, this study estimates that a monetary loosening during this period leads to a deterioration in stability for banks with a high proportion of deposit funding. The same effect is not seen for banks with lower levels of deposit funding, as their relative cost of funding is less constrained.

Further investigation suggests that this result could be due to risk-shifting along the lines of Hellmann et al. (2000). It is estimated that the decrease in bank stability is more acute for the high deposit banks with lower levels of capital. The inability to fully pass-through the policy rate cut to deposit rates devalues the franchise value of all high deposit banks, putting downward pressure on existing tangible capital and accentuating existing agency problems. But for high deposit banks with low levels of capital, the effect is strengthened as they are already more exposed to agency problems.

Figure 2.1.1: Net interest margin (NIM) and retained earnings by deposit quintile



(a) NIM and Federal Funds effective rate



(b) Ratio of NIM of high deposit banks to NIM of low deposit banks

Note: The NIM presented is the median of banks sorted into deposit-asset quintiles. Low deposit banks are in the first quintile, and high deposit banks in the fifth quintile.

As well as contributing to the discussion on the role of low interest rates on bank outcomes, the study contributes to the literature on the risk-taking channel of monetary policy. While monetary loosening might increase incentives for riskier lending, the impact of this on bank stability is conditional on the macroeconomic environment. Existing literature tells us that, at the margin, when interest rates are far from zero the effect of a monetary loosening on bank riskiness is theoretically ambiguous (Dell'Ariccia et al., 2014). A lower policy rate may make safe assets less attractive via a portfolio reallocation effect, but could also increase the bank's franchise value, promoting better monitoring.

Empirical research finds some evidence that lower interest rates increase *ex-ante* bank risk taking (e.g., Dell'Ariccia et al., 2017; Paligorova and Santos, 2017). However, an increase in marginal risk taking does not necessarily increase the risk of existing loan portfolios or overall bank riskiness (Jiménez et al., 2014; Ioannidou et al., 2015; Bonfim and Soares, 2018). The transformation of 'ex-ante' to 'ex-post' risk depends on earlier lending decisions and macroeconomic conditions. A monetary loosening improves macroeconomic conditions, increasing asset values which improve bank capital, which works to offset the effects of an increase in bank risk appetite. At the same time, lower interest rates can increase risk tolerance, improving the likelihood of project success (Bauer et al., 2023). This study uses the Z-score of the probability of insolvency (which would occur when current bank losses exhaust capital) to measure overall bank risk (Laeven and Levine, 2009; Khan et al., 2017) to show that bank stability improves following a monetary loosening when interest rates are far away from zero.[5]

The perspective of this study also differs by using a macroeconomic framework to assess the broader effects of monetary policy on bank stability. Unlike static microeconometric approaches, this study employs a dynamic model that integrates overall bank riskiness with macroeconomic variables. The FAVAR provides a unified set-up to combine a large amount of macroeconomic data to obtain monetary policy shocks. The shocks are identified using a high-frequency instrument measured over a tight announcement window, improving identification of a policy shock relative to recursive techniques (Gertler and Karadi, 2015; Kerssenfischer, 2019). Data on bank stability at different deposit-aset quintiles is projected onto these shocks, to reflect that banks do not operate in isolation and will use a large amount of exogenous information in their operations. This approach represents a novel contribution to the literature on bank stability responses to monetary policy, and follows De Giorgi and Gambetti (2017) and Cantore et al. (2022) who use the same approach for measuring consumption responses to a monetary policy shock across the income distribution.

The chapter is organised as follows. Section 2.2 provides an overview of the relevant literature. Section 2.3 outlines the conceptual framework and the hypotheses being tested. Section 2.4 sets up the empirical model used in the estimation, and Section 2.5 describes the estimation approach. Section 2.6 introduces the data. Section 2.7 presents the results which are discussed in Section 2.8, and Section 2.9 concludes.

2.2 Summary of relevant literature

2.2.1 Bank capital channel of monetary policy

The credit view of monetary policy transmission posits that, in addition to the direct effect of short-term interest rates, additional channels of transmission exist as a result of the process of extending credit via imperfections in financial markets (Bernanke and Gertler, 1995). Credit channels of monetary policy depend on the external finance premium, which produces a financial accelerator that amplifies the effect of monetary policy on the economy. For the bank lending channel, the size of the external finance premium is altered by the effect of monetary policy on bank capital (Bernanke, 2007; Disyatat, 2011).[6] When interest rates fall, this is accompanied by a fall in expected losses for the bank, reducing its probability of default. As a result, the bank's funding

[5] It is worth mentioning upfront that ex-ante measures of risk taking are applied within this macroeconometric framework to evidence the presence of ex-ante risk taking in the same set up.

[6] Note that this mechanism is separate to the 'traditional' bank lending channel, which is described to operate via the opportunity cost of holding reservable deposits (Bernanke and Blinder, 1988; Kashyap and Stein, 1995) and has been demonstrated to have depended on the structure of the US financial system of the time (Romer and Romer, 1990), leading to a focus on the effect of monetary policy on alternative bank characteristics.

costs improve as the external finance premium is reduced, and the bank can lend more. In this mechanism, bank stability informs bank funding costs and thus the bank's lending constraints. Meh and Moran (2010) alternatively model a role for capital using the double moral hazard problem of Holmstrom and Tirole (1997), where capital serves a monitoring signal: when capital is high, outsiders perceive the bank to have more 'skin-in-the-game' and the external finance premium is reduced. Higher capital may also force the bank to internalise default costs, thus incentivising greater monitoring (Allen et al., 2011). The role of bank capital in monetary policy transmission may also depend on a binding regulatory constraint (Van den Heuvel, 2009). When the constraint is binding, issuance of additional equity can worsen the bank's cost of funding (Bolton and Freixas, 2006).

2.2.2 Monetary policy, bank risk taking and bank stability

The risk taking channels of monetary policy focus on how monetary policy influences banks' *incentives* to take risks, particularly regarding the riskiness of new loans. These channels are distinct from the financial accelerator mechanism, and emphasise the riskiness of marginal lending. The risk taking channel closest in spirit to the financial accelerator is described by Borio and Zhu (2012), where low interest rates affect risk tolerance and improve agency problems by increasing firm valuation and cash-flow.

Several other mechanisms have been proposed to describe the risk taking channel. For instance, Dell'Ariccia et al. (2014) suggest a portfolio reallocation effect, where banks reallocate resources toward riskier investments as safe assets become less attractive. Rajan (2006) labels this 'searching-for-yield'. Additionally, Dell'Ariccia et al. (2014) highlight a risk-shifting effect, where lower policy rates increase the bank's franchise value, enhancing monitoring intensity. This depends on bank leverage, as agency problems partly isolate the bank from downside investment risks (Hellmann et al., 2000). Combining these effects, Dell'Ariccia et al. (2014) find that the size of the risk channel depends on the degree of pass-through to bank assets and the responsiveness of bank capital.

Empirical research tends to support the presence of risk taking channels (e.g., Dell'Ariccia et al., 2017; Paligorova and Santos, 2017), though the effect on overall bank riskiness is more nuanced. Jiménez et al. (2014) finds risk-taking is more pronounced for banks with lower capital, though this effect holds only for short-term rates. Long-term rates, which reflect future macroeconomic conditions, do not influence ex-ante lending risk. Bonfim and Soares (2018) find that while lower interest rates increase funding for riskier borrowers at the extensive margin, their ex-post riskiness remains unaffected by the interest rate at origination. Ioannidou et al. (2015) show that while lower policy rates prior to loan origination encourages riskier loans, expansionary monetary policy over the life of the loan can reduce its risk.

Overall, these complexities suggest that although lower rates may increase incentives to take on more risk, the overall impact on bank stability depends on how ex-ante risk evolves into ex-post risk and the bank's ability to bear that risk. Buch et al. (2014*b*) show that non-performing loans decline following a monetary policy expansion in a FAVAR, and Boungou and Hubert (2021) similarly show an improvement in non-performing loans during the negative interest rate period due to an improvement in the economic outlook. This highlights the conditional nature of bank risk-taking channels.

2.2.3 Role of a low interest rate environment

The literature discussed so far does not account for potential non-linearities that might occur at certain levels of interest rates, including when rates are very low. A period of low interest rates may impede these channels by disrupting the pass-through of monetary policy to bank funding costs, including deposits. When the policy rate is far from zero, it is generally the case that deposit rates are very responsive to a change in the policy rate (e.g., Neumark and Sharpe, 1992; Drechsler et al., 2017). However, recent literature has evidenced that this pass-through is limited when the policy rate reaches a certain threshold, including Wang et al. (2022) in the US and Heider et al. (2019) and Eggertsson et al. (2023) in the Euro area. Altavilla et al. (2022) estimate that when the policy rate sits between 0.2% and -0.2%, changes in the rate are not passed through to corporate deposit rates in the same way as when the policy rate is above 0.2%. The authors posit that in this interval, market participants are uncertain about how far below zero the policy rate will go and so wait for a clearer signal on the path of rates from the central bank.

By increasing relative bank funding costs, this friction has been shown to suppress bank earning power with the effect more pronounced for banks with a higher deposit funding mix (Ampudia and Van den Heuvel, 2022; Wang et al., 2022). This deposit lower bound is described as the 'reversal' interest rate by Abadi et al. (2023), whereby the capital gains from a reduction in the policy rate (which accrue from fixed long-term assets) are offset by a compressed net interest income channel. Over time as the yield curve remains flat, this offsetting effect intensifies as net interest income losses accumulate and the capital gains deteriorate as long-term assets refinance at lower rates.

Some evidence suggests that the deposit lower bound on bank earning capability may influence the riskiness of bank lending and overall bank stability. Heider et al. (2019) find that during this period, high deposit banks are more likely to extend loans to ex-ante riskier firms, and overall reduce lending. Complementary to this, Bubeck et al. (2020) find evidence that banks with higher proportions of deposit holdings increase holdings of securities with relatively higher returns. In terms of overall bank riskiness, Nucera et al. (2017) finds that high deposit banks (described as 'traditional') are perceived to be more risky, as measured by conditional capital shortfall. Brana et al. (2019) identify non-linearities in bank stability and monetary loosening, where bank stability deteriorates more following a monetary loosening when interest rates are low and the central bank uses unconventional monetary policies.

2.3 Conceptual framework

This section presents a framework to study the impact of a monetary policy loosening on bank stability. It begins with assumptions (2.3.1) and the role of pricing (2.3.2), then describes the response of bank stability when interest rates are away from the lower bound (2.3.3). The final subsection describes how bank stability responds to a monetary loosening when interest rates are close to zero (2.3.4).

2.3.1 Set up

The objective of the conceptual framework is to demonstrate how banks with varying dependence on deposits might differ in susceptibility to stability issues in a low interest rate environment. To that end, we are concerned with the bank's ability to maintain its operations and avoid financial distress. A deterioration in the bank's net worth or an increase in earnings volatility following a monetary loosening that harms the bank's stability would imply that the bank is riskier.

Consider a bank funded by deposits and market-based debt, with a fixed liability structure in the short- to medium-term. This assumption can be rationalised by the fact that wholesale financing is more expensive than stable deposits, which are supported by government guarantees. While the bank might shift to non-deposit financing over the longer term, its assets would also need to adjust to this less stable funding source (Hanson et al., 2015). The bank also holds equity, though new equity cannot be issued easily, particularly in periods of crisis due to adverse selection problems and agency costs. Therefore, assets accumulate internally via profits. The bank is protected by limited liability.

The bank faces an external finance premium, which depends on its net worth as an indicator of collateral and monitoring intensity (this is the double moral hazard mechanism of Holmstrom and Tirole, 1997). Monitoring is costly and unobservable, but when net worth is higher, uninformed investors reduce the external finance premium required for their participation. Net worth also acts as a cushion for liability holder losses when firms default on their loans; a larger cushion means a smaller premium is required (Disyatat, 2011).

The bank's net worth depends on the accumulation of internal profits and the macroeconomic environment. Net worth may deteriorate if the likelihood of loan repayment decreases (Disyatat, 2011), leading to higher expected losses (Agénor and Zilberman, 2015). This is the classic financial accelerator mechanism of Bernanke et al. (1999), where an improved macroeconomic environment reduces the risk of loan failure, reducing the external finance premium demanded by outsiders and relaxing the constraint on bank lending. Consequently, this means that the bank can lend more, and bank stability improves as returns on assets become less variable.

2.3.2 Pricing of liabilities and assets

The accumulation of profits, and thus the bank's stability, depends on its pricing power. On the liability side of the balance sheet, the bank is assumed to be a price taker for market-based debt and a price maker for deposits. The rates paid on deposits and market-based debt depend directly on the policy rate r_p, set by an independent central bank. Market-based debt responds strongly to changes in r_p, regardless of the starting level of r_p. This is due to the substitutability of bank-issued debt and government-issued debt (Krishnamurthy and Vissing-Jorgensen, 2015), which closely follows changes in monetary policy rates (Gertler and Karadi, 2015). Market based debt is also more credit sensitive, making it more sensitive to policy induced changes in the external finance premium.

Deposit rates are less sensitive to changes in r_p due to bank market power and depositor preference for the liquidity of bank deposits relative to physical currency. However, as shown by Wang et al. (2022), the degree of bank market power in deposit markets depends on the level of the policy rate. When the policy rate is far away from zero, banks can maintain the spread charged on deposits following a policy rate cut (Neumark and Sharpe, 1992). However, as the policy rate approaches zero, the bank is unable to fully pass on further policy rate cuts to depositors. This compresses the spread charged by the bank for holding deposits, making deposits a relatively more expensive source of funding.

There are two reasons for this. First, deposits and physical currency are substitutes, with currency offering a nominal rate of zero. If deposit returns fell below zero, this could induce some depositors to carry cash instead (notwithstanding the additional holding and transacting costs). Second, zero acts as a focal point for banks and depositors. A bank offering a negative rate is more noticeable than one offering a very low positive rate, particularly if it is the first to do so. The risk is greatest for the first bank to offer a negative rate, particularly whilst its competitors still offer positive rates. As a result, an effective lower bound on deposits exists.

On the asset side, lending rates respond strongly to changes in r_p as credit risk premia keep them far from zero, even when r_p is close to zero. However, the speed of this response is slowed by the fact that bank assets tend to be longer dated. Returns on assets may improve bank stability following a monetary loosening as the macroeconomic environment improves.

2.3.3 Bank stability and monetary loosening outside of the low rate environment

With this background, we now consider the response of bank stability following a cut in the policy rate when the rate is far from zero. Pass-through to the bank's cost of funding is unimpeded across funding types, allowing the bank to maintain the spread charged on deposits. The rate on long-term assets remains unchanged immediately. Consequently, bank stability improves for two reasons. First, there is an improvement in the bank's net interest margin, enhancing the bank's internal capital generating capability. Second, the macroeconomic environment improves, stabilising the bank's return on assets. These two forces contribute to an improvement in the franchise value of banks (English et al., 2018, evidence this via an increase in bank equity values), and an improvement in stability.

2.3.4 Bank stability and monetary loosening with low policy rates

This sequencing is disrupted when the policy rate is close to zero. The bank's market power in deposit markets deteriorates, preventing full pass-through of rate cuts to depositors. This compresses the spread between deposit rates and the policy rate. Using data for the US, Wang et al. (2022) show this compression of the deposit spread for low levels of the policy rate (Wang et al., 2022, Figure 1). Rates on market-based funding move more flexibly, and rates on long-term assets are similarly able to eventually fall. The net interest margin of banks that are heavily dependent on deposits compresses by more than those with less dependence (Figure 2.1.1), limiting their capacity for internal capital generation.

The compression of NIM and limitations on internal capital generation has a downwards effect on bank stability. Abadi et al. (2023) describe this as the net interest channel outweighing the capital gains channel of lower rates on fixed long term assets. There is also the possibility of a risk-shifting effect along the lines of Hellmann et al. (2000), as the relative rate paid to depositors has increased compared to a usual monetary policy loosening. The incentive for depositors to participate in financial intermediation is satisfied at some rate $r_D(r_p)$, but the bank is now offering $r^*_D(r_p) > r_D(r_p)$ so that depositors now experience a net surplus. Equivalently, this has the effect of reducing the bank's franchise value by decreasing its expected future profit stream. Franchise value acts as intangible capital, which can substitute for tangible capital. So, the relative increase in deposit cost of funding can be interpreted as a cut in the bank's net worth.

This cut in net worth exacerbates agency problems for outsiders to the bank and reduces the bank's incentive to monitor (Allen et al., 2011). The effects are more acute for deposit-dependent banks, potentially making lending returns more unstable and further deteriorating bank stability. While improvements in the macroeconomic environment from monetary loosening may limit this deterioration, these macroeconomic effects apply to all banks. Consequently, high deposit banks are expected to experience a relative decrease in stability following a monetary policy loosening in a low rate period. Within high deposit banks, the effect is expected to be greater for more highly levered banks with lower levels of initial tangible capital.

2.4 Empirical model

To estimate the impact of monetary policy shocks on the stability of banks with different levels of deposits, I estimate a structural FAVAR for the US. The model assumes that the economy takes a factor structure and may be represented by the sum of a common aggregate component and an idiosyncratic component, each of which are orthogonal to one another. Formally, for each macroeconomic variable x_{it} where $i = 1, ..., N$:

$$x_{it} = \chi_{it} + \xi_{it}^{x} \tag{2.1}$$

Where χ_{it} is the common component and ξ_{it}^{x} is the idiosyncratic component. The idiosyncratic component arises from shocks which only have a considerable effect on variable i and do not have widespread effects; in this sense they are not necessarily 'macroeconomic' shocks (e.g., they may be sector specific or due to measurement error). Conversely, the common components are responsible for the majority of the co-movement between macroeconomic variables. The common component is assumed to be a linear combination of $r \ll N$ macroeconomic factors:

$$\chi_{it} = \Lambda_i \mathbf{f}_t \tag{2.2}$$

Where Λ_i is a $1 \times r$ vector of factor loadings and $\mathbf{f}_t$ is a $r \times 1$ vector of factors representing the economy at time t. The dynamic properties of the model are obtained by modelling the vector of common factors $\mathbf{f}_t$ as an invertible VAR relation:

$$\begin{aligned} D(L)\mathbf{f}_t &= \epsilon_t \\ \epsilon_t &= S u_t \end{aligned} \tag{2.3}$$

Where $D(L) = I - A_1 L - ... - A_p L^p$ is a matrix of polynomials in the lag operator (equivalently, the Wold coefficients), S is a matrix used in identification of structural shocks (described later in Section 2.5.2), and u_t is a r-dimensional vector of orthonormal white noise structural macroeconomic shocks driving the common component. Then, using Equation 2.3 in 2.1, variable x_{it} is given a dynamic representation:

$$\begin{aligned} x_{it} &= \Lambda_i D(L)^{-1} S u_t + \xi^x_{it} \\ &= B_i(L) u_t + \xi^x_{it} \end{aligned} \tag{2.4}$$

The first term on the right hand side of Equation 2.4 describes the relation between variable x_{it} and the rest of the economy, where $B_i(L)$ are the impulse response functions for variable i. The second term is the idiosyncratic component, as before.

If we assume that bank riskiness also takes a factor structure, equivalent impulse response functions may be obtained. Consider that for the individual bank $j = 1, ..., M$ at time t, the measure of bank stability may be decomposed into the sum of two orthogonal components:

$$\begin{aligned} b_{jt} &= \chi^b_{jt} + \xi^b_{jt} \\ &= \Lambda^b_j \mathbf{f}_t + \xi^b_{jt} \end{aligned} \tag{2.5}$$

The interpretation of Equation 2.5 is similar to 2.1 for the macroeconomic variables. That is, χ^b_{jt} is the common aggregate component driven by common aggregate shocks and directly affects the risk level of all banks. The degree to which bank j is affected by macroeconomic conditions is captured by Λ^b_j, the bank-specific factor loading. The idiosyncratic component ξ^b_{jt} arises from individual bank characteristics independent of the economy, such as manager sophistication. The common component and idiosyncratic component remain orthogonal, and it is assumed that the idiosyncratic component is stationary.

The measures of bank stability can be aggregated into deposit-asset quintiles, where the mid-point of each quintile is the measure of risk for banks with 'high' and 'low' proportions of deposits. For the k^{th} quintile, we can write Equation 2.5 as:

$$\begin{aligned} a_{kt} &= \chi^a_{kt} + \xi^a_{kt} \\ &= \Lambda^a_k \mathbf{f}_t + \xi^a_{kt} \end{aligned} \tag{2.6}$$

Where for deposit-asset quintile k of size n_k we have $a_{kt} = \frac{\sum_{j-1}^{n_k} b_{jt}}{n_k}$, $\Lambda^a_k = \frac{\sum_{j-1}^{n_k} \Lambda^b_j}{n_k}$ and $\xi^a_{kt} = \frac{\sum_{j-1}^{n_k} \xi^b_{jt}}{n_k}$. This implies that bank risk at the quintile level is driven by two orthogonal components: the common component $\chi^a_{kt} = \Lambda^a_k \mathbf{f}_t$ and the idiosyncratic component ξ^a_{kt}. The idiosyncratic component now contains quintile level determinants of bank stability unrelated to aggregate conditions, which will address any measurement error associated with assessing bank stability at different levels of the deposit-asset distribution.

Using the dynamic representation of the factors and the corresponding impulse response functions in Equations 2.3 and 2.4, bank risk at the deposit-asset quintile level may be written as:

$$a_{kt} = B_k^a(L)u_t + \xi_{kt}^a \tag{2.7}$$

Where $B_k^a(L) = \Lambda_k^a D(L)^{-1}S$ is the matrix of impulse response functions for the risk of deposit-asset quintile k given structural shock u_t. Provided a monetary policy shock may be identified in the macroeconomic framework, then the equivalent impulse response function of bank risk to the same monetary policy shock may also be estimated by substitution of the factor loadings.

2.5 Estimation

2.5.1 Estimation of the macroeconomic factors

The macroeconomic factors are estimated using principal components. Each series undergoes a stationary transformation, and is demeaned and standardised. The number of latent factors to include in the FAVAR is important, since the exclusion of later factors implies that their information is idiosyncratic. Therefore, the number of factors included in the structural model is guided by the criterion of Alessi et al. (2010), which applies a modification to the popular Bai and Ng (2002) criterion to remove dependency on the user-specified maximum number of observed factors.

2.5.2 Identification of structural shocks

Identification of the structural shock uses an external instrument, following the approach of Stock and Watson (2012*b*), Gertler and Karadi (2015) and Kerssenfischer (2019), amongst others. The approach assumes that selected macroeconomic variables can be observed without error, and so can be included as observable factors. Specifically, industrial production, the consumer price index and a market-based interest rate are included as observed factors, following Kerssenfischer (2019). The observed and latent factors may then be written as:

$$\mathbf{f}_t = \begin{bmatrix} y_t \\ f_t^* \end{bmatrix} \tag{2.8}$$

Where y_t contains the observed factors and f_t^* are the r^* principal components estimated as described in Section 2.5.1. Then, identification requires us to find a value for S as defined in Equation 2.4. To this end, three assumptions are made, assuming the shock of interest is ordered first:

1. **Relevance** of the instrument: $E(Z_t, u_{1t}) = \phi \neq 0$
2. **Exogeneity** of the instrument: $E(Z_t, u_{\bullet t}) = 0$
3. **Uncorrelated shocks**: $\Sigma_{uu} = G = diag(\sigma^2_{u_1}, ..., \sigma^2_{u_r})$

Assumptions 1 and 2 are analogous to the standard validity assumptions placed on instrumental variables in micro-econometric applications, and imply:

$$E(\epsilon_t Z_t) = E(S u_t Z_t) = \begin{bmatrix} S_1 S_\bullet \end{bmatrix} \begin{bmatrix} E(u_{1t} Z_t) \\ E(u_{\bullet t} Z_t) \end{bmatrix} = S_1 \phi \tag{2.9}$$

Where u_{1t} is the shock of interest and $u_{\bullet t}$ denotes all remaining disturbances. Further, utilising Assumption 3 which implies $\Sigma_{\epsilon\epsilon} = SGS'$, Stock and Watson (2012*a*) show that $S_1\phi$ may be found by a regression of the instrument Z_t on all reduced-form shocks ϵ_t,[7] allowing identification of u_t up to scale and sign. Structural IRFs of each variable are then obtained as in Equation 2.4, using $B_i(L) = \Lambda_i D(L)^{-1} S$, and the factor loadings of macroeconomic variable i (Λ_i) are estimated by a linear OLS regression.

The instrument is constructed from high frequency financial market data as the change in Federal Fund rate futures from the 10 minutes before to 20 minutes after FOMC meetings. The use of a tight window is to ensure that any change to Federal Fund futures during this time is only due to revised market expectations and no other structural shock, thus supporting the identification assumptions. The data-led approach is considered more appropriate for the identification of a monetary policy shock during the low interest rate period in question, compared to traditional recursive approaches.

2.5.3 Structural shocks to bank riskiness in a low interest rate environment

Impulse response functions for the measures of bank stability are obtained by exploiting the role of Λ_k in $B^a_k(L) u_t = \Lambda^a_k D(L)^{-1} S$ (Equation 2.7). The vector of loadings are estimated with a modification following Buch et al. (2014*a*) to capture differences in the hypothesised response of bank riskiness to a monetary policy shock when interest rates are above or below some level. Specifically, the loading of the measure of bank stability on the observed market interest rate is allowed to vary:

$$\begin{aligned} a_{kt} &= \begin{bmatrix} \lambda^{r(1)}_k \lambda^\bullet_k \end{bmatrix} \mathbf{f}_t + \xi^a_{kt} \quad \text{for} \quad t < \tau_1 \\ a_{kt} &= \begin{bmatrix} \lambda^{r(2)}_k \lambda^\bullet_k \end{bmatrix} \mathbf{f}_t + \xi^a_{kt} \quad \text{for} \quad \tau_1 \leq t \leq \tau_2 \\ a_{kt} &= \begin{bmatrix} \lambda^{r(1)}_k \lambda^\bullet_k \end{bmatrix} \mathbf{f}_t + \xi^a_{kt} \quad \text{for} \quad t > \tau_2 \end{aligned} \tag{2.10}$$

[7] The full derivation is found on pages 105-7 of Stock and Watson (2012*a*).

Where $\lambda_k^{(1)}$ represents the loading of deposit-asset quintile k on the market interest rate outside of the low interest rate period, and $\lambda_k^{r(2)}$ represents the loading during the low interest rate period. This implies two regimes, within which the factor loadings are constant. The loadings of bank riskiness on the other factors are assumed unchanged by the regime switch, so that $\lambda_k^{\bullet}$ is unchanged for all t.

The loadings are estimated by an OLS regression of the bank riskiness measure on the set of factors, which includes the market interest rate interacted with a dummy variable equal to one when $\tau_1 \leq t \leq \tau_2$ and zero otherwise. This permits the production of two sets of impulse responses by substitution of $\lambda_j^{r(1)}$ and $\lambda_j^{r(2)}$ in Equation 2.6, conditional on the prevailing monetary policy regime.[8]

2.5.4 Measures of bank riskiness

Z-score

The main measure of bank risk is a time-varying Z-score. The measure is attributed to Boyd and Graham (1986) and Hannan and Hanweck (1988), and has been applied more recently by Laeven and Levine (2009) and Khan et al. (2017), amongst others. The Z-score measures the bank's probability of insolvency, which occurs when the bank cannot repay its creditors and may happen if the loan portfolio defaults. Using *car* to represent the bank's capital-asset ratio and *roa* its return on assets, insolvency can be defined as the state where $(car + roa) \leq 0$. Using the Bienaymé–Chebyshev inequality,[9] Boyd et al. (1993) demonstrate how Z is an upper-bound on the probability of bankruptcy if roa is a random variable with mean μ_{roa} and finite variance σ_{roa}:

$$\begin{aligned} &p(roa \leq -\, car) \leq Z^{-2} \\ &\text{where } Z = (car + \mu_{roa})/\sigma_{roa} \end{aligned} \tag{2.11}$$

The measure is not reliant on the distribution of roa, though in a time series setting the probabilistic interpretation of Z implies that μ_{roa} and σ_{roa} are moments of the distribution that are possibly time varying and hence need to be estimated as $\mu_{roa,t}$ and $\sigma_{roa,t}$. Changes in the bank's operating environment make it reasonable to assume that the moments of the distribution are time varying. Further, for the purpose of estimating the effect of a monetary policy shock on bank riskiness, a reasonable amount of variation must be assumed in the moments of the distribution of roa else the statistic will be primarily capturing variation in car. Comparatively, $(-car_t)$ may be taken as

[8] The use of latent factors estimated using principal components remains a valid approach due to the evidence presented by Bates et al. (2013), who show such estimates to be consistent in the presence of a structural break.

[9] The Bienaymé–Chebyshev inequality specifies that no more than Z^{-2} of a distribution's values can be Z or more standard deviations from the mean.

given, that is, either the contemporaneous value or an average over some time period. With this in mind, two separate measures of time-varying Z-score are estimated:

$$
\begin{aligned}
Z_t^1 &= \frac{\mu_{car,t}(n) + \mu_{roa,t}(n)}{\sigma_{roa,t}(n)} \\
Z_t^2 &= \frac{car_t + \mu_{roa,t}(n)}{\sigma_{roa,t}(n)}
\end{aligned}
\tag{2.12}
$$

Where the window width $n = 8$ is measured in quarters.

Alternative market based measures of bank riskiness

To support the results obtained from the Z-scores, two alternative market-based indicators of bank riskiness are used. Unlike balance sheet or income statement indicators, market-based indicators reflect the sentiment of market operators who respond to a broad range of bank-specific information. The market-based indicators are:

1. **Volatility of daily equity returns per quarter**, σ_{it}^r, estimated as the standard deviation of daily returns in quarter t.
2. **Share price volatility**, measured as $(p_t^{max} - p_t^{min})/p_t^{min}$, where p_t^{max} is the maximum share price in quarter t and p_t^{min} is the minimum.

The second measure intends to address the existence of zero returns due to very low trading volumes for certain banks and periods, which will influence return volatility even in the presence of intermittent, though large, swings in stock prices.

2.6 Data

2.6.1 Macroeconomic data

The latent macroeconomic factors are estimated from 134 monthly macroeconomic series from March 1990 to December 2019, presented in Appendix 2.A.1. The FRED-MD database (McCracken and Ng, 2016) is the starting point, with minor adjustments for improved identification using the external instrument approach. The adjustments follow Kerssenfischer (2019) and include the addition of real and nominal exchange rates and interest rate spreads between countries to address the possibility of spillover effects from close trading partners. I additionally include information relevant to bank characteristics (e.g., nominal house prices, consumer loans), and remove some sub-indices and spreads on government and corporate bonds to limit cross-correlation in the idiosyncratic error terms (Boivin and Ng, 2006).

Monthly macroeconomic data is used to improve identification of the monetary policy shock using the external instrument. The instrument is constructed from high-frequency financial market data, and measures the financial market surprise to the three-month ahead futures rate following FOMC decisions within a 30-minute window. Identification assumes that asset price movements in this window may only be attributed to a genuine monetary policy surprise that could not otherwise have been anticipated. The instrument contains some information on forward guidance, making the one-year Treasury bond a suitable observed factor. The instrument is obtained from the replication files of Gürkaynak et al. (2022) and is presented in Figure 2.B.1 in the Appendix.

2.6.2 Measures of bank riskiness

Bank-level data for constructing risk measures across the deposit-asset distribution is sourced from CRSP Compustat via WRDS for 1996Q1 to 2019Q1. Attention is limited to depository credit institutions and bank holding companies, where the latter are included to avoid excluding systemically important firms that became bank holding companies after the financial crisis in 2009. Implausible values are removed (e.g., missing or negative total assets, total loans and total deposits; loan-to-asset or capital-to-asset ratio greater than one; total deposits to total loans strictly greater than zero), and data is Winsorised at the 1st and 99th percentiles. The whole bank is removed from the sample if it does not have at least five years of consecutive data points. The final sample consists of 880 unique banks, with an average of 489 included in each quarter.

To estimate returns volatility, stock price data is obtained from Refinitiv by matching the CUSIP codes included in the CRSP dataset with RIC identifiers in Refinitiv. Stock price data cannot be identified for a small number of banks leaving a final sample of 760 unique banks with market data. For these variables, the deposit-asset ratios are re-estimated to reflect the sub-sample.

Table 2.6.1 presents the descriptive statistics for the measures of bank riskiness by deposit-asset quintiles. The quintiles are estimated each quarter so that they are 'moving' to account for changes in bank size and balance sheet-composition over time. The mean deposit-asset ratio for the first quintile ('low' deposit banks, Q_1) is around 63% and for the last quintile ('high' deposit banks, Q_5) is around 86%. This implies that the reliance on deposits as a funding source differs across the first and last deposit-asset quintiles by more than one fifth of total assets. High deposit banks tend to be smaller as measured by total assets, and have a larger NIM over the sample period. Whilst the loan-asset ratio for low deposit banks is smaller than the rest of the sample, the difference is not significant.

To interpret the Z-score, consider Equation 2.11. If $Z = 100$, this implies a probability of insolvency in period t of $p(roa_t \leq -car_t)$ of 0.01%. Equivalently, Z is the number of standard deviations profits must fall below the mean to eliminate equity. Interestingly, the mean values of Z-score for the low and high deposit banks are not statistically different, but high deposit banks exhibit more variance over time. The moments of the time-varying Z-scores estimated for this study are comparable to Lepetit and Strobel (2013).

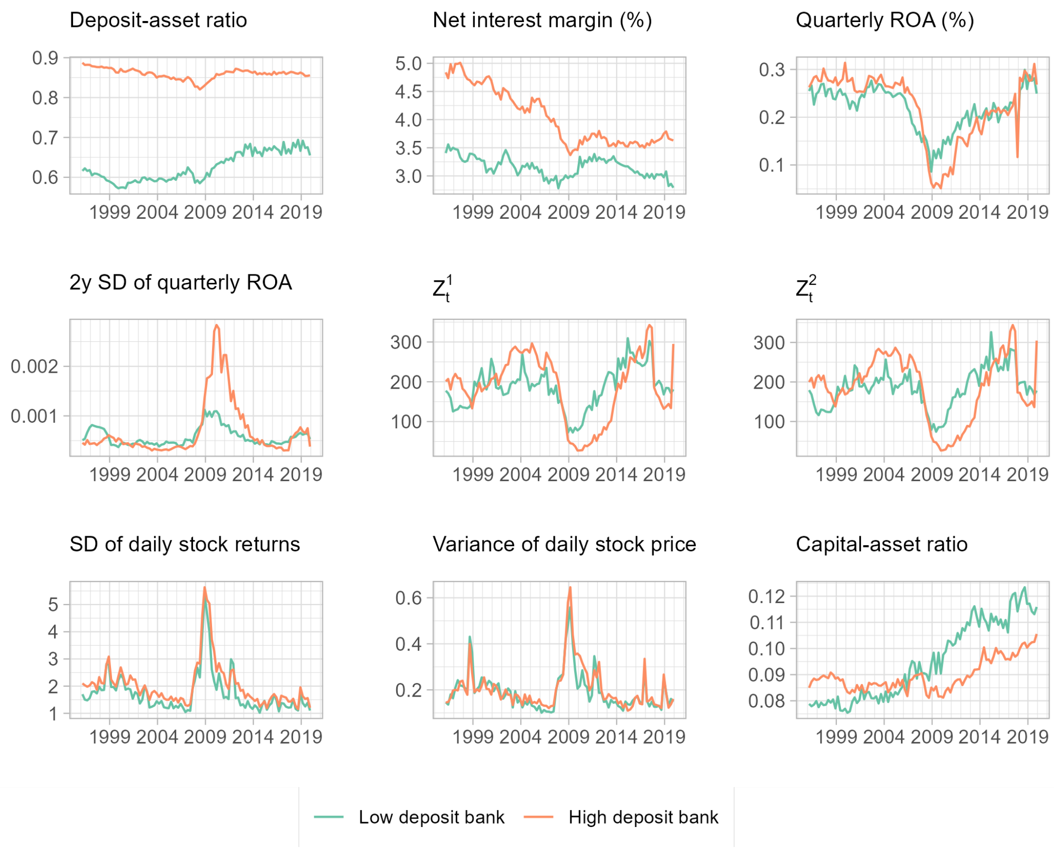
Table 2.6.1 suggests that banks with higher deposit-asset ratios (Q_5) are riskier by some measures, with marginally lower capital-asset ratios, lower Z-scores, and greater volatility in ROA, stock prices and stock returns. This aligns with Khan et al. (2017), who find a positive association between high deposit ratios and risk-taking measured by the Z-score from 1986 to 2014. The characteristics support the idea that low deposit banks are larger and better capitalised, with superior access to non-deposit market funding. Figure 2.6.1 suggest that high deposit banks were lower risk prior to the GFC, as indicated by Z-scores and capital-asset ratios. A binary variable is included in Equation 2.10 to address the structural break around the GFC. After adjusting for this break, the measures of bank riskiness are diagnosed as stationary by the KPSS and PP tests.

Table 2.6.1: Descriptive statistics for measures of bank riskiness

		Q_1	Q_2	Q_3	Q_4	Q_5	All
Deposit-asset ratio	*mean*	0.6256	0.7143	0.7679	0.8118	0.8588	0.7557
	median	0.6103	0.7025	0.7633	0.8169	0.8614	0.7645
	sd	0.0366	0.0339	0.0235	0.0156	0.0122	0.0849
Size (log assets)	*mean*	8.2755	7.5602	7.3227	7.044	6.7241	7.3853
	median	8.0567	7.3341	7.1656	7.202	6.797	7.2487
	sd	0.7263	0.6552	0.591	0.4492	0.383	0.7777
Loan-asset ratio	*mean*	0.6409	0.6837	0.6954	0.6996	0.6867	0.6813
	median	0.6341	0.6814	0.6885	0.6942	0.6822	0.6815
	sd	0.0351	0.0265	0.0291	0.0311	0.0331	0.0374
Capital-asset ratio	*mean*	0.0957	0.1000	0.0982	0.0965	0.0897	0.096
	median	0.0931	0.0976	0.0936	0.0936	0.0882	0.0922
	sd	0.0148	0.0125	0.0109	0.0082	0.0061	0.0114
NIM	*mean*	3.1447	3.5341	3.7643	3.9048	4.0035	3.6703
	median	3.1475	3.5225	3.7175	3.7875	3.7700	3.6200
	sd	0.1625	0.1635	0.2271	0.3255	0.4742	0.4248
ROA	*mean*	0.2173	0.2252	0.2276	0.2237	0.2188	0.2225
	median	0.2294	0.2365	0.2438	0.246	0.2505	0.2384
	sd	0.0454	0.0548	0.0602	0.0693	0.0718	0.0609
σ_{ROA}	*mean*	0.0408	0.0424	0.0414	0.043	0.0475	0.043
	median	0.0356	0.0320	0.0321	0.0310	0.0322	0.0325
	sd	0.0164	0.0267	0.0222	0.0298	0.0333	0.0263
Z_t^1	*mean*	186.91	204.2	206.01	205.32	185.96	197.68
	median	188.96	224.47	210.05	224.35	196.29	205.52
	sd	52.37	69.71	75.67	74.35	83.89	72.24
Z_t^2	*mean*	186.42	204.52	204.44	204.90	185.16	197.08
	median	188.50	217.98	207.05	223.54	193.14	204.41
	sd	50.24	69.43	75.89	72.96	82.29	71.28
σ_r	*mean*	1.7396	1.7841	1.8412	1.9756	2.0331	1.8747
	median	1.4928	1.5043	1.5578	1.7125	1.7988	1.6137
	sd	0.7590	0.8576	0.7686	0.8332	0.8345	0.8158
Price variance	*mean*	0.1941	0.1942	0.1981	0.1999	0.2056	0.1984
	median	0.1683	0.1624	0.1683	0.1721	0.1788	0.1721
	sd	0.0853	0.0917	0.0909	0.0911	0.0937	0.0903

Note: Q_x refers to the deposit-asset quintile, and 'All' refers to the whole sample. In the paper, the median of Q_1 is described as a 'low' deposit bank and Q_5 is labelled as a 'high' deposit bank. Summary statistics are estimated for the median bank in the deposit-asset quintile over the sample period. Size is the natural log of total assets, NIM is net interest margin as reported in CRSP-Compustat, ROA is quarterly return on total assets, σ_{ROA} is the two year standard deviation in quarterly ROA, Z_t^1 and Z_t^2 are as defined in Equation 2.12 and σ_r is the volatility of daily stock returns.

Figure 2.6.1: Time series of variables for low and high deposit banks



Note: The time series for low (high) deposit banks represents the median value of banks in the first (fifth) deposit-asset ratio quintile. Quarterly ROA is estimated using quarterly net income. Z_t^1 and Z_t^2 are as defined in the text. The standard deviation of daily stock returns is estimated over the quarter, and the capital-asset ratio estimates capital as the difference between total assets and total liabilities (i.e. is a balance sheet rather than regulatory measure).

2.7 Results

2.7.1 The estimated factors

The validity of factor models relies on the correct specification of the number of factors. Figure 2.A.1 in Appendix 2.A shows a scree plot of explained variance for the first 20 factors. The criterion of Alessi et al. (2010) suggests 7 and 10 factors best explain the data; the main results use 9 latent factors, and robustness tests subsequently show that the conclusions are unchanged when varying this over the suggested range.

Next, the latent factors are given economic interpretation. Table 2.A.2 in Appendix 2.A presents the proportion of variance explained by factor, for the most important variables per factor. Factor 1 primarily explains asset price variation (including interest

Table 2.7.1: Correlation between Z_t^1 and latent macroeconomic factors across the deposit-asset ratio distribution

	Low deposit banks		Median	High deposit banks	
Latent factor	Q_1	Q_2	Q_3	Q_4	Q_5
1	0.3265	0.4428	0.3318	0.5773	0.5894
2	0.4812	0.4011	0.3394	0.4002	0.2969
3	-0.1683	-0.3422	-0.2538	-0.4670	-0.4899
4	-0.4414	-0.4516	-0.4743	-0.5193	-0.6079
5	0.0526	0.2072	0.1479	0.2342	0.3528
6	-0.2500	-0.1049	-0.1619	-0.0114	0.1184
7	-0.0047	0.0238	0.0557	-0.0366	0.1377
8	0.1769	0.0987	0.1764	0.2105	0.1432
9	-0.1642	-0.2975	-0.2743	-0.2525	-0.3126

Note: Q_x refers to the deposit-asset quintile, where the median of Q_1 is described as a 'low' deposit bank and Q_2 is labelled as a 'high' deposit bank.

rates) and decisions by economic agents (household consumption and manufacturing utilisation); Factors 2 and 4 primarily explain real economic activity in terms of production and unemployment; Factor 3 primarily explains prices; Factors 5, 6 and 7 are primarily explained by business conditions including funding costs (e.g., equity, loans) and output; and the variance of Factors 8 and 9 is primarily explained by monetary variables.

Finally, the empirical model in Section 2.4 (in particular Equation 2.6) is supported by correlations between bank riskiness and the latent macroeconomic factors (Table 2.7.1). Correlations are broadly similar across deposit-asset ratios in direction and magnitude, with bank stability strongly correlated with factors representing asset prices and productive capacity (1, 2, and 4). Intuitively, this supports the role of the macroeconomic environment in the quality of bank assets. There is some disagreement in the direction of association between Z_t^1 and latent factors 6 and 7, which respectively are strongly explained by stock prices and interest and exchange rates, possibly due to differences in asset and liability structures as indicated by different proportions of deposit funding (English et al., 2018).

2.7.2 Response of macroeconomic variables to a monetary policy shock

Before examining the responses of bank riskiness to a monetary policy shock, it is informative to look at the aggregate responses of key macroeconomic variables. The FAVAR is estimated with $p = 6$ lags, representing half a year and a compromise between the BIC suggestion of 2 months and the AIC suggestion of 7 months. Identification follows Section 2.5.2 and 2.6.1, using the one year Treasury Bond rate as the observed interest rate and the external instrument from high frequency data. Throughout, the

IRFs represent the response to a monetary policy shock that is equivalent to a 10bp decrease in the effective FFR. While this shock is small relative to those used in similar structural models, it is more appropriate for the low interest rate period.

Figure 2.7.1 presents the impulse responses for ten of the 134 macroeconomic variables in the FAVAR. The confidence intervals are estimated using a Wild bootstrap approach with 2,000 draws as is typical for structural VAR models identified using external instruments (Mertens and Ravn, 2013; Gertler and Karadi, 2015; Kerssenfischer, 2019).[10] As a robustness check, the impulse responses are also estimated with an increasing number of factors, shown in Figure 2.C.1 in the Appendix. The responses of the variables are consistent with the main results.

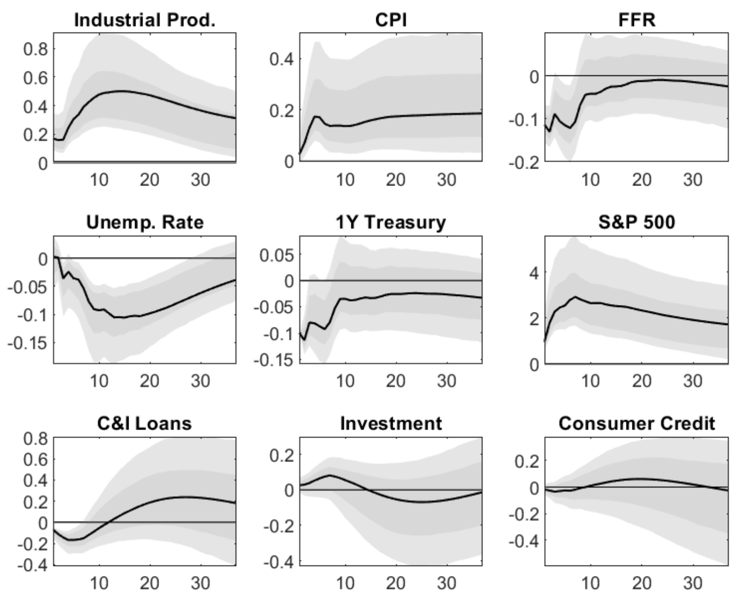
The impulse responses generally behave as expected by theory and align with findings from similar FAVAR models using external instrument identification (e.g., Kerssenfischer, 2019; Cantore et al., 2022). A reduction in the policy rate increases the industrial production index and reduces unemployment. Importantly, the use of a large number of variables and data-led identification does not result in a 'price-puzzle', and there is an increase in the rate of price increases following a cut in the policy interest rate. Equity prices (S&P 500) increase immediately due to lower interest rates and an improved future outlook (Jarociński and Karadi, 2020), and the yield on one year Treasury bonds follow a similar path to the FFR.

Lending to businesses via C&I (commercial and industrial) loans increases after around seven months evidencing the credit channel of monetary policy (Bernanke and Gertler, 1995). The initial decline, contrary to standard economic theory, is also evidenced by den Haan et al. (2007), who theorise it may result from banks reconfiguring loan portfolios due to substitution effects. Similarly, consumer credit eventually rises, though with a smaller initial decline, indicating a stronger balance-sheet channel for consumers who have fewer external finance options.

[10]The standard errors are estimated using a Wild bootstrap, with a modification to account for uncertainty in the idiosyncratic component as suggested Stock and Watson (2016). The algorithm runs as follows:

1. The parameters of the FAVAR (Λ, $\mathbf{f}$, ξ, $D(L)$ and ϵ) are estimated using the data as described in Section 2.5.
2. Artificial values of the reduced form shock ϵ are generated using the Rademacher distribution (which randomly draws values of $[-1, 1]$ with equal probability), which is used along with $D(L)$ and Λ to estimate an artificial common component $\hat{\chi}$.
3. Artificial values of each idiosyncratic component ξ_{it} are obtained by estimation of an AR(4) process for each ξ_{it}, such that $\xi_{it} = \sum_{p=1}^{4} d_p^i \xi_{it-p} + \zeta_{it}$. The artificial idiosyncratic component $\hat{\xi}_t$ is obtained using the autoregression coefficients $\hat{d}_p^i$ and draws of $\zeta_{it} \sim N(0, \hat{\sigma}^2_{\zeta_i})$.
4. An artificial dataset is estimated as $\hat{X} = \hat{\chi} + \hat{\xi}$, and the estimation described in Section 2.5 is applied to $\hat{X}$.

Figure 2.7.1: Impulse response functions for selected macroeconomic variables included in the FAVAR following a monetary policy shock equal to a 10bps decrease in the effective FFR



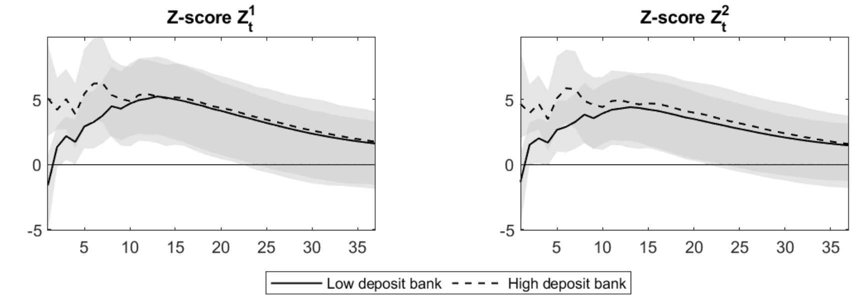
Note: The figure shows impulse responses (solid lines) together with 68% (dark grey shaded area) and 90% confidence bands (light grey shaded area) to a monetary policy shock equivalent to a 10bps decrease in the effective FFR. The x-axis shows horizons (months) since the policy shock and the y-axis shows the variable response in their respective units.

2.7.3 Response of bank risk

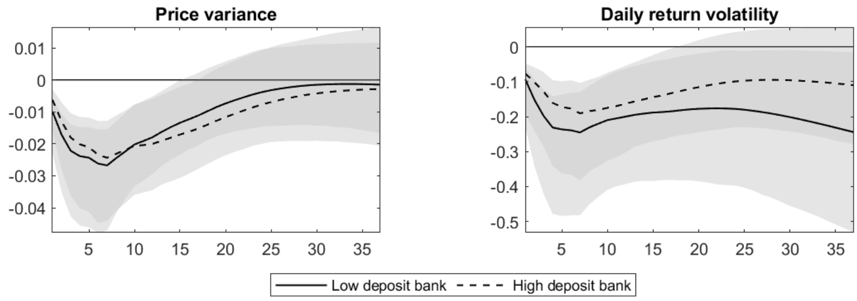
The factor loadings for estimating impulse responses of bank riskiness to a monetary policy shock are obtained by averaging the monthly macroeconomic factors over the quarter. This method is preferred over using the quarter-end value, as quarterly bank balance sheet information reflects the entire quarter. Results remain consistent regardless of the method used.

Figure 2.7.2 presents the impulse response functions of low and high deposit banks to a monetary policy shock outside of the low interest rate period (regime 1 in Equation 2.10). As predicted by the conceptual framework, Figure 2.7.2a indicates a small but significant increase in the Z-score, implying an improvement in bank stability. There is no statistically significant difference between low and high deposit banks, except at the impact horizon ($h = 0$). After around one year, the Z-scores of both bank types converge to zero. This finding is supported by a decline in riskiness as measured by the market-based measures of bank stability (Figure 2.7.2b), with the responses similar for low and high deposit banks. The results align with the empirical evidence of Buch et al. (2014*b*), who show an improvement in bank riskiness following an expansionary monetary policy shock.

Figure 2.7.2: Baseline impulse response functions for measures of bank stability following a monetary policy shock equivalent to a 10bps decrease in the FFR



(a) Response of Z_t^1 and Z_t^2 to a monetary policy shock



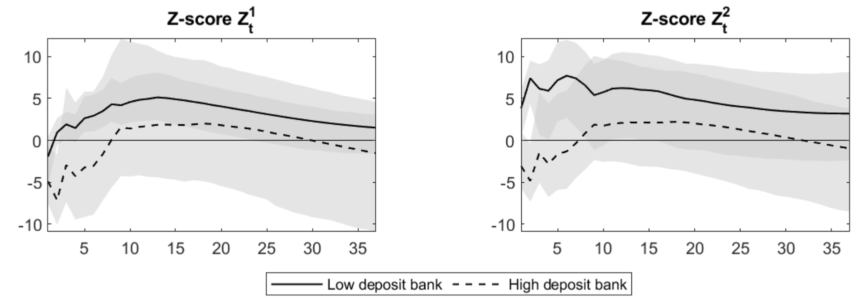
(b) Response of σ_{ROA} and σ_r to a monetary policy shock

Note: Grey shaded areas indicate significance at the 90% level. The x-axis for each plot shows the number of months following the monetary policy shock up to three years. Low (high) deposit bank is the median value for banks in the first (last) quintile of the deposit-asset ratio.

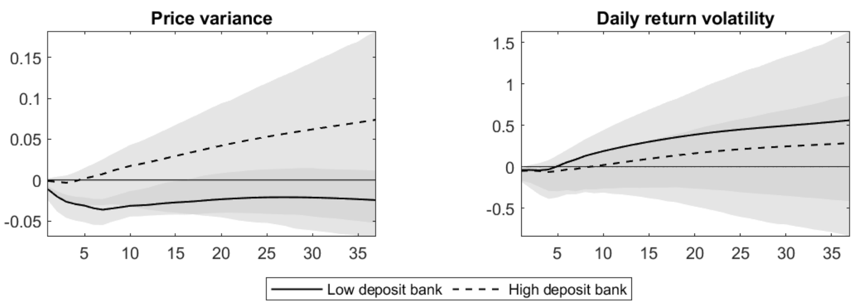
This improvement in stability arises for two reasons. First, the improved macroeconomic environment (Figure 2.7.1) enhances bank stability over time as credit demand increases and returns to intermediation become less variable. Lower rates make debt cheaper to service, reducing borrower default risk. This aligns with the financial accelerator concept, where monetary loosening improves asset prices and investment prospects (Bernanke and Gertler, 1995; Bernanke et al., 1999; Disyatat, 2011). Second, there may be a short-term widening of the bank's NIM, as rate cuts are not immediately passed-on to long-term assets but are to short-term liabilities. This benefits the bank's expected earnings and stability (English et al., 2018).

Moving to the low interest rate period, Figure 2.7.3 shows impulse response functions estimated using the augmented factor loading in Equation 2.10. The values of τ_1 and τ_2, defining the low interest rate period, are set as 2009Q1 and 2015Q4 respectively. This coincides with the first and last full quarters for which the effective FFR was below 0.25, which is the upper end of the zero lower bound range used in modelling shadow interest rates, e.g., Wu and Xia (2016). Robustness tests confirm that changing this window to exclude the tail-end of GFC recovery does not alter the main conclusions.

Figure 2.7.3: Impulse response functions for measures of bank stability following a monetary policy shock equivalent to a 10bps decrease in the FFR during the ultra low interest rate period



(a) Response of Z_t^1 and Z_t^2 to a monetary policy shock during the low interest rate period



(b) Response of σ_{ROA} and σ_r to a monetary policy shock during the low interest rate period

Note: Grey shaded areas indicate significance at the 90% level. The x-axis for each plot shows the number of months following the monetary policy shock up to three years. Low (high) deposit bank is the median value for banks in the first (last) quintile of the deposit-asset ratio.

Both charts in Figure 2.7.3a show a deterioration in the Z-scores of high deposit banks relative to low deposit banks following a monetary loosening equivalent to a 10bps decrease in the FFR when the rate is already below 25bps. The deterioration is statistically significant for the immediate months. Comparatively, the Z-score of low deposit banks is relatively unchanged compared to the baseline period. Notably the Z_t^2 measure of the Z-score for low deposit banks improves on impact during the low rate period, which is possibly due to the use of the contemporaneous capital-asset ratio in the numerator as opposed to the rolling window mean $\mu_{car,t}$ which is used in Z_t^1. The market-based measures of bank riskiness go some way to support this result (Figure 2.7.3b), with the price variance of high deposit banks increasing across the three years following the monetary policy shock and that of low deposit banks following a similar path to the baseline estimates. Daily return volatility does not show a statistically significant change for either high or low deposit banks.

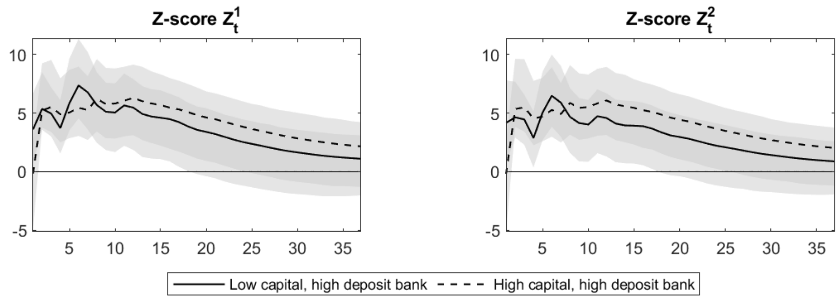
For the low deposit banks, the greater reliance on non-deposit funding means that pass-through of the policy rate to overall funding costs (which includes more non-deposit sources) faces less friction. As a result, there is limited change in the response of bank stability to a monetary policy loosening when the policy rate is low. Comparatively, the pass-through of the lower policy rate to the overall funding costs of high deposit banks is relatively more constrained, thus leading to a compression in NIMs. Whilst the deposit share of funding for low deposit banks will face the same frictions as for high deposit banks, research by Landi et al. (2020) shows how low deposit banks are more responsive in offsetting negative pressure on interest margins. Landi et al. show how low deposit banks were more likely to change their strategy towards fee income than high deposit banks following forward guidance from the FOMC of maintained low effective rates.

The deterioration in stability for high deposit banks following a monetary policy loosening during the low rate period presented here is supported by evidence presented in the literature. Much of the research into this question has focused on the banks of Euro area countries where the policy rate fell below zero, though some US-based evidence can be identified. For instance, using a cross-country sample including the US, Ulate (2021) shows that when the policy rate is above a threshold, there is no difference in the effect of a monetary policy loosening on the ROA of low vs. high deposit banks (as measured by deposit-asset quintile). However, when the policy rate falls below a threshold, the ROA of high deposit banks deteriorates more than that of low banks. Ngambou Djatche (2019) does not differentiate between low vs. high deposit banks, but does observe a deterioration in bank Z-score following a monetary loosening when the policy rate is already below that implied by the Taylor rule.

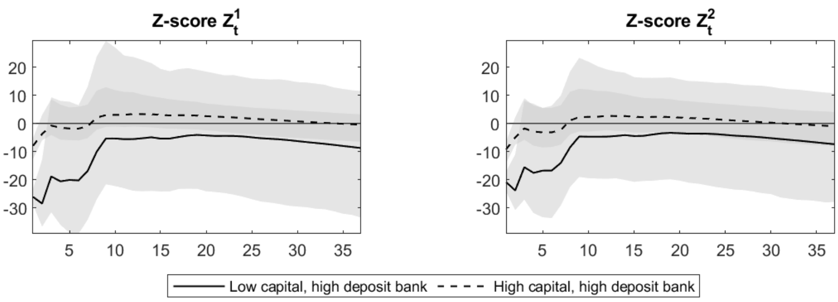
Looking to the Euro area, the evidence presented here is supported by Nucera et al. (2017), Heider et al. (2019) and Bubeck et al. (2020). Nucera et al. (2017) finds higher deposit banks become riskier using a measure of capitalisation following a cut to an already low policy rate, while Heider et al. (2019) and Bubeck et al. (2020) each find higher deposit banks to engage in more risk taking when the policy rate is low. In respect of the market response of bank equity, Ampudia and Van den Heuvel (2022) find the equity price of high deposit banks to fall on a monetary loosening when interest rates are below zero. While Euro area banks faced a more acute version of the deposit lower bound since the ECB's deposit facility rate turned negative, empirical evidence presented by Altavilla et al. (2022) suggests evidence of a lower bound due to uncertainty when the policy rate 'hovers' close to zero.

Finally, Figure 2.7.4 shows how this deterioration in bank stability is strongest for high deposit banks with lower levels of capital. Within high deposit banks, the capital-asset ratio is split into quintiles and the median of the first and last quintile is taken to represent high deposit banks with low and high levels of capital, respectively. The level of capital is seen to not make a difference to the response of the Z-score to a monetary policy loosening when the policy rate is far from zero (Figure 2.7.4a). However, when the monetary policy rate is already very low, the stability high deposit banks with low levels of capital is shown to deteriorate significantly more than that of well-capitalised high deposit banks.

Figure 2.7.4: Impulse response functions for the Z-score of high deposit banks with high vs. low levels of capital following a monetary policy shock equivalent to a 10bps decrease in the FFR



(a) Response of Z_t^1 and Z_t^2 to a monetary policy shock outside of the low interest rate period for high deposit banks separated by levels of capital



(b) Response of Z_t^1 and Z_t^2 to a monetary policy shock during the ultra-low interest rate period for high deposit banks separated by levels of capital

Note: Grey shaded areas indicate significance at the 90% level. The x-axis for each plot shows the number of months following the monetary policy shock up to three years. A low (high) capital bank is defined as the median value in the first (last) quintile of the capital-asset ratio for high deposit banks only.

For all high deposit banks, the monetary policy loosening has a negative effect on the bank's franchise value as frictions in pass-through to deposit rates imply a decrease in the bank's future expected profit stream. For the high deposit banks with lower capital levels, this effect is accentuated as lower capital means greater exposure to agency problems (Hellmann et al., 2000; Dell'Ariccia et al., 2017). The result presented here is supported by evidence in Europe, where Bubeck et al. (2020) finds that highly levered high deposit banks are more likely to invest in securities (i.e. riskier assets) following the introduction of negative interest rates, which they describe as evidence of reaching for yield.

2.7.4 Further robustness tests

Two further robustness tests are conducted to support the results. First, as for the macroeconomic variables, the IRFs of the Z-scores are estimated for a varying number of macroeconomic factors (Figure 2.C.2 in Appendix 2.C). The results continue to hold: when the interest rate is away from zero, a monetary policy loosening leads to an improvement in bank stability, though when the interest rate is close to zero, a monetary policy loosening leads to a deterioration in bank stability for high deposit banks.

Second, there is the possibility that the initial monetary loosening which led to the period of ultra-low interest rates could be contaminating the results. Following the initial large cut to the policy rate, the banking sector was also continuing to to recover from the aftermath of the GFC, and the US was in recession until June 2009. A robustness test excluding this period is conducted to demonstrate that the effect of a monetary loosening in the low rate period on bank stability is not the result of the GFC-aftermath. Figure 2.C.3 presents a comparison of the estimates with the low interest period starting in 2009Q1 as in the main results, and one year later in 2010Q1. The results are largely unchanged, in that the stability of high deposit banks still weakens relative to low deposit banks following a monetary policy loosening during the low interest rate period.

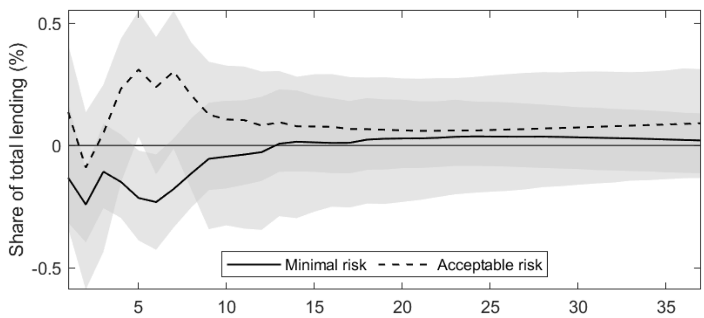
2.8 Discussion

The results show that within a macroeconometric framework when the policy rate is away from zero, bank stability improves following a monetary loosening. Comparatively, when the policy rate is close to zero, a surprise monetary loosening leads to heterogeneity in the response. The stability of banks with higher dependence on deposits deteriorates, whilst that of banks with lower deposit dependence improves in the same way as when the policy rate is away from zero. This result contrasts with, though does not contradict, evidence suggesting that monetary easing increases ex-ante bank risk (e.g., Buch et al., 2014*a*; Dell'Ariccia et al., 2017). This suggests that the realisation of ex-ante bank risk is conditional on the wider macroeconomic environment.

To support this claim and to address any concern that the macroeconometric set up is driving the results, a proxy for ex-ante bank risk is incorporated into the FAVAR to demonstrate that it responds similarly to existing literature. The Survey of Terms of

Business Lending (STBL),[11] used by Buch et al. (2014*a*) and Dell'Ariccia et al. (2017), is employed and the results are presented in Figure 2.8.1. The figure shows that the response of overall bank risk appetite increases following a monetary loosening in a framework that is rich in macroeconomic information. The proportion of loans of 'minimal risk' (the lowest risk category) deteriorates, whilst the proportion of 'acceptable risk' loans (the highest risk category) increases. This implies that while banks might be incentivised to take on riskier loans, it does not necessarily lead to a decrease in bank stability. Monetary easing may boost broader risk appetite against improved macroeconomic conditions (Bauer et al., 2023), improving firm access to non-bank finance and project success. This idea corresponds with Bonfim and Soares (2018), that higher ex-ante risk is not a necessary condition for ex-post risk.

Figure 2.8.1: Impulse response functions of the proportion of lending by risk category following a monetary policy shock equivalent to a 10bps decrease in the FFR



Note: Grey shaded areas indicate significance at the 90% level. The x-axis shows the number of months following the monetary policy shock up to three years. Proportion of lending by risk category is obtained from the Federal Reserve's STBL, a survey of new lending made to businesses covering a sample period of 1992Q2 to 2017Q2. 'Minimal' risk refers to the lowest risk level, and 'acceptable' risk refers to the highest risk level.

The focus of the FAVAR framework for this study is restricted to the impact of a conventional monetary policy shock via a change in the effective FFR. This raises three points for further discussion: first, the possibility of a role for persistently low interest rates; second, the isolation of the effects of conventional (over unconventional) monetary policy; and third, the possibility of second round effects.

Possibility of a role for persistently low interest rates. The FAVAR identifies the impacts of a monetary policy shock, not the effects of a prolonged period of low interest rates, even for the shock estimated during such periods. The results suggest that for high deposit banks, a sustained low interest rates environment could lead to

[11] The STBL collects data on new loans made to businesses, including information on perceived loan risk, during the first full business week of the mid-month of each quarter. The sample period runs from 1992Q2 to 2017Q2, when the survey was discontinued. The panel for the survey is a stratified sample of 398 banks, and loan risk is categorised into minimal risk (the lowest risk level), low risk, moderate risk and acceptable risk (the highest risk level).

continued deterioration in bank stability, measured by the likelihood of insolvency. This may occur as long-term assets are refinanced at lower rates as the yield curve is flattened, supporting NIM compression and bank earning capability. Claessens et al. (2018) shows how each additional year of a low-for-long interest rate policy increases pressure on bank profitability and NIMs. This could limit a bank's ability to generate internal capital over time, reducing its value of market equity, and raising wholesale funding costs. This may serve to undermine bank resilience to future shocks, particularly for small domestic banks more dependent on deposit funding.

Additionally, persistent refinancing of long-term assets at persistently low rates may encourage banks to reach for yield to maintain higher NIMs, per the risk taking channel (Jiménez et al., 2014; Dell'Ariccia et al., 2017). Bank resilience and a portfolio of ex-ante riskier loans may not be prepared for an unexpected subsequent move out of a low interest rate environment. Bonfim and Soares (2018), for example, shows that loans originated during a prolonged low rate period are more likely to default if monetary policy tightens. This presents a channel for interaction between monetary and financial stability policies.

Focus on the effects of a conventional monetary policy shock. The FOMC influence the effective Federal Funds rate through open market operations, though over the low rate period and in response to the GFC engaged in unconventional monetary policies such as Large Scale Asset Purchases (LSAPs). The external instrument used for identification of conventional monetary policy shocks is constructed using the dates on which the FOMC announced the target Federal Funds rate (i.e., does not include LSAP announcements). Some research has alternatively considered the role of unconventional monetary policy actions on bank performance; for example, Mamatzakis and Bermpei (2016) find a negative relation between unconventional monetary policy and bank performance which is particularly acute for banks that are more reliant on deposit funding. This evidence would only serve to strengthen the results presented in this study.

Possibility for second round effects following a monetary policy shock. The FAVAR identifies the impact of a monetary policy shock; whilst the later horizons of the impulse response functions capture some of the post-shock interaction between variables, it is not possible to identify the size of these effects. Of particular interest is the response of banks to a monetary policy loosening during a low rate period and any macroeconomic effects of this response. The current model assumes that bank stability depends on the macroeconomic factors, but not vice versa. This assumption holds for an individual bank, though there is a version of the model where the dependency is bilateral. In particular, Abadi et al. (2023) describe the 'reversal interest rate' where looser monetary policy has contractionary macroeconomic effects due to the channels described in this study. The compression in bank profits leads to declines in bank asset values resulting in tighter capital constraints, which puts constraints on credit. Such a macroeconomic contraction would only serve to worsen bank stability via the bank's loan portfolio.

Additionally, the response of the market, as measured by stock price volatility, is crucial for second round effects, potentially raising wholesale funding costs as markets internalise higher instability. A negative market reaction may limit the ability of high deposit banks to improve their capital position via equity issuance (Bolton and Freixas, 2006).

2.9 Conclusions

The effect of monetary policy on bank stability is an important area of research, with relevance to monetary policy and financial stability policy makers alike. However, the period of low interest rates that followed the financial crisis presented a series of unknowns for policy makers, with questions around how bank stability would respond a flatter yield curve. This study evidences that the impacts are heterogeneous, depending on the bank's reliance on deposit funding due to a lower bound on deposit rates. The role of capital is also shown to be important for high deposit banks, supporting the use of regulatory capital constraints.

The study also presents evidence that, when interest rates are away from zero, increased incentives to take risks does not necessarily materialise in a decrease in bank stability. This result may be of reassurance to policy makers, though importantly it relies on the improved macroeconomic environment that follows a monetary policy loosening. Further research might look to explore the second round effects of a monetary policy shock on bank stability, including whether persistent low rate induced risk taking is important.

Appendix

2.A Macroeconomic factors

2.A.1 Macroeconomic series used in estimation of latent factors

Table 2.A.1: Macroeconomic series used to estimate latent factors

No.	tcode	Series name	FRED mneomic
Financial markets			
1	1	Effective Federal Funds Rate	FEDFUNDS
2	1	3-Month Treasury Bill	TB3MS
3	1	6-Month Treasury Bill	TB6MS
4	1	1-Year Treasury Rate	GS1
5	1	5-Year Treasury Rate	GS5
6	1	10-Year Treasury Rate	GS10
7	1	3-Month AA Financial Commercial Paper Rate minus GS10	CP3Mx_TB3MS
8	1	Moody's AAA Corporate Bond minus GS10	AAA_GS10
9	1	Moody's BAA Corporate Bond minus GS10	BAA_GS10
10	1	30Y Fixed Rate Mortgage Average (US) minus GS10	MORTGAGE30US_GS10
11	1	Switzerland-US short-term interest rate spread	IRDIFSZUS
12	1	Japan-US short-term interest rate spread	IRDIFJPUS
13	1	Canada-US short-term interest rate spread	IRDIFCAUS
14	1	UK-US short-term interest rate spread	IRDIFUKUS
15	5	S&P's Common Stock Price Index: Composite	S.P.500
16	5	S&P's Common Stock Price Index: Industrials	S.P..indust
17	5	S&P's Composite Common Stock: Dividend Yield	S.P.div.yield
18	5	S&P's Composite Common Stock: Price-Earnings Ratio	S.P.PE.ratio
19	5	Trade Weighted U.S. Dollar Index	TWEXAFEGSMTHx
20	5	Switzerland / U.S. Foreign Exchange Rate	EXSZUSx
21	5	Japan / U.S. Foreign Exchange Rate	EXJPUSx
22	5	Canada / U.S. Foreign Exchange Rate	EXCAUSx
23	5	U.S. / U.K. Foreign Exchange Rate	EXUSUKx
24	4	Switzerland/US Real Exchange Rate	REXSZUSx

Table 2.A.1: Macroeconomic series used to estimate latent factors

No.	tcode	Series name	FRED mneomic
25	4	Japan/US Real Exchange Rate	REXJPUSx
26	4	Canada/US Real Exchange Rate	REXCAUSx
27	4	UK/US Real Exchange Rate	REXUSUKx
28	1	VIX	VIXCLSx
29	1	Excess Bond Premium (Gilchrist and Zakrajšek, 2012)	ebp
Households			
30	5	Personal Cons. Exp: Durable goods	DDURRG3M086SBEA
31	5	Personal Cons. Exp: Nondurable goods	DNDGRG3M086SBEA
32	5	Personal Cons. Exp: Services	DSERRG3M086SBEA
33	5	Personal Cons. Expend.: Chain Index	PCEPI
34	5	Real personal consumption expenditures	DPCERA3M086SBEA
35	5	Real Personal Income	RPI
36	5	Real personal income ex transfer receipts	W875RX1
Housing market			
37	4	Housing Starts, Midwest	HOUSTMW
38	4	Housing Starts, Northeast	HOUSTNE
39	4	Housing Starts, South	HOUSTS
40	4	Housing Starts, West	HOUSTW
41	4	Housing Starts: Total New Privately Owned	HOUST
42	4	New Private Housing Permits (SAAR)	PERMIT
43	4	New Private Housing Permits, Midwest (SAAR)	PERMITMW
44	4	New Private Housing Permits, Northeast (SAAR)	PERMITNE
45	4	New Private Housing Permits, South (SAAR)	PERMITS
46	4	New Private Housing Permits, West (SAAR)	PERMITW
47	5	Nominal house prices	NOMHP
Industry and services			
48	1	Capacity Utilization: Manufacturing	CUMFNS
49	5	IP Index	INDPRO
50	5	IP: Business Equipment	IPBUSEQ
51	5	IP: Consumer Goods	IPCONGD
52	5	IP: Durable Consumer Goods	IPDCONGD
53	5	IP: Durable Materials	IPDMAT
54	5	IP: Final Products (Market Group)	IPFINAL
55	5	IP: Final Products and Nonindustrial Supplies	IPFPNSS
56	5	IP: Fuels	IPFUELS
57	5	IP: Manufacturing (SIC)	IPMANSICS
58	5	IP: Materials	IPMAT
59	5	IP: Nondurable Consumer Goods	IPNCONGD
60	5	IP: Nondurable Materials	IPNMAT
61	5	IP: Residential Utilities	IPB51222S
62	1	ISM Manufacturing: Prices Index	USNAPMCP

Table 2.A.1: Macroeconomic series used to estimate latent factors

No.	tcode	Series name	FRED mneomic
63	1	ISM Manufacturing: Production Index	USNAPMPR
64	1	ISM: Inventories Index	USNAPMIV
65	1	ISM: New Orders Index	USNAPMNO
66	1	ISM: PMI Composite Index	USCNFBUSQ
67	1	ISM: Supplier Deliveries Index	USNAPMDL
68	5	New Orders for Durable Goods	AMDMNOx
69	5	New Orders for Nondefense Capital Goods	ANDENOx
70	5	Real Manu. and Trade Industries Sales	CMRMTSPLx
71	5	Retail and Food Services Sales	RETAILx
72	5	Total Business Inventories	BUSINVx
73	1	Total Business: Inventories to Sales Ratio	ISRATIOx
74	5	Unfilled Orders for Durable Goods	AMDMUOx
Labour market			
75	5	All Employees: Construction	USCONS
76	5	All Employees: Durable goods	DMANEMP
77	5	All Employees: Financial Activities	USFIRE
78	5	All Employees: Goods-Producing Industries	USGOOD
79	5	All Employees: Government	USGOVT
80	5	All Employees: Manufacturing	MANEMP
81	5	All Employees: Mining and Logging: Mining	CES1021000001
82	5	All Employees: Nondurable goods	NDMANEMP
83	5	All Employees: Retail Trade	USTRADE
84	5	All Employees: Service-Providing Industries	SRVPRD
85	5	All Employees: Total nonfarm	PAYEMS
86	5	All Employees: Trade, Transportation & Utilities	USTPU
87	5	All Employees: Wholesale Trade	USWTRADE
88	1	Average Duration of Unemployment (Weeks)	UEMPMEAN
89	5	Avg Hourly Earnings : Construction	CES2000000008
90	5	Avg Hourly Earnings : Goods-Producing	CES0600000008
91	5	Avg Hourly Earnings : Manufacturing	CES3000000008
92	1	Avg Weekly Hours : Goods-Producing	CES0600000007
93	1	Avg Weekly Hours : Manufacturing	AWHMAN
94	1	Avg Weekly Overtime Hours : Manufacturing	AWOTMAN
95	5	Civilian Employment	CE16OV
96	5	Civilian Labor Force	CLF16OV
97	1	Civilian Unemployment Rate	UNRATE
98	1	Civilians Unemployed - 15 Weeks & Over	UEMP15OV
99	1	Civilians Unemployed - Less Than 5 Weeks	UEMPLT5
100	1	Civilians Unemployed for 15-26 Weeks	UEMP15T26
101	1	Civilians Unemployed for 27 Weeks and Over	UEMP27OV
102	1	Civilians Unemployed for 5-14 Weeks	UEMP5TO14
103	4	Initial Claims	CLAIMSx

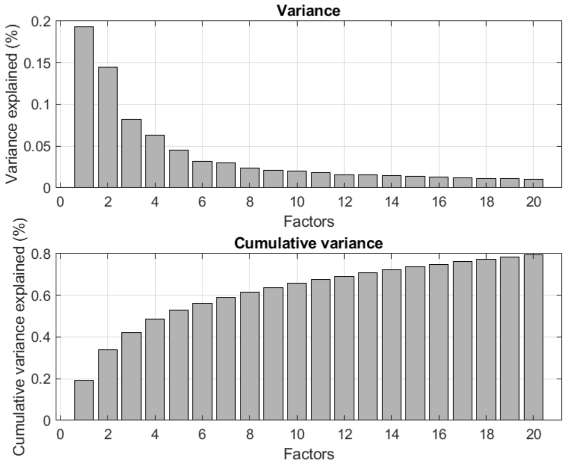
Table 2.A.1: Macroeconomic series used to estimate latent factors

No.	tcode	Series name	FRED mneomic
104	1	ISM Manufacturing: Employment Index	USNAPMEM
Money and credit			
105	5	Commercial and Industrial Loans	BUSLOANS
106	5	Consumer Motor Vehicle Loans Outstanding	DTCOLNVHFNM
107	5	M1 Money Stock	M1SL
108	5	M2 Money Stock	M2SL
109	5	Monetary Base	BOGMBASE
110	1	Nonrevolving consumer credit to Personal Income	CONSPI
111	5	Real Estate Loans at All Commercial Banks	REALLN
112	5	Real M2 Money Stock	M2REAL
113	5	Securities in Bank Credit at All Commercial Banks	INVEST
114	5	Total Consumer Loans and Leases Outstanding	DTCTHFNM
115	5	Total Nonrevolving Credit	NONREVSL
116	5	Total Reserves of Depository Institutions	TOTRESNS
Prices			
117	5	CPI : All Items	CPIAUCSL
118	5	CPI : All Items Less Food	CPIULFSL
119	5	CPI : All items less medical care	CUSR0000SA0L5
120	5	CPI : All items less shelter	CUSR0000SA0L2
121	5	CPI : Apparel	CPIAPPSL
122	5	CPI : Commodities	CUSR0000SAC
123	5	CPI : Durables	CUSR0000SAD
124	5	CPI : Medical Care	CPIMEDSL
125	5	CPI : Services	CUSR0000SAS
126	5	CPI : Transportation	CPITRNSL
127	5	CPI: All Urban Consumers All Items	CUUR0000SA0L2
128	5	CPI: All Urban Consumers Durables	CUUR0000SAD
129	5	Crude Oil, spliced WTI and Cushing	OILPRICEx
130	5	PPI: Crude Materials	WPSID62
131	5	PPI: Finished Consumer Goods	WPSFD49502
132	5	PPI: Finished Goods	WPSFD49207
133	5	PPI: Intermediate Materials	WPSID61
134	5	PPI: Metals and metal products:	PPICMM

Note: tcode ('transformation code') refers to the transformation applied to the data in levels, where the code is based on the stationarity of the data and follows McCracken and Ng (2016). 1 = no transformation (levels), 2 = first difference, 3 = second difference, 4 = natural log, 5 = first difference of the natural log, 6 = second difference of the natural log, 7 = first difference of percentage change. ISM series are sourced from Refinitiv. The EBP of Gilchrist and Zakrajšek (2012) is sourced from the Federal Reserve FEDS Notes (accessed May 2023). Real exchange rates are estimated using CPI and using data sourced from the FRED Economic Data resource. Nominal house prices are obtained from Robert Shiller's website (accessed May 2023).

2.A.2 Variance explained by latent factors

Figure 2.A.1: Scree plot of latent factors following EM algorithm



Note: The top graph presents the overall variance explained in the data by the first 20 latent factors, and the second graph presents the cumulative variance.

2.A.3 Proportion of factor variance explained by macroeconomic variables

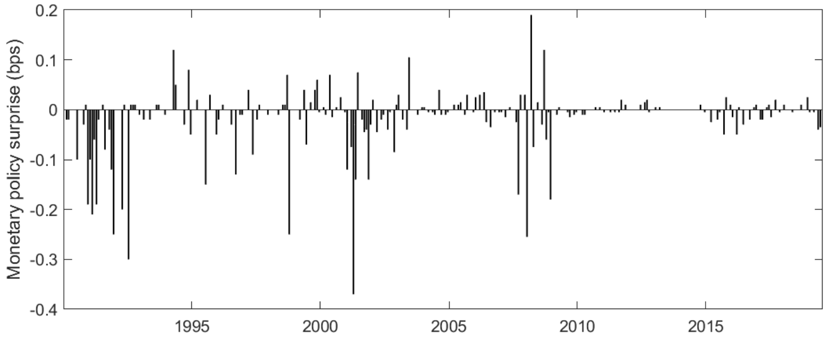
Table 2.A.2: Proportion of variance explained by latent macroeconomic factors for macroeconomic variables with highest explained variance

Latent factor 1		**Latent factor 2**	
AAA_GS10	0.6260	AWHMAN	0.6350
BAA_GS10	0.5844	CES0600000007	0.5796
CUMFNS	0.5243	AWOTMAN	0.5500
HOUST	0.5091	USGOOD	0.5095
PCEPI	0.4755	USCNFBUSQ	0.4844
HOUSTW	0.4678	USNAPMNO	0.4755
TB6MS	0.4665	USNAPMPR	0.4635
REXJPUSx	0.4656	USNAPMEM	0.4599
GS1	0.4616	DMANEMP	0.4559
TB3MS	0.4595	MANEMP	0.4480
Latent factor 3		**Latent factor 4**	
REXCAUSx	0.4287	UNRATE	0.5014
CPITRNSL	0.3807	IPCONGD	0.3163
WPSID61	0.3785	IPFPNSS	0.3144
DNDGRG3M086SBEA	0.3720	IPFINAL	0.3077
CUSR0000SAC	0.3704	INDPRO	0.2974
WPSFD49502	0.3541	IPMANSICS	0.2882
WPSFD49207	0.3440	UEMP5TO14	0.2612
CUSR0000SA0L2	0.3231	UEMPLT5	0.2606
UEMP27OV	0.3196	IPDCONGD	0.2564
UEMP15OV	0.2990	CLAIMSx	0.2535
Latent factor 5		**Latent factor 6**	
S.P.div.yield	0.3927	S.P.500	0.2315
S.P.500	0.3594	S.P..indust	0.2289
S.P..indust	0.3525	IPCONGD	0.2115
S.P.PE.ratio	0.3323	S.P.div.yield	0.1927
EXCAUSx	0.2106	IPFINAL	0.1652
BUSLOANS	0.1786	IPNCONGD	0.1490
TOTRESNS	0.1624	IPFPNSS	0.1349
TWEXAFEGSMTHx	0.1620	INDPRO	0.1158
CP3Mx_TB3MS	0.1620	VIXCLSx	0.1041
USNAPMIV	0.1583	IPDCONGD	0.1019
Latent factor 7		**Latent factor 8**	
IRDIFJPUS	0.3135	IRDIFUKUS	0.1648
IRDIFUKUS	0.2198	IRDIFJPUS	0.1575
EXSZUSx	0.1866	MORTGAGE30US_GS10	0.1487
EXJPUSx	0.1674	PERMITS	0.1486
S.P.500	0.1640	IRDIFSZUS	0.1468
S.P..indust	0.1551	NONREVSL	0.1389
S.P.div.yield	0.1546	CUMFNS	0.1151
TWEXAFEGSMTHx	0.1498	M2SL	0.0999
IRDIFSZUS	0.1314	DTCOLNVHFNM	0.0983
M1SL	0.1078	UEMP5TO14	0.0765
Latent factor 9			
CONSPI	0.1921		
IRDIFCAUS	0.1111		
M2SL	0.1005		
CES0600000008	0.0958		
REXUSUKx	0.0901		
UEMPLT5	0.0796		
IPB51222S	0.0790		
REXCAUSx	0.0780		
DPCERA3M086SBEA	0.0699		
CES3000000008	0.0695		

Note: The variable codes are the FRED mnemonics as presented in Table 2.A.1. For each macroeconomic variable $i = 1, ..., N$ and each latent factor $j = 1, ..., r^*$, the variance explained is the ratio of $\sigma^2_{\lambda_i f_j}$ to $\sigma^2_{x_i}$. Only the ten variables with the highest explained variables are included for brevity.

2.B External instrument for monetary policy shocks

Figure 2.B.1: External instrument for identification of monetary policy shocks

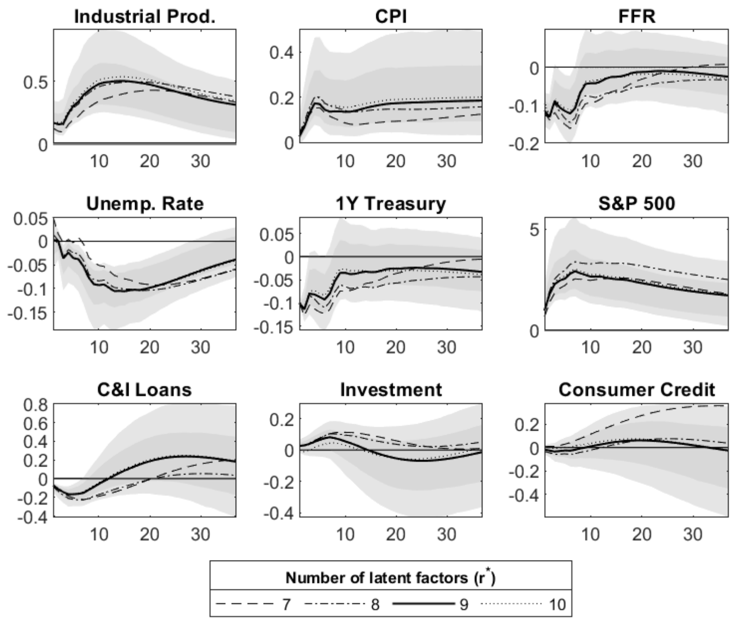


Note: Change in the three month ahead Fed Futures rate from 10 minutes before the release of the FOMC meeting decision to 20 minutes after the meeting.

2.C Robustness tests

2.C.1 Comparison of macroeconomic IRF for increasing latent factors

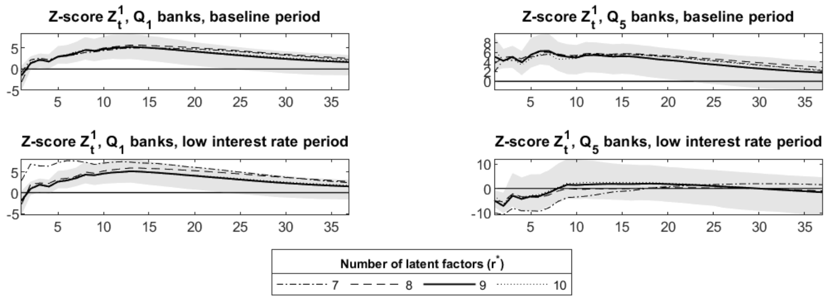
Figure 2.C.1: Impulse response functions for selected macroeconomic variables included in the FAVAR following a monetary policy shock equal to a 10bps decrease in the effective FFR, with an increasing number of latent factors



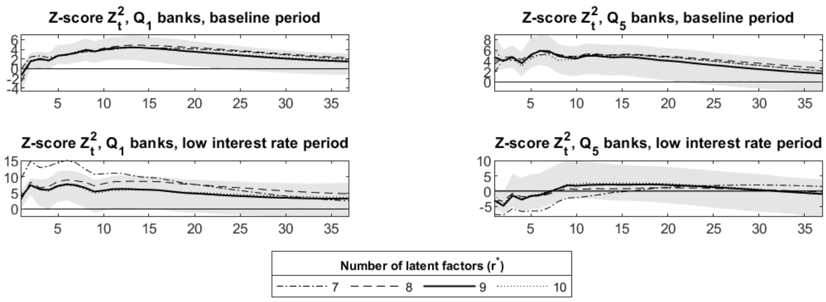
Note: The confidence intervals are estimated for $r^* = 7$, where the dark grey shaded area represents 68% confidence and the light grey shaded area represents 90% confidence. The solid black lines the IRFs estimated for $r^* = 7$, and the dotted/dashed lines are as labelled in the legend. The impulse responses follow a monetary policy shock equivalent to a 10bps decrease in the effective FFR. The x-axis shows horizons (months) since the policy shock and the y-axis shows the variable response in their respective units.

2.C.2 Comparison of Z-score IRFs for increasing latent factors

Figure 2.C.2: Impulse response functions for each Z-score estimate following a monetary policy shock equal to a 10bps decrease in the effective FFR



(a) Response of Z_t^1 for Q_1 and Q_5 (low deposit and high deposit) banks away from and close to the effective lower bound.

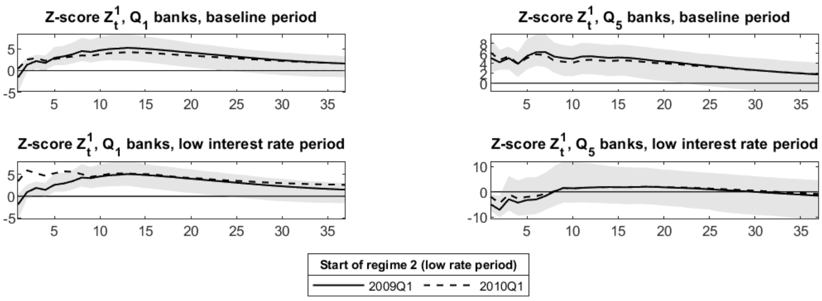


(b) Response of Z_t^2 for Q_1 and Q_5 (low deposit and high deposit) banks away from and close to the effective lower bound.

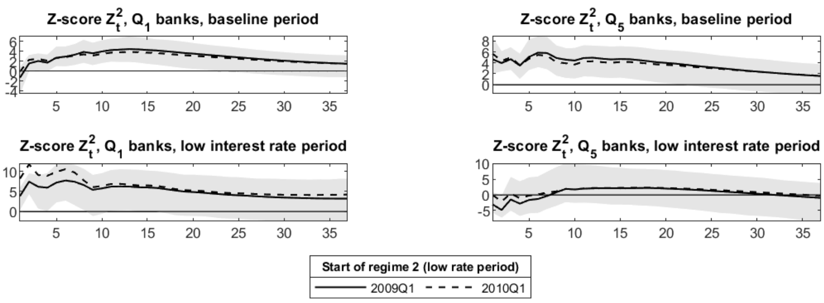
Note: The confidence intervals are estimated for $r^* = 9$ with the shaded area representing 90% confidence. The solid black lines the IRFs estimated for $r^* = 9$, and the dotted/dashed lines are as labelled in the legend. The impulse responses follow a monetary policy shock equivalent to a 10bps decrease in the effective FFR. The x-axis shows horizons (months) since the policy shock and the y-axis shows the response of the Z-score.

2.C.3 Comparison of Z-score IRFs for alternative start in low interest rate period (Regime 2)

Figure 2.C.3: Impulse response functions for each Z-score estimate following a monetary policy shock equal to a 10bps decrease in the effective FFR



(a) Response of Z_t^1 for Q_1 and Q_5 (low deposit and high deposit) banks away from and close to the effective lower bound.



(b) Response of Z_t^2 for Q_1 and Q_5 (low deposit and high deposit) banks away from and close to the effective lower bound.

Note: The shaded area represents 90% confidence for the estimates where Regime 2 starts in 2009Q1. The solid black lines are the IRFs estimated for Regime 2 starting in 2009Q1, and the dotted/dashed lines are set a later start date of 2010Q1. The impulse responses follow a monetary policy shock equivalent to a 10bps decrease in the effective FFR. The x-axis shows horizons (months) since the policy shock and the y-axis shows the response of the Z-score.

Chapter 3

Bank equity prices and monetary policy announcements: does bank transparency matter?

3.1 Introduction

What role does bank transparency play in the response of bank equity prices to monetary policy announcements? Bank financial statements are an important source of information for outsiders, though can create information asymmetry if the true quality of bank assets deviates from the quality reported.[1] At the same time, the credit channel of monetary policy is clear in its role for financial frictions that arise from information asymmetry, primarily via the external finance premium.[2] It is generally assumed that information asymmetry unconditionally increases the cost of external finance because of the burden it places on outsiders for evaluation and monitoring. However, this study shows that the effect is conditional on the quality of the banks existing assets and its operating environment, in line with the role for bank opacity in risk sharing across liability holders.[3]

This study introduces transparency into Disyatat's (2011) theoretical framework of the bank lending channel. Crucially, the primary proposition of Disyatat's model is that *the*

[1] There is an extensive literature examining how transparent (or opaque) banks are (e.g., Morgan, 2002; Flannery et al., 2004; Hirtle, 2006; Beatty and Liao, 2014), and how this relates to outcomes including risk levels (e.g., Bushman and Williams, 2012; Jungherr, 2018), lending and deposit flows (e.g., Zheng, 2020; Chen et al., 2022) and efficacy of market discipline (e.g., Acharya and Ryan, 2016).

[2] Specifically, the bank capital channel concerns the role of the external finance premium in monetary transmission through banks, first proposed by Bernanke (2007) and formally modelled by Meh and Moran (2010) and Disyatat (2011).

[3] Otherwise known as the Hirshleifer (1971) effect; see also Dang et al. (2017) and Goldstein and Leitner (2018).

bank lending channel works through the impact of monetary policy on banks' external finance premium as determined by their perceived balance sheet strength and ability to withstand shocks. In other words, the bank lending channel operates through the characteristics that make its marginal cost of funds more sensitive to changes in short-term interest rates. It is shown in this study that this proposition is strengthened when transparency allows outsiders to observe the true quality of bank assets, as depositors are better able to price the likelihood of the bank's default risk. Put another way, policy induced changes in depositor perceptions of bank asset quality lead to variations in the bank's external finance premium, and these perceptions are altered by the bank's level of transparency.

In reality, perceptions of bank balance sheet strength rely on the information it publishes, such as financial statements or external communications. How reliable these publications are for perceptions of financial health will depend on how *transparent* the bank is. I follow Chen et al. (2022) and measure bank transparency as the degree to which variance in reported non-performing assets and loan loss provisions can explain variance in eventual write-offs. This proxy captures uncertainty around bank balance sheet quality in a neutral fashion, without relying on strategic managerial behaviour or relative asset opacity. The measure aligns with the theoretical framework presented here and broader transparency theory (e.g., Dang et al., 2017; Bouvard et al., 2015). The measure is shown to reduce analyst forecast error and disagreement across a range of earnings forecasts, supporting its use.

To assess the role of bank transparency in monetary policy transmission, the study employs an event study approach, examining bank equity prices around monetary policy announcements. This approach isolates the effect of the monetary policy surprise within a short window, reducing interference from broader macroeconomic responses. Equity prices reflect the present value of future earnings, as measured by market expectations (Drechsler et al., 2021). High frequency monetary policy surprises, which are unlikely to be correlated with other economic news, are used to identify the exogenous effect of interest rate changes. Baseline tests confirm the established finding in the literature that bank stock prices typically decline in response to contractionary monetary policy shocks (e.g., English et al., 2018; Ampudia and Van den Heuvel, 2022; Paul, 2023), with a 25bp unanticipated surprise leading to a 2.1% fall.

The main empirical results show that transparency does play a role in the transmission of monetary policy through banks, but the size and direction of the effect is conditional on the bank's perceived health and operating environment. Specifically, for the full sample period (1998Q1 to 2019Q4), transparency strengthens transmission only for those banks with relatively lower quality assets. For those banks, a 25bp monetary tightening results in an additional 0.8pp decline in equity prices when the bank is more transparent. However, the sample spans periods of contrasting macroeconomic and financial conditions, with higher levels of non-performing assets dominating the financial crisis period when previously overlooked risks became apparent. The theoretical framework highlights how adverse operating environments combined with low quality assets can intensify the bank's default risk, making the bank's external finance premium more sensitive to policy induced interest rate changes.

To explore this further, the sample is divided into sub-periods to separate the financial crisis episode from stable periods. These tests confirm that transparency strengthens the equity price response for banks reporting lower quality assets during stress periods. However, during non-stress periods, transparency *attenuates* the response for banks with higher quality assets, with the fall in equity prices mitigated by between 0.3pp and 0.9pp. This occurs as depositor confidence in these banks is stronger, allowing them to better shield their balance sheets from the policy shock, in line with the findings of Altunbas et al. (2010). In stable periods, transparency does not have a significant impact on the equity price response of banks with lower quality assets: the theoretical framework suggests that this happens as the improved conditions reduce the bank's risk of default.

This research bridges two important areas of the literature: bank transparency and the bank lending channel. While there is limited empirical research on how transparency[4] affects monetary policy transmission, its importance has been theoretically acknowledged (e.g., Gertler and Gilchrist, 1994; Disyatat, 2011; Borio and Zhu, 2012). Notable exceptions are Ozdagli (2018) and Armstrong et al. (2019) in the case of non-financial firms, each of which find a role for informational frictions in monetary policy transmission measured by accounting disclosures. In terms of the bank transparency literature, this study supports findings of Chen et al. (2022) and Zheng (2020) that more transparent banks tend to be more information sensitive, which can influence lending outcomes. Additionally, the study provides insights into the theory that bank transparency increases during periods of financial stress, as stronger banks seek to differentiate themselves from weaker ones to mitigate rollover risks (e.g., Bouvard et al., 2015; Jungherr, 2018).

In terms of the extensive literature on the bank capital channel of monetary policy transmission, the study contributes to the empirical research on bank equity price responses to monetary policy surprises (e.g., English et al., 2018; Ampudia and Van den Heuvel, 2022; Paul, 2023) and the role of bank financial health (e.g., Kishan and Opiela, 2012; Altunbas et al., 2010). Furthermore, the findings support evidence that monetary policy transmission is stronger during periods of financial stress due to financing constraints (e.g., He and Krishnamurthy, 2013; Dahlhaus, 2017).

[4]Equivalently opacity, information asymmetry or information frictions.

This chapter is organised as follows: first, a summary of the relevant literature is presented (3.2), followed by a presentation of the theoretical framework and hypotheses for empirical testing (3.3). The approach to measuring bank transparency is then described (3.4), and the following two sections present the empirical analysis (3.5 and 3.6). The study closes with a discussion of the results (3.7) and conclusions (3.8).

3.2 Summary of relevant literature

3.2.1 Bank transparency and opacity

The true bank balance sheet itself is unobservable; instead, we see the accounting balance sheet, which is a quantitative depiction of a bank's economic reality shaped by managerial judgement and discretion applied to accounting rules (Bushman, 2014). In theory, some degree of opacity is required in the process of financial intermediation, which requires the transformation of risk and provision of liquidity. This idea is encapsulated by the 'Hirshleifer effect' (Hirshleifer, 1971), which describes the process by which an increase in information can reduce efficiency in exchange economy. Opacity in banks removes the opportunity for liability holders to frequently rebalance their portfolios based on the arrival of new information about the bank's investments. This separation of liabilities' value from asset risks facilitates risk sharing among liability holders. Maintaining a level of opacity means that banks are able to produce money-like safe liquidity for depositors while financing risky investments (Kaplan, 2006; Dang et al., 2017). Excess transparency beyond some optimum could destabilise the financial system, as mismatches in risk appetite become apparent to the liability holder, a concept seen in early models of banks such as Diamond and Dybvig (1983).

However, the optimal level of bank opacity depends on expectations of returns, influenced by the state of the financial system or macroeconomic conditions. Opacity is beneficial when the bank and the economy is performing well, but when returns are expected to be negative, opacity and associated risk sharing become sub-optimal and can lead to inefficient investments. This is demonstrated by Goldstein and Leitner (2018), where a regulators' disclosure decision is a trade-off between the Hirshleifer effect and avoiding a breakdown of the market as a result of asymmetric information that prevents risk-sharing arrangements. Bouvard et al. (2015), Moreno and Takalo (2016) and Jungherr (2018) similarly outline how the optimal level of transparency is a delicate balance that seeks to limit rollover risk without exposing investors to excessive levels of risk.

Transparency may limit risks (including rollover risk) by improving market discipline and closing the wedge between insider and outsider understanding of the bank's balance sheet (Acharya and Ryan, 2016). For example, Hirtle (2006) shows stronger stock price revisions for opaque banks subject to SEC certification, and Flannery et al. (2017) finds that stock prices of riskier banks react more to stress test results. In a theoretical framework, Ratnovski (2013) demonstrates how liquidity requirements are more effective at reducing rollover risk when paired with transparency regulation. Studies also indicate that more opaque banks tend to be considered 'riskier' (e.g., Bushman and Williams, 2015; Fosu et al., 2017), and opacity is linked to higher funding costs and more sensitive deposit flows (Chen et al., 2022), which affects lending (Zheng, 2020).

3.2.2 Bank capital channel of monetary policy and state dependencies

The credit view of monetary policy transmission posits that beyond the direct effect of short-term interest rates, additional channels of transmission exist via imperfections in financial markets. As explained by Bernanke and Gertler (1995) for non-financial firms, an external finance premium exists due to the imperfect substitutability between internal and external finance. The resulting external finance premium produces a financial accelerator which amplifies monetary policy shocks. The bank capital channel operates in much the same way (Bernanke, 2007), with the mechanism formalised by Disyatat (2011). Here, the external finance premium depends on depositor perceptions of a bank's balance sheet strength, and bank capital provides a cushion for depositors when firms default on their loans. When interest rates increase, this is accompanied by an increase in the bank's expected losses, which increases the bank's overall riskiness and funding costs, causing the bank to shrink its balance sheet.

Meh and Moran (2010) alternatively base a role for capital on the double moral hazard problem of Holmstrom and Tirole (1997). In this case, capital signals to outsiders that the bank is committed to monitoring: higher capital suggests the bank has more 'skin-in-the-game', which reduces the external finance premium. High capital also forces the bank to internalise default costs, incentivising greater monitoring (Allen et al., 2011). Bank capital can influence outcomes when regulatory capital is near a required minimum, potentially limiting lending (Van den Heuvel, 2009), and cost of funding can worsen if the bank issues more equity (Bolton and Freixas, 2006).

Some frameworks highlight state dependencies of financial frictions, for instance due to the macroeconomic environment or a firm's financial health.[5] The credit channel may be stronger during periods of stress when the financial condition of the borrower is perceived to be weaker, as noted by Gertler and Gilchrist (1994) and Ravn (2014). Specific to financial intermediaries, He and Krishnamurthy (2013) model occasionally

[5]Importantly, these channels are distinct from the risk taking channels of monetary policy, which concern how monetary policy impacts bank risk taking decisions in lending following a change in policy. Here, we are concerned with *existing* balance sheet health and its role in monetary transmission.

binding capital constraints in financial intermediation which amplifies shocks when constraints are binding. This aligns with research on banks' willingness to lend during crisis periods, such as by Diamond and Rajan (2011) and Kapan and Minoiu (2018). Additionally, Kishan and Opiela (2012) find evidence of a risk pricing channel, where risk premia on large bank deposits increase as capital constraints bind following a change in monetary policy.

Empirical evidence supports this idea. Dahlhaus (2017) finds monetary policy shocks in the US are stronger and more persistent during periods of financial stress. Altunbas et al. (2010) shows that banks with lower expected default frequency are better able to shield their loan supply from changes in monetary policy, and Breitenlechner and Scharler (2021) demonstrates that monetary policy surprises affecting bank funding supply (rather than demand) have a stronger impact on bank lending.

3.2.3 Bank equity returns and monetary policy announcements

Several studies have explored how bank equity returns respond to a monetary policy surprise, as these serve as a key indicator of the eventual lending response. Using equity prices allows for an event study approach, where a short window around the monetary policy announcement minimises interference from subsequent macroeconomic responses. As noted by Drechsler et al. (2021), estimating the impact on bank equity returns is akin to testing the effect on the present value of bank income and expenses, as opposed to a cash-flow approach which focuses on realised values.

There is a broad consensus that monetary policy surprises are inversely related to equity prices, both for the whole stock market (e.g., Bernanke and Kuttner, 2005; Gürkaynak et al., 2005) and bank stocks (e.g., English et al., 2018; Drechsler et al., 2021). While interest rates are important determinants of the cost of funds for all types of firms, their impact is particularly significant for banks. Paul (2023) shows that bank equity declines more sharply than non-bank equity following an increase in short-term interest rates, attributing this to banks' exposure to interest rate risk.

Bank's interest rate risk exposure arises from their traditional role in maturity transformation: banks invest in long-term assets funded by short-term liabilities. This textbook view suggests that banks are vulnerable to a tightening of short-term interest rates which increases the bank's cost of funding relatively more quickly than they are able to adjust rates on their long-term, fixed-rate loans. However, the equity price response to this risk could be more muted if banks structure their balance sheets to hedge against short-term movements (English et al., 2018), or if they have market power in deposit markets (Drechsler et al., 2021).

Other differences in bank business models and balance sheet composition means that heterogeneities in bank equity price responses to monetary policy surprises can be identified. For example, Madura and Schnusenberg (2000) and Yin and Yang (2013) find that larger banks' equity prices are more sensitive to changes in the Federal Funds Rate. There is some disagreement in the role for funding sources: Yin and Yang (2013) find the response of banks who are more reliant on non-deposit funding to be stronger, whereas English et al. (2018) find the effect to be stronger for banks who are more reliant on core deposits.

3.3 Transparency in the bank capital channel

The underlying proposition of the bank capital channel presented by Disyatat (2011) is that variations in the health of financial intermediaries and outsider perceptions of this health are the key mechanisms through which monetary policy shocks propagate. Bank transparency can influence this process by shaping outsider perceptions of a bank's ability withstand shocks. Clearer perceptions can alter the external finance premium demanded by outsiders, which is associated with reduced lending.

This section introduces the concept of bank transparency to Disyatat's framework to demonstrate its role. A partial version of the model is presented with a focus on the external finance premium (3.3.1), followed by a presentation of the equilibrium level of lending (3.3.2). Finally, two hypotheses are stated for empirical testing (3.3.3).

3.3.1 The model

There are three agents: firms, banks, and households, all of equal number. All agents are risk neutral and subject to limited liability. Banks invest in firms by extending credit of size L, which will be repaid in full with probability θ at the end of the period if the firm's project succeeds.[6] Banks operate in a competitive market and do not earn profits in equilibrium. Loans are funded by deposits, which are not insured and so subject to default risk. This element of the model captures the role of wholesale funds as the marginal source of funding for banks and where credit risk matters. Households have the choice of depositing with the bank or investing in a risk-free government bond, and a competitive money market exists.[7]

At the start of the period, the balance sheet of a representative bank is:

$$w = A - D \tag{3.1}$$

[6] This simplification is sufficient for the purpose of demonstrating the role of bank transparency in the external finance premium, though the full framework in Disyatat (2011) uses the production function for the firm to place conditions on the minimum and maximum values of equilibrium lending.

[7] The existence of a competitive money market is to eliminate the effects of segmentation between retail and wholesale deposits.

Where respectively A and D are existing assets and deposits. Existing assets may be long term investments from previous iterations of the game and are varying in quality. To capture this, we can define:

$$\dot{A} = A(1-\eta) \quad \text{and} \quad \dot{w} = \dot{A} - D \tag{3.2}$$

Where $0 < \eta \ll 1$ is the very small share of assets that are non-performing and with the possibility of being written off. Implicitly, $\dot{A} < A$, so that non-performing assets reduce the amount of 'quality' capital that is recognised by depositors.

The value of η takes two values at random with equal probability: a low value $\eta_L = \bar{\eta} - \sigma_\eta$ or a high value $\eta_H = \bar{\eta} + \sigma_\eta$. Therefore, the share of non-performing assets has a mean $\bar{\eta}$ and variance σ_η, with the restriction $\sigma_\eta \leq \min(\bar{\eta}, 1-\bar{\eta})$ so that $\eta \in (0,1)$. Only the bank knows whether η is high or low with certainty. Households receive a signal s which with probability p will tell them the true value of η. With residual probability $1-p$, households must make a best estimate of non-performing assets using $\bar{\eta}$, so that on average they do not make errors. In this sense, the parameter s can be thought of as accounting disclosures and publications made by the bank, and the parameter p can be thought of as describing the quality of the disclosures including their ease of interpretation. For example, $p = 1$ would describe the situation where disclosures are accurate so that the signal s allows households to accurately estimate η as being high or low. However, if $p = 0$, households are only able to base their estimates on the average. Since A is based on historic lending, we can think of η as being dependent on historic values of θ and likely to vary over time.

Adding to the uncertainty, the bank's balance sheet is subject to a random disturbance $u \sim U[\underline{u}, \bar{u}]$ where $-1 < \underline{u} < 0 < \bar{u}$. The disturbance is not realised until the end of the period, and represents the fact that banks are exposed to risks associated with existing assets and liabilities. The disturbance u is independent of asset quality η, but as will be shown, η alters the ability of banks to withstand the end of period disturbance. At the end of the period before any claims are settled, bank net worth will be:

$$\psi \equiv \dot{w}(1+u) \tag{3.3}$$

If the loan is not repaid at the end of the period, the bank will only be able to repay depositors if $\psi > (1+R)L$, where R is the interest rate paid on deposits. This means that there is a critical value of the shock to net worth at which point the bank will be unable to repay its creditors:

$$u^* = \frac{(1+R)L}{\dot{w}} - 1 \tag{3.4}$$

That is, the bank will only be able to repay its creditors if $u > u^*$. The probability of bank default *conditional* on the bank not being able to repay its creditors is then:

$$\begin{aligned} q &\equiv \Pr(\psi < (1+R)L) \\ &= \Pr(u < u^*) \\ &= \frac{u^* - \underline{u}}{\bar{u} - \underline{u}} \end{aligned} \tag{3.5}$$

Since $du^*/d\eta > 0$ and $dq/d\eta > 0$, intuitively when the bank's share of non-performing assets is higher, it will be more susceptible to the end of period disturbance and will have a higher probability of conditional default. The *unconditional* probability of bank default requires both the loan to fail and the bank's net worth to be insufficient to cover its debts. This happens with probability:

$$1 - x = (1 - \theta)q \tag{3.6}$$

So that x is the unconditional probability that the bank will repay depositors in full. Then, the lending rate is determined by:

$$\theta(1 + r_L)L = x(1 + R)L + (1 - x)\psi^d \tag{3.7}$$

Where ψ^d is the expected net worth of the bank if it defaults. Importantly, ψ^d represents the cushion that depositors demand to withstand the realisation of unconditional bank default, and may be interpreted as the amount of risk that the bank is able to absorb. Formally:

$$\begin{aligned} \psi^d &= E\left[\psi | \psi < (1+R)L\right] \\ &= \dot{w}\left[1 + \frac{\int_{\underline{u}}^{u^*} u g(u) du}{G(u^*)}\right] \end{aligned} \tag{3.8}$$

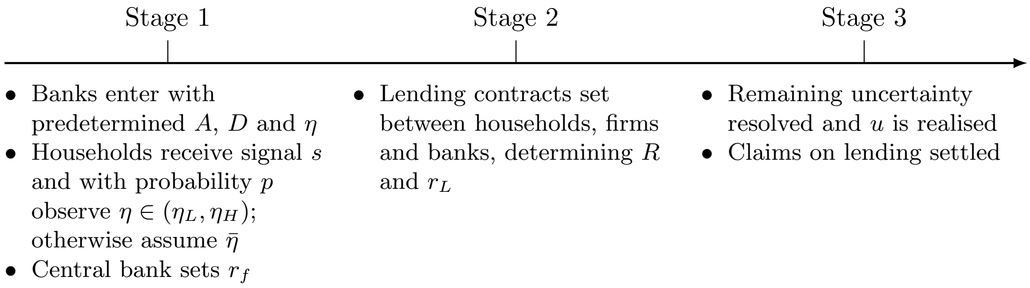
Where $g(u)$ and $G(u)$ respectively represent the probability and cumulative density functions of u. Households make an assessment of ψ^d using their understanding of η and u, and this is reflected in their decision to deposit with the bank or in the risk-free government bond which returns $1 + r_f$. The required rate of return on deposits R is determined by:

$$(1 + r_f)L = x(1 + R)L + (1 - x)(\psi^d - cL) \tag{3.9}$$

Where c represents contract enforcement costs in the case of default and is assumed to be proportional to the size of the loan.[8] It is shown in Appendix 3.A.1 that the deposit rate can be represented as a mark-up rule where it exceeds the return on the risk-free

[8]Contract enforcement costs represent the costly state verification friction of Gale and Hellwig (1985). The purpose of this financial friction is to represent the idea that banks borrow at a premium from households, resulting in higher costs for firms.

Figure 3.3.1: Timeline of events



asset by the sum of two terms: the expected revenue lost in the case of default, and the expected costs of contract enforcement:

$$R - r_f = \frac{(1-\theta)}{L} \left[\int_{\underline{u}}^{u^*} \left[\dot{w}(u^* - u) \right] g(u) du + cL \int_{\underline{u}}^{u^*} g(u) du \right] \tag{3.10}$$

Importantly, each of these terms is contingent on the depositors perception of the distribution of u and understanding of η (contained in $\dot{w}$). If the bank is transparent and the household observes η_L, the external finance premium demanded will be greater than if η_H is observed. Comparatively, the external finance premium for an opaque bank will not vary with the level of η as outsiders cannot accurately assess asset quality.

3.3.2 Equilibrium and response to a monetary tightening

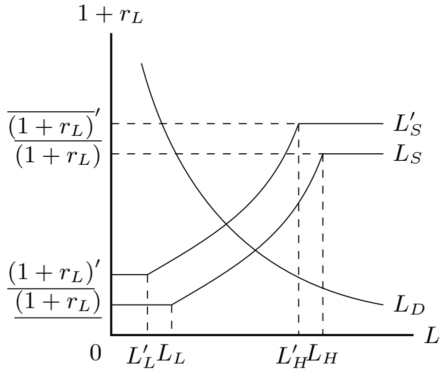
The timeline of events is described in Figure 3.3.1, where the sequencing across the period is set out in three stages. The solution of the model can be fully characterised by equilibrium in the market for loans, which is obtained from zero profit conditions of the household and the firm. A summary of the exposition is presented in Appendix 3.A and Disyatat (2011) is referred to for the full proof. This subsection describes the transmission of monetary policy in the model and role of bank transparency in equilibrium.

Figure 3.3.2 illustrates equilibrium in the lending market and the response to a monetary tightening which increases $(1 + r_f)$. The loan supply schedule L_S is non-linear and perfectly elastic at points as we have limited $q \in (0, 1)$, which has constrained $(1 + r_L)$ (see Equation 3.26 in Appendix 3.A). When $0 < q < 1$, financial frictions are present and the supply curve is upward sloping. Loan demand is determined by the firm's profit function, taking $(1 + r_L)$ as given.

A monetary tightening works as follows. The increase in $(1 + r_f)$ increases household opportunity costs of deposits, and the loan supply schedule shifts inwards from L_S to

L'_S. The minimum and maximum levels of lending for $\underline{(1+r_L)}$ and $\overline{(1+r_L)}$ each move inwards, and equilibrium lending falls. This shift is not induced by a change in the availability of deposits; rather, the higher lending rate reduces loan demand on behalf of the firm, meaning that households (who supply labour) receive fewer wages, which reduces deposits available in the system.

Figure 3.3.2: Monetary policy tightening



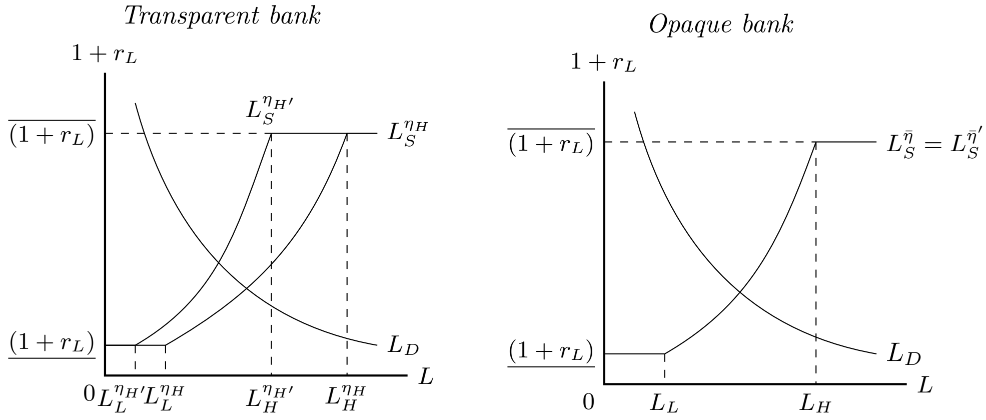
3.3.3 The role for bank transparency

Recall that the level of bank transparency is represented by signal s which with likelihood p means that households will learn the true value of η and the bank's susceptibility to the end of period disturbance. The level of p may be determined by the accuracy of bank financial disclosures, external communications, or household sophistication in interpreting the bank's publications. Bank transparency can serve to propagate monetary policy shocks by altering household perceptions of endogenous changes in the quality and value of bank capital. Bank asset quality can be affected by a monetary tightening by inducing changes in firm balance sheets and impacting certainty of debt repayments, including due to a slowdown in economic activity. This is shown empirically to be the case by Buch et al. (2014*b*).

These effects can be presented in the model as an increase in the share of non-performing loans, so that $\eta'_H > \eta_H$. If a bank is fully transparent, so that $p = 1$, this would imply that the lending supply curve shifts in even further relative to the benchmark monetary tightening (left panel of Figure 3.3.3), from $L_S^{\eta_H}$ to $L_S^{\eta_H'}$. Logically, if depositors perceive the bank's capital to be of lower quality, they will perceive that the bank has reduced capacity to absorb risks if current period lending defaults. This will increase the bank's cost of funds as depositors demand a higher spread over the risk free rate. At the same time, the lending activity of transparent banks with higher quality assets will be less affected. Comparatively, the right panel of Figure 3.3.3 demonstrates that this is not the case for the fully opaque bank, with $p = 0$. In this case, as $\bar{\eta}$ is taken as an average across banks, depositors do not change their assessment of asset quality and the lending supply schedule is unchanged. This gives us the first hypothesis:

Hypothesis 1. The role of transparency in bank equity price responses to a monetary policy surprise depends on the bank's reported asset quality.

Figure 3.3.3: Effect of endogenous change in perceived asset quality for a transparent versus opaque bank



The household's mark-up over the risk free rate additionally depends on their assessment of $u \sim U[\underline{u}, \bar{u}]$. We can think about the levels of $\underline{u}$ and $\bar{u}$ as representing the health of the financial system and macroeconomic environment in which the bank is operating: in periods of crisis, $\underline{u}$ might be very close to -1 so that an adverse shock is more severe, whilst in more benign periods when it is less likely that the disturbance is detrimental, $\underline{u}$ will be closer to 0. Similarly, $\bar{u}$ will be increasing with the health of the bank's operating environment.

It can be shown that $d^2L/d\eta d\underline{u} < 0$, implying that in the case of full transparency, a lower value of $\underline{u}$ intensifies the effect of observing a higher η. Similarly, if the operating environment improves so that $\underline{u}$ is closer to 1, this may work to attenuate the impacts of revealed η. In the case of full transparency, this means that an adverse operating environment can act to strengthen the effect of a monetary policy surprise for banks with lower asset quality, whilst a positive operating environment may attenuate the effects of transparency. Macroeconomic research has documented state dependencies in the capital channel (e.g., Dahlhaus, 2017), and this could be one mechanism by which they materialise.

Hypothesis 2. The role of transparency in bank equity price responses to a monetary policy surprise will depend on both the bank's reported asset quality and the operating environment.

3.4 Measuring bank transparency

Testing these hypotheses requires a measure of transparency. This section first describes the motivation (3.4.1) and chosen measurement approach applied in this study (3.4.2), followed by a presentation of the measure (3.4.3). Finally, the section assesses the viability of the transparency proxy by comparing it to an alternative used by the literature.

3.4.1 Motivation for bank transparency measure

Measures of transparency used in the literature can broadly be classified into market-based measures and those derived from bank disclosures. Market-based measures assume that lower transparency leads to greater disagreement among outsiders about a bank's economic value. This can be reflected in split-ratings (Morgan, 2002; Iannotta, 2006)[9] or errors in analyst forecasts of income statement variables (Flannery et al., 2004; Anolli et al., 2014; Fosu et al., 2017). Disclosure-based measures of bank transparency either analyse the composition of the bank's balance sheet (e.g., Cao and Juelsrud, 2020), or employ empirical analysis of income statements (e.g., Bushman and Williams, 2012; Zheng, 2020; Chen et al., 2022).

This study estimates transparency in the same way as Chen et al. (2022), using the R^2 from rolling regressions of reported bank asset quality variables on reported defaults. The R^2 measure reflects how much variance in reported asset quality explains variance in future defaults, aiming to capture the idea that outsider understanding of a bank's balance sheet quality relies on information released by the bank. Bank accounting disclosures are an important source of information for outsiders and subject to analyst scrutiny, though their relevance in resolving uncertainty around the bank's true external finance premium will depend on their accuracy. When financial disclosures more accurately explain the possibility of future defaults, depositors' information acquisition costs are lower, and there is greater confidence in the bank's ability to weather unforeseen shocks.

There are two technical advantages to using the regression R^2 as the transparency measure. First, it aligns with the theoretical framework presented in Section 3.3, where transparency is defined as the extent to which information released by the bank can explain the true underlying health of its assets. To see this, consider the definition of R^2:

$$R^2 \equiv 1 - \frac{\sigma_\eta - \sigma_{\eta|s}}{\sigma_\eta} \tag{3.11}$$

Where $\sigma_{\eta|s}$ is the variance of η conditional on the information contained in s. The case

[9] Split-ratings occur when the same bond receives different ratings from different agencies, indicating informational opacity.

of full transparency with $p = 1$ implies that $\sigma_\eta = \sigma_{\eta|s}$ and $R^2 = 1$. Comparatively, as the value of p decreases (e.g., as s becomes less informative), so will the value of R^2. Second, the measure is grounded in information theory. It can be shown that regression R^2 is a scaled version of the 'mutual information' between the dependent and independent variables.[10] When R^2, or mutual information, is high, this is interpreted as the bank being more transparent.

3.4.2 Approach to measuring transparency: regression R^2

The R^2 measure of transparency is obtained as the adjusted R^2 from bank-level regressions on rolling windows of $w = 12$ quarters. The specification applied follows Chen et al. (2022):

$$nco_{|t,t+1|} = \alpha_0 + \sum_{j=2}^{2} \gamma_j llp_{t-j} + \sum_{j=2}^{2} \beta_j ebp_{t-j} + \sum_{j=2}^{2} \rho_j \Delta npa_{t-j} + \delta equity_{t-1} + \epsilon_t \quad (3.12)$$

Where $nco_{|t,t+1|}$ is the sum of net charge offs in quarters t and $t+1$, llp_t are loan loss provisions, ebp_t are earnings before provisions, Δnpa_t are non-performing assets, and $equity_t$ is the ratio of equity capital to total assets. Except for capital, all variables are scaled by total loans. The dependent variable uses cumulative net charge offs over two quarters to account for the lag between a loan becoming non-performing or included in a provision and the same loan being written off.

Of the independent variables, the main accounting disclosures of interest in understanding future net charge offs are changes in non-performing assets and loan loss provisions. Non-performing assets are typically defined by regulators as loans that are 90 days past due, so a change in this variable indicates a deterioration in asset quality which could lead to future charge offs. Loan loss provisions are made when non-performing loans arise, however are subject to managerial discretion, introducing additional uncertainty about future net charge offs (Beatty and Liao, 2014). If the bank's disclosures regarding current credit risk (i.e., llp_t and Δnpa_t) are transparent, they should be able to explain variation in future charge offs.

Two additional variables are included: earnings before provisions and equity as a ratio to total assets. Earnings before provisions may add incremental information on future charge offs by reflecting the banks' earlier lending behaviour. Credit booms, often associated with higher earnings before provisions, tend to be followed by financial instability which may be characterised with higher defaults (e.g., Dell'Ariccia and

[10] According to information theory, the reduction in uncertainty around random variable Y due to another random variable X is called mutual information. Formally, mutual information can be represented as $I(X, Y) = H(X) - H(X|Y)$, where $H(X)$ is is entropy of random variable X (that is, the measure of the average uncertainty in the random variable), and $H(X|Y)$ is the conditional entropy (that is, uncertainty about X when other variable Y is known) (Cover and Thomas, 2005).

Marquez, 2006). Similarly, bank equity may provide incremental information about the bank's incentives towards risk taking (Holmstrom and Tirole, 1997).

Finally, it is worth stating that a relatively high R^2 estimate does not imply that the bank is higher risk. Instead, R^2 measures the proportion of uncertainty that outsiders can resolve about the bank's future defaults using accounting disclosures, rather than the level of default risk itself. Table 3.4.2 shows the correlation between R^2 and the rolling standard deviation of *nco*, measured over the same $w = 12$ quarter window. Variation in *nco* will be controlled for in subsequent analysis to ensure that results are not driven by the mechanical relation between R^2 and variance in defaults.

3.4.3 Data and descriptive analysis of R^2

Bank-level data is obtained from CRSP Compustat (accessed via WRDS) to estimate R^2. The data is reported quarterly for commercial banks in the US, with a sample period of 1995Q1 to 2019Q4. This means that the resulting R^2 measure is available from 1998Q1.[11] As is standard for empirical research using bank-level data, a series of steps are taken to avoid spurious data points (e.g., see Acharya and Lambrecht, 2015; Chen et al., 2022). Specifically, observations are excluded when assets and gross loans are less than or equal to zero, the loan-to-asset ratio is greater than one, and when the capital asset ratio is greater than one. Banks are excluded from the sample when less than three years of consecutive observations are available. Additionally, continuous variables are Winsorised at 1% and 99% level.

Table 3.4.1 presents the summary statistics of the estimated R^2, the variables used in its construction, and other bank characteristics used in later analysis. The average quarterly write-off as a proportion of total loans is -0.12%, which is close the the average quarterly loan loss provision at 0.13%, reflecting the dynamics between these two variables. This negative association is supported by the high correlation coefficient presented in Table 3.4.2. The descriptive statistics of the other bank characteristics align with those reported elsewhere in the literature. For example, the average capital to asset ratio ($equity_t$, 10.0%) matches the 10% reported by Chen et al. (2022) for a sample covering 1994 to 2019. The average share of non-performing assets is 1.84%, which is close to the 1.76% reported by Beatty and Liao (2021) for a sample period of 1991 to 2017.

The R^2 estimate itself has a mean of 0.34 and a standard deviation of 0.52,[12] implying

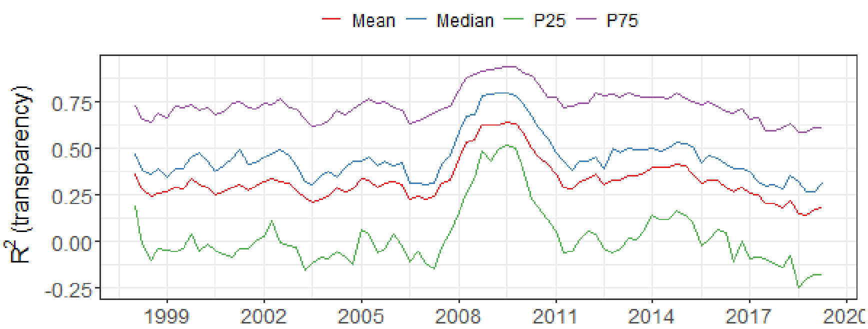
[11]The start of the sample is limited due to a large number of banks joining the sample in the early 1990s, the implementation of the Federal Deposit Insurance Corporation Improvement Act (FDICIA) in 1991 and the transition period to Basel I. Each of these factors could potentially cause structural breaks in the series due to adjustments in provisioning or lending practices. The end of the sample is limited by the onset of the Covid-19 pandemic, which saw large increases in loan loss provisioning and unprecedented uncertainty.

[12]Note that since an adjusted R^2 measure is employed, the measure can be negative if financial

a large amount of cross-bank variation. The mean average is higher than the 0.22 reported by Chen et al. (2022), as the current sample is restricted to public banks; indeed, they report a higher mean R^2 when restricting to large banks only. Figure 3.4.1 shows that the R^2 measure remains fairly stable over time, with the exception of an increase during the financial crisis (2007-9). This is consistent with theoretical work that suggests information revelation is optimal when expected losses are high (e.g., Bouvard et al., 2015). To alleviate concern that this drives any of the results, subsequent analysis will control for this period. Changing the window over which R^2 is estimated smooths the estimate slightly but does significantly alter the output (see Figure 3.B.1 in Appendix 3.B).[13]

The interpretation of the transparency measure is as follows: a high R^2 indicates a relatively high level of transparency, as it means that the variation in the independent variables is effective at explaining current and future defaults. In other words, accounting disclosures resolve uncertainty about the quality of the bank's assets. As noted by Chen et al. (2022), the R^2 measure of transparency does not reflect managerial *willingness* to disclose private information; rather, a bank may be more transparent due to the inherent predictability of its assets' defaults. If defaults are easier to predict, the bank's disclosures naturally provide more clarity about its asset quality.

Figure 3.4.1: Estimate of R^2 over time



Note: The figure plots the summary statistics of the R^2 estimates over the sample period. R^2 is the adjusted R-squared obtained from bank-level $w = 12$ quarter rolling window estimations of Equation 3.12.

disclosures are not very informative and do not explain much of the future variance in defaults.

[13]The empirical tests presented in the following subsections are robust to altering the window size used to estimate R^2, though are not reported for brevity.

Table 3.4.1: Summary statistics of R^2 and variables used in estimation

	Mean	Median	SD	Min	25th p.	75th p.	Max
nco_{it}	-0.1150	-0.0423	0.2171	-1.3400	-0.1170	-0.0085	0.0888
llp_{it}	0.1341	0.0642	0.2370	-0.1107	0.0249	0.1345	1.4741
npa_{it}	1.8371	0.9641	2.3614	0.0000	0.4846	2.1248	13.0028
Δnpa_{it}	0.0270	-0.0035	0.4919	-1.7545	-0.1115	0.1184	2.1933
ebp_{it}	0.5920	0.5631	0.4090	-0.7351	0.3907	0.7610	2.7363
$equity_{it}$	10.0269	9.5212	3.0984	4.3124	8.0229	11.3901	22.8238
$size_{it}$	7.5761	7.2383	1.5739	3.7092	6.4602	8.3904	14.8224
$\sigma(nco_{it})$	0.1775	0.0793	0.2557	0.0020	0.0380	0.1897	1.4426
R^2_{it}	0.3388	0.4594	0.5169	-1.2461	0.0220	0.7581	0.9907
gap_{it}	-0.0706	-0.0046	0.8960	-3.5169	-0.2293	0.2249	2.9351
$beta^{inc}_{it}$	0.1976	0.3151	0.9934	-2.4118	0.0286	0.5791	2.2448
$beta^{exp}_{it}$	0.2682	0.3093	0.3965	-0.6903	0.1085	0.4676	1.1051
$loans_{it}$	66.8899	68.2637	12.1511	24.3679	60.5720	75.3192	88.6701
$deposits_{it}$	75.8269	77.6452	9.1949	46.1952	70.5203	82.6015	91.2467
$deposits^{unins}_{it}$	30.8788	29.4466	12.2504	6.0335	22.1306	38.1595	65.4311
$deposits^{time}_{it}$	28.9120	28.8998	12.4997	4.5427	19.6132	37.4519	61.9524

Notes: The summary statistics are presented for the final sample period (1998Q1 to 2019 Q4), though a barely changed for the sample period used to estimate R^2_{it} which starts three years earlier in 1995Q1. The variables nco_{it}, llp_{it}, npa_{it} and ebp_{it} are ratios to total gross loans; Δnpa_{it} is the difference between npa_{it} at periods t and $t-1$; $size_{it}$ is the natural log of total assets; $equity_{it}$, $loans_{it}$ and all deposit measures (where the superscripts *unins* and *time* denote shares of uninsured and time deposits respectively) are the ratio to total assets; $\sigma(nco_{it})$ is the rolling standard deviation of net charge offs over a 12 quarter window (same estimation window as R^2_{it}); and gap_{it}, $beta^{inc}_{it}$ and $beta^{exp}_{it}$ respectively represent estimates of the maturity gap, sensitivity of interest income to changes in the federal funds rate and sensitivity of interest and related expenses (see Section 3.5.3 for a description of their construction).

Table 3.4.2: Correlation matrix of variables included in measuring transparency

	R^2_{it}	$\sigma(nco_{it})$	nco_{it}	llp_{it}	npa_{it}	Δnpa_{it}	ebp_{it}	$equity_{it}$	$size_{it}$	gap_{it}	$loans_{it}$	$deposits_{it}$
R^2_{it}	1.00											
$\sigma(nco_{it})$	0.12	1.00										
nco_{it}	-0.14	-0.56	1.00									
llp_{it}	0.15	0.45	-0.80	1.00								
npa_{it}	0.09	0.63	-0.58	0.52	1.00							
Δnpa_{it}	0.05	-0.08	-0.01	0.21	0.10	1.00						
ebp_{it}	-0.02	-0.22	0.12	-0.10	-0.28	-0.03	1.00					
$equity_{it}$	-0.00	-0.05	0.11	-0.12	-0.06	-0.04	0.02	1.00				
$size_{it}$	0.12	-0.06	-0.09	0.07	-0.08	-0.00	0.29	0.02	1.00			
gap_{it}	0.01	-0.03	-0.04	0.05	-0.01	0.03	0.01	-0.02	0.01	1.00		
$loans_{it}$	0.02	-0.05	0.01	0.04	-0.01	0.09	-0.35	-0.01	-0.19	0.05	1.00	
$deposits_{it}$	-0.07	0.13	-0.02	0.00	0.11	-0.04	-0.12	-0.14	-0.29	-0.01	0.18	1.00

Notes: All variables are as described in the notes of Table 3.4.1.

3.4.4 Assessing the viability of R^2 as a transparency proxy

To show that R^2 is measuring transparency, I test its effect on quarterly analyst forecasts of earnings. If a higher R^2 is associated with an improvement in the amount and quality of information released by the bank, it should reduce the size of analyst forecast errors and disagreement among forecasters. Analyst forecast errors can be interpreted as a misunderstanding or disagreement among outsiders about the bank's economic value (Flannery et al., 2004), implying that more information should reduce both the magnitude of these errors and the level of disagreement.

Measures of analyst forecast error and disagreement are regressed on R^2 as follows:

$$Fcast_{it} = \alpha + \beta R^2_{it-1} + \Lambda X + u_i + \epsilon_{it} \tag{3.13}$$

Where $Fcast_{it}$ represents the measure of forecast error for return on equity (ROE) and earnings per share (EPS) estimates. Earnings forecasts are chosen because they are the most closely monitored by analysts and are directly influenced by the quality of information published by the bank, including perceptions of risk. The following measures of forecast error are employed:

- Actual forecast surprise for *roe* and *eps*: this is the difference between the mean analyst forecast and the realised value, expressed as a percentage.
- Variance in forecast estimates for *roe* and *eps*: this is calculated as the ratio between the cross-sectional standard deviation of forecasts and the mean forecast, multiplied by 100 to obtain percentage deviation from the mean.
- Standardised forecast error for *eps*: this is the difference between the mean analyst forecast and the realised value, deflated by the end-of-period share price.

The standardised measure follows much of the literature on analyst forecasting abilities, for example Bolliger (2004) and Anolli et al. (2014). Across the measures of forecast error, if R^2 improves the quality of information, we would expect $\beta < 0$. The specification also controls for bank specific effects via u_i, a set of bank specific control variables included in X (specifically, Δroe_{it}, $size_{it-1}$, $equity_{it-1}$, $\sigma(nco)_{it-1}$) as well as the unusual operating environment around the financial crisis period, using a dummy variable equal to 1 during 2007Q1 to 2009Q2. Banks are excluded from the sample if there are fewer than three years of R^2 estimates available.

LSEG IBES Estimates are used for analyst forecasts, and these are matched to the CRSP Compustat data using instrument codes. Only observations based on the forecasts of at least two analysts are included, and the data is Winsorised at the 1st and 99th percentiles to remove extreme observations. The sample of roe_{it} analyst forecasts is only available from 2002Q2 onwards, whilst eps_t is available from the start of the R^2 sample (1998Q1). Both samples end in 2019Q4. The number of banks for which return on equity forecasts are available is 283, and for earnings per share the number is 298.

Table 3.4.3 presents the summary statistics of the forecast surprise measures.[14] The average number of analysts included in each estimate is around 5 for *roe* and 7 for *eps*. The errors in the forecasts of *roe* exhibit greater dispersion than those of *eps*, as indicated by the higher average coefficient of variation. This might reflect a smaller number of analysts contributing to the *roe* forecast on average (Flannery et al., 2004). The mean forecast errors are uniformly negative (roe_{as}, eps_{as}, eps_{fe}), implying that analysts tend to be optimistic. Evidence of this is found in the descriptive statistics of other studies (e.g., Anolli et al., 2014), and Lim (2001) shows that this behaviour may be rational.[15] Finally, forecast error measures show high standard deviations, indicating substantial variability over time. Much of this arises from the financial crisis period, which is controlled for in Equation 3.13.

Table 3.4.3: Summary statistics analyst forecast surprise variables

	Mean	Median	SD	10th p.	25th p.	75th p.	90th p.
roe_{actual}	8.3764	9.2700	10.8610	2.8100	6.4800	12.0900	15.2400
roe_{as}	-2.1566	0.9490	73.0998	-26.1540	-7.2020	9.3730	28.8400
roe_{cv}	7.0102	3.9674	28.7154	0.7194	1.9296	8.8877	21.8130
N_{roe}	5.2856	4.0000	3.5822	2.0000	3.0000	7.0000	10.0000
eps_{actual}	0.2259	0.3467	23.6559	0.0751	0.1911	0.5500	0.9133
eps_{as}	-3.3333	1.5230	70.2271	-19.6670	-3.6370	7.9650	22.3670
eps_{cv}	3.9833	2.8169	18.6381	0.0000	1.4900	5.5309	12.8644
eps_{fe}	-0.3353	0.0208	3.1684	-0.3318	-0.0558	0.1212	0.3596
N_{eps}	7.1563	5.0000	6.2298	2.0000	3.0000	9.0000	17.0000

Notes: The variable *roe* is return on equity, and *eps* is earnings per share. The subscripts are defined as follows: '*actual*' refers to the realised out turn of the variable; '*as*' refers to analyst surprise, defined as the difference between the actual and the most recent average forecast and expressed as a percentage; '*cv*' refers to coefficient of variation, defined as the cross-sectional standard deviation of forecasts as a percentage of the mean forecast; fe refers to the standardised forecast error, which is the forecast error divided by the share price expressed as a percentage. N_x refers to the number of analysts included in the sample.

Table 3.4.4 presents the results of Equation 3.13. The $\hat{\beta}$ estimates are negative across all specifications, indicating that higher levels of transparency tend to reduce the size of analyst forecast errors and disagreement. The coefficients are generally significant, though some exceptions exist. In particular, the transparency measure tends to perform better at reducing the size of analyst error on the *eps* estimates, while it is more effective at reducing disagreement in the *roe* estimates.

[14] The balance sheet and income statement characteristics for the sample of banks with analyst surprise data are broadly similar to those in the main sample, though the banks are slightly larger (log of total assets is 8.57 versus 7.58 in the main sample). This is to be expected, given the greater market interest in larger banks, though should not interfere with the viability of the test. For that reason, summary statistics of bank characteristics for this subsample are not repeated.

[15] In particular, the results of Lim (2001) suggest that optimistic forecasts are favoured by management due to their value improving properties, which may gain analysts access to management information.

For a more transparent bank with an R^2 in the fourth quartile (around 0.76), the analyst forecast of *eps* is estimated to be around 2.39pp lower than that of a less transparent bank, which has an R^2 in the first quartile (around 0.02). Similarly, the standardised forecast error of *eps* is around 0.20pp lower for a more transparent bank. The size of this effect is substantial, representing 72% and 60% of the respective sample mean errors.

The relatively low regression R^2 across most of the estimates could be attributed to the fact that the variance of the analyst forecast errors depends on various factors beyond just the quality of bank disclosures, including analyst sophistication and ex-ante communications about the bank's performance. Nonetheless, the findings support the hypothesis that transparency as measured by R^2 reduces forecast error and disagreement.

Table 3.4.4: Effectiveness of R^2 in reducing analyst forecast error

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	roe_{as}	roe_{as}	roe_{cv}	roe_{cv}	eps_{as}	eps_{as}	eps_{cv}	eps_{cv}	eps_{fe}	eps_{fe}
R^2_{it-1}	-3.257*	-1.376	-1.514**	-1.384**	-6.146***	-3.241**	-0.787*	-0.531	-0.479***	-0.273***
	(-1.72)	(-0.82)	(-2.29)	(-2.21)	(-3.97)	(-2.57)	(-1.79)	(-1.32)	(-4.64)	(-3.25)
Observations	9476	9475	9657	9656	12962	12959	12969	12966	12974	12971
Banks	283	283	283	283	298	298	298	298	298	298
Controls	No	Yes	No	Yes	No	Yes	No	Yes	No	Yes
F-stat	2.9625	17.1984	5.2583	1.1810	15.7491	54.2458	3.1891	1.7206	21.5114	35.5266
R^2	0.0005	0.0597	0.0006	0.0020	0.0017	0.1791	0.0004	0.0046	0.0053	0.2081

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: The table shows the estimated beta coefficient on R^2_{it-1} using the regression specified in Equation 3.13. Each regression is estimated with bank level fixed effects and standard errors clustered at the bank level. Control variables included are $equity_{it-1}$, $size_{it-1}$, Δroe_{it}, $\sigma(nco_{it-1})$ and a dummy variable equal to 1 over the period 2007Q1 to 2009Q4 to account for variability in forecast errors around the financial crisis.

3.5 The impact of monetary policy surprises and bank transparency on bank equity prices

This section examines how the response of bank equity prices to monetary policy induced interest rate surprises is impacted by the level of bank transparency. First, I set out the method and describe some of the additional data (3.5.1). I then set out the baseline results (3.5.2) and robustness by controlling for other channels of monetary policy transmission through banks (3.5.3 and 3.5.4). The final subsection (3.5.5) provides an interpretation of the results.

3.5.1 Approach and data

To examine how bank transparency affects monetary policy transmission through banks, I use bank equity prices in an event study set up. Testing the response of bank equity prices is equivalent to testing the impact of a monetary tightening on the present value of future bank earnings, and so serves to indicate how bank intermediation activity may respond to a change in the monetary policy stance. Using equity prices over a short window additionally helps isolate the effects of monetary policy from other factors that could influence bank earnings, such as the macroeconomic response to the policy change.

The method is an extension of Bernanke and Kuttner (2005) and Gürkaynak et al. (2005), and has been applied to bank equity prices in other studies (e.g., English et al., 2018; Ampudia and Van den Heuvel, 2022). The baseline test uses the following interactive specification:

$$ret_{it} = \alpha + \beta_1 mps_t + \beta_2 \left(mps_t \times R^2_{it-1}\right) + \epsilon_{it} \tag{3.14}$$

Where ret_{it} is bank i's stock return over the FOMC announcement day t on which the monetary policy shock occurs and the day after, mps_t is the monetary policy surprise, and R^2_{it-1} is the transparency proxy described in Section 3.4. Selecting the stock return window length involves a trade-off between allowing sufficient time for expectations to be fully incorporated into asset prices, and keeping the window narrow enough to avoid the influence of other information. Figure 3.C.1 in the Appendix shows that it takes more than one day for the full effect of a monetary policy surprise to be reflected in returns, and Ippolito et al. (2018) notes that a 2-day window accounts for the FOMC blackout period.[16] Moreover, measuring equity responses over several days (rather than intraday) suggests that the effects persist, rather than jumps which reverse on the announcement day. Later tests control for wider market returns, which should capture any information unrelated to the monetary policy announcement.

The monetary policy surprise is the unexpected change in the three month ahead federal fund futures rate over a 30-minute window around FOMC announcements.[17] A shorter window is chosen to limit the extent to which the interest rate change reflects information except for the announcement, to isolate the effect of an exogenous interest rate change on bank stock returns. The rate change over the window is scaled by a factor associated with the number of days outstanding in the month.[18] As is

[16]During the FOMC blackout period, FOMC staff are restricted from public speaking or granting interviews.

[17]Data obtained from the replication files of Gürkaynak et al. (2022).

[18]This adjustment is necessary because the payoff to the federal funds futures contract is based on the average effective federal funds rate that prevails over the calendar month. Therefore, immediately before the FOMC meeting, the implied rate from the current-month federal funds futures contract

standard in the literature, monetary policy surprises are filtered for the meeting on 17 September 2001. Additional tests confirm that an equivalent surprise to longer dated interest rates does not interfere with the main results, considering the maturity transformation function of banks and their exposure to interest rate risk (English et al., 2018).

Equation 3.14 is estimated using OLS. The data consists of irregularly spaced stock returns determined by FOMC announcement dates, suggesting that the error term ϵ_{it} is unlikely to be serially correlated. However, since the analysis focuses on a very specific set of shocks to bank equity returns, the error terms are likely dependent in the cross-section. To address this, the standard errors use Driscoll-Kraay corrections.

3.5.2 Baseline results

Table 3.5.1 presents the results of estimating Equation 3.14. The β_1 estimate in Column 1 indicates that an unanticipated 25bp increase in the federal funds rate will significantly reduce bank share prices by around 2.1% on average over the two days following the announcement. This impact is consistent with the findings of English et al. (2018) for a shorter sample period (1997-2007) and remains largely unchanged when including the equivalent shock to a longer interest rate (Table 3.C.1 in the Appendix), which is positive but statistically insignificant. Column 2 includes a role for transparency by interacting R^2_{it} with the monetary policy surprise. The coefficient on $mps_t \times R^2_{it}$ is negative but insignificant, suggesting that on average, unconditional bank transparency does not influence monetary policy transmission via banks.

Next, the sample of banks is split by balance sheet quality to test Hypothesis 1 and assess whether the role of transparency depends on asset quality.[19] Non-performing assets are used to represent balance sheet quality, since they are one of the variables employed to explain net charge offs in construction of the transparency measure. Outsider interpretation of a bank's declaration of high non-performing assets will depend its past ability to assess future net charge offs using this information. If the bank is more transparent and reports high non-performing assets, outsiders may become more pessimistic about the banks future health as they are able to make a more accurate assessment of η. Columns 3 and 4 compare the role of transparency for banks with non-performing assets above and below the sample median, while Columns 5 and 6

is a weighted average of the rate that has prevailed so far, and the expected rate for the rest of the month. Kuttner (2001) shows that the unexpected target rate change for an event on day d in month m with D total days is given by $mps = \frac{D}{D-d}\left(f^0_{m,d} - f^0_{m,d-1}\right)$, where $f^0_{m,d} - f^0_{m,d-1}$ is the change in the current-month implied futures rate.

[19]The summary statistics for the split samples are broadly consistent with those for the full and are therefore not presented. This fact supports the identification approach that banks with different quality balance sheets are otherwise similar and face the same demand environment. This identification approach is common in the literature absent more granular data, see for example Gambacorta (2005) or Ulate (2021).

differentiate between banks above and below the 90th percentile.

Column 3 shows that when a banks share of non-performing loans exceeds the sample median, higher transparency strengthens the negative impact of the monetary policy surprise. Specifically, following a 25bp monetary policy surprise, the equity price of a high transparency bank (with R^2_{it} in the fourth quartile, around 0.76) with a higher proportion of non-performing assets is estimated to fall by an additional 0.83%, compared to a less transparent bank (with R^2_{it} in the fourth quartile, around 0.02), whose equity price is estimated to fall by an additional 0.02%. This effect is more pronounced and significant when the bank's non-performing assets are in the tail of the distribution (Column 5), where transparency appears to dominate the response of returns. Notably, transparency has no significant effect on bank equity returns when the bank's asset quality is higher (Columns 4 and 6). These findings support Hypothesis 1, that the role of bank transparency in the transmission of monetary policy is conditional on its quality of assets.

Table 3.5.1: Monetary policy surprise and bank equity returns: baseline results

	(1) Full sample	(2) Full sample	(3) $npa_{it} > \mu_{npa}$	(4) $npa_{it} \leq \mu_{npa}$	(5) $npa_{it} > P^{90}_{npa}$	(6) $npa_{it} \leq P^{90}_{npa}$
mps_t	-8.589**	-7.780**	-6.860**	-8.710**	-4.579	-8.161**
	(-2.21)	(-2.27)	(-2.29)	(-2.28)	(-1.35)	(-2.39)
R^2_{it-1}		0.00695	-0.0111	0.0484	-0.224*	0.0452
		(0.11)	(-0.16)	(0.77)	(-1.89)	(0.69)
$mps_t \times R^2_{it-1}$		-2.492	-4.405*	-0.599	-5.686***	-2.273
		(-1.30)	(-1.86)	(-0.41)	(-2.86)	(-1.14)
Constant	0.0694	0.0665	0.0671	0.0590	0.00324	0.0685
	(0.71)	(0.71)	(0.76)	(0.59)	(0.04)	(0.72)
Observations	58783	58783	29958	28733	5751	52940
Banks	635	635	580	557	261	631
R^2	0.0171	0.0175	0.0151	0.0218	0.0088	0.0197

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: The dependent variable is the bank's stock return over the day of and day following the monetary policy announcement. The sample comprises 181 events (announcements) and 635 banks. Subsamples for high and lower quality balance sheets are obtained using the sample median and sample fifth quintile of non-performing assets as a share of gross loans across the full sample. Test statistics reported are obtained using Driscoll-Kraay standard errors.

3.5.3 Controlling for other bank characteristics: approach

This section uses additional bank-level data to control for interference from other channels of monetary policy transmission, to provide further evidence that a mechanism exists via bank transparency. Equation 3.14 is re-estimated with a series of additional interaction variables:

$$ret_{it} = \alpha + \beta_1 mps_t + \beta_2 \left(mps_t \times R^2_{it-1}\right) + \lambda \left(mps_t \times X_{it-1}\right) + \theta Y_t + \phi ret_{mt} + \epsilon_{it} \quad (3.15)$$

Where X_{it-1} contains the additional bank-level variables, Y_t controls for non-bank specific time varying factors, and ret_{mt} represents the market return measured over the same window as ret_{it}, orthogonalised to the monetary policy surprise.[20] Bank-level variables lagged to mitigate potential endogeneity issues.

Summary statistics for the additional bank level variables are presented earlier in Table 3.4.1. The variables included are variation in net charge offs, equity, size, maturity mismatch, loans and deposits. Variation in net charge offs ($\sigma(nco)_{it-1}$) is estimated over the same rolling window as R^2 and is included to address concerns that the results are driven by a mechanical relation between R^2 and bank riskiness. Since variance in charge offs is used to construct R^2, it could influence the bank's equity price response to a monetary policy surprise if existing risk levels make the bank more susceptible to the risk taking channel of monetary policy (Jiménez et al., 2014). Equity is included to control for the capital channel, while size accounts for the well-established effects of bank size on monetary policy transmission (Kashyap and Stein, 2000).

Maturity mismatch controls for a bank's exposure to interest rate risk, which may influence its response to a monetary policy surprise (English et al., 2018; Ampudia and Van den Heuvel, 2022). It is approximated by comparing estimates of pass-through from market rates to interest income and expense.[21] Finally, loans and deposits as a share of total assets are included to account for potential differences in response due to reliance on lending as an income source or on deposits as a funding source.

Non-bank specific time-varying factors are included in Y_t to control for the current macroeconomic and financial environment. Specifically, I use the first two principal components from the changes in the unemployment rate, CPI, GDP, and the house price index, and the level of the VIX. The changes are measured over the quarter leading up to the monetary policy surprise.

3.5.4 Controlling for other bank characteristics: results

Table 3.5.2 presents the results for Equation 3.15 including bank-level control variables. The first panel (3.5.2a) contains the results for banks with non-performing assets above

[20] This is achieved by regressing ret_{mt} on mps_t and using the residuals of this regression in Equation 3.15. This approach controls for market factors unrelated to the monetary policy surprise, including responses to additional macroeconomic information contained in post-announcement FOMC communications.

[21] The method follows Drechsler et al. (2021) and Ampudia and Van den Heuvel (2022), and briefly comprises separate rolling regressions of changes in interest income and interest expense (each as a share of total assets) on the current and lagged changes of the quarterly average FFR. The coefficient on the FFR provides an estimate of interest sensitivity, while the difference between the sensitivity for liabilities and assets approximates a bank's duration mismatch, or 'gap'. The results are barely changed when using a 1 year Treasury security as an alternative. Lags of the FFR are included to account for the cumulative effect of rate changes over a full year, and these are summed to obtain the sensitivity measure.

the sample median, and the second panel (3.5.2b) contains the results for banks with non-performing assets below the sample median. The full sample results are reported in Table 3.C.2 in Appendix 3.C. All specifications in Table 3.5.2 include dummy variables for the period when the effective FFR was below 0.25% and for the financial crisis (2007Q4 and 2009Q2).

The role of transparency remains negative and significant for banks who have higher levels of non-performing assets when including a full set of controls. For banks with lower levels of non-performing assets and the full sample, transparency remains insignificant. The size of the effect does not change much when varying the controls variables included: following a 25bp monetary policy shock, the equity price of a more transparent bank with a higher proportion of non-performing assets falls by around 0.7pp more than that of a less transparent bank. Interestingly, for banks with lower shares of non-performing assets, including some control variables results in a positive, though insignificant, effect of transparency on bank equity prices. This supports the idea that high quality information combined with quality assets may attenuate the size of the external finance premium.

When accounting for all bank-level variables included in the specification, the marginal effect of a 25bp monetary policy surprise evaluated at the median of the bank-level variables is around -1.9% for both the full and the sub-samples. This is only slightly less than the impact reported in Table 3.5.1 with no control variables (-2.1%), suggesting that the characteristics included in the specification effectively capture key factors influencing monetary policy transmission via banks.

Turning to the control variables, their directions and significance are mixed. Variation in net charge offs ($\sigma(nco_{it-1})$) does not tend to have a significant impact, though the negative sign is conducive to the role of balance sheet health in strengthening monetary policy transmission. The coefficient on the maturity gap proxy shows no consistent direction and is insignificant across estimates, likely due to intertemporal differences in interest rate risk exposure caused by the changing slope of the yield curve over the sample period. Larger bank's equity prices tend to respond more strongly to monetary policy surprises, though with mixed significance. This is consistent with findings by Yin and Yang (2013) and English et al. (2018); Yin and Yang (2013) argues that this result is due to higher reliance by larger banks on the federal funds and other money markets for funding. This idea is supported by the current data, which shows that banks with assets greater than $3b have a lower proportion of deposit funding.

The equity prices of banks with a large loan-to-asset ratio also respond more strongly to a monetary policy surprise, and this effect is fairly consistently significant. This result reflects that a monetary tightening slows loan growth via the interest rate channel, eventually reducing bank earnings from intermediation. Holod and Peek (2007) show that this effect is stronger for publicly traded banks. While banks will eventually pass on the higher policy rate to borrowers to support net interest margins, this occurs with a lag as some loans are fixed term. Additionally, the benefits may be offset by changes in funding costs and a weaker lending environment.

The negative coefficient on equity might be surprising when considering the role of bank equity in Disyatat's (2011) framework, as well as empirical suggesting that monetary tightening has a strong effect on poorly capitalised banks (e.g., Kishan and Opiela, 2000; Gambacorta and Shin, 2018). However, these studies focus on differences in lending responses to a change in monetary policy for different levels of capital. In a similar empirical set up for a sample of European banks, Ampudia and Van den Heuvel (2022) finds that banks with higher capital levels experience stronger responses in equity prices to short-term interest rate surprises. In unreported tests, when the sample is split by capital level, the coefficient for banks with higher capital is smaller than that of banks with lower levels of capital, supporting the bank capital channel of transmission. The negative coefficient may be due to confounding effects between capital and lending.[22]

Finally, the level of deposits moderates the effect of the monetary policy surprise, with the size and significance of the effect strongest for the low non-performing asset sample. This aligns with Yin and Yang (2013) and may be driven by insured deposits, which make up a relatively large share of total liabilities and are less information sensitive. To test differences in the effect of deposit types, Column 8 presents results using uninsured deposits and time deposits.[23] In this analysis, banks with a high share of uninsured deposits (defined as accounts of $100k or more until 2009Q4 and accounts of $250k thereafter) show a negative response to a monetary policy surprise. This is consistent with the the theory set out in Section 3.3 and the empirical evidence of Chen et al. (2022). In contrast, banks with high shares of time deposits (non-transaction deposits payable after a specified period) show a positive response, as their cost of funding is less sensitive to short-term interest rate changes.

[22]Introducing a triple interaction ($mps_t \times loans_{it-1} \times equity_{it-1}$) changes the sign on $mps_t \times equity_{it-1}$ to be positive (results not reported), suggesting that the coefficient presented in Table 3.5.2 may also capture the effects of future lower lending, as higher capital banks will have lower overall lending capacity in a higher rate environment.

[23]Data on different deposit types is unavailable in CRSP-Compustat, however Chen et al. (2022) kindly shared their dataset derived from Call Reports, which includes estimates of uninsured and time deposits. These were aggregated to the top holder (public) bank level and matched to the CRSP-Compustat data using the CRSP-FRB Link published by the Federal Reserve Bank of New York.

Table 3.5.2: Monetary policy surprise and bank equity returns: with control variables

(a) Banks with non-performing assets above the sample median

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$mps_t \times R^2_{it-1}$	-3.914*	-3.428*	-4.317*	-3.853*	-4.033*	-3.870**	-4.286**	-3.947**	-3.173*	-3.355**	-3.585**	-3.982***
	(-1.77)	(-1.85)	(-1.84)	(-1.77)	(-1.84)	(-2.13)	(-2.19)	(-2.22)	(-1.83)	(-2.54)	(-2.29)	(-3.82)
$mps_t \times \sigma(nco_{it-1})$	-0.930	-2.423	-0.568	-1.529	-1.473	1.824	0.608	1.458	-3.074	-0.879	-3.710	-1.652
	(-0.20)	(-0.55)	(-0.12)	(-0.33)	(-0.32)	(0.38)	(0.13)	(0.30)	(-0.71)	(-0.19)	(-1.03)	(-0.43)
$mps_t \times equity_{it-1}$	-0.663								-0.760	-0.919	-0.837	-1.014
	(-1.18)								(-1.32)	(-1.13)	(-1.53)	(-1.27)
$mps_t \times size_{it-1}$		-1.865							-2.093	-2.922	-1.938	-2.863
		(-1.41)							(-1.44)	(-1.24)	(-1.33)	(-1.23)
$mps_t \times gap_{it-1}$			-1.529						-1.503	-1.249	-1.019	-0.614
			(-1.48)						(-1.44)	(-0.94)	(-1.07)	(-0.45)
$mps_t \times loans_{it-1}$				-0.124					-0.205*	-0.306***	-0.285***	-0.385***
				(-1.45)					(-1.92)	(-3.19)	(-2.93)	(-6.87)
$mps_t \times deposits_{it-1}$					0.0799				0.00739		0.0735	
					(0.91)				(0.16)		(1.40)	
$mps_t \times deposits^{unins}_{it-1}$						-0.109		-0.110		-0.0487		-0.0923
						(-1.31)		(-1.36)		(-0.80)		(-1.45)
$mps_t \times deposits^{time}_{it-1}$							0.196**	0.197*		0.158		0.167
							(1.98)	(1.96)		(1.49)		(1.47)
Observations	29956	29958	27535	29958	29958	21384	21512	21384	27533	20531	27533	20531
Banks	580	580	530	580	580	486	487	486	530	459	530	459
R^2	0.0207	0.0241	0.0212	0.0208	0.0205	0.0212	0.0212	0.0222	0.0267	0.0299	0.0722	0.0721
Non-Bank Controls											Y	Y

(b) Banks with non-performing assets below the sample median

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$mps_t \times R^2_{it-1}$	-0.381	0.314	-0.893	-0.464	0.215	-1.368	-1.193	-1.394	0.240	-0.301	-0.174	-0.889
	(-0.28)	(0.28)	(-0.48)	(-0.31)	(0.17)	(-0.53)	(-0.48)	(-0.54)	(0.17)	(-0.16)	(-0.13)	(-0.46)
$mps_t \times \sigma(nco_{it-1})$	-1.141	-1.435	-6.998	-1.053	-0.917	-4.620	-5.388	-4.779	-8.694	-9.452	-2.916	-3.485
	(-0.11)	(-0.15)	(-0.60)	(-0.10)	(-0.09)	(-0.41)	(-0.48)	(-0.42)	(-0.81)	(-0.79)	(-0.28)	(-0.31)
$mps_t \times equity_{it-1}$	-0.593**								-0.354	-0.473	-0.463*	-0.602
	(-2.38)								(-1.31)	(-1.17)	(-1.81)	(-1.44)
$mps_t \times size_{it-1}$		-3.296**							-3.073**	-4.040*	-3.012**	-3.978*
		(-2.26)							(-1.98)	(-1.67)	(-2.01)	(-1.68)
$mps_t \times gap_{it-1}$			-0.217						0.0833	-1.401	1.003	-0.120
			(-0.13)						(0.05)	(-0.71)	(0.64)	(-0.07)
$mps_t \times loans_{it-1}$				-0.0958***					-0.192***	-0.156***	-0.236***	-0.219***
				(-2.65)					(-3.77)	(-3.48)	(-4.29)	(-4.81)
$mps_t \times deposits_{it-1}$					0.250**				0.134*		0.187**	
					(2.44)				(1.90)		(2.46)	
$mps_t \times deposits^{unins}_{it-1}$						-0.142		-0.116		-0.146		-0.196**
						(-1.43)		(-1.12)		(-1.46)		(-2.12)
$mps_t \times deposits^{time}_{it-1}$							0.146	0.106		-0.0108		0.000816
							(1.54)	(1.13)		(-0.10)		(0.01)
Observations	28729	28733	26502	28733	28733	20605	20829	20605	26502	20112	26502	20112
Banks	557	557	506	557	557	465	466	465	506	445	506	445
R^2	0.0266	0.0340	0.0284	0.0257	0.0270	0.0261	0.0259	0.0271	0.0392	0.0372	0.1145	0.1117
Non-Bank Controls											Y	Y

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: The dependent variable is the bank's stock return over the day of and day following the monetary policy announcement. The sample comprises 181 events (announcements) and 635 banks. Subsamples for high and lower quality balance sheets are obtained using the sample median non-performing assets as a share of gross loans across the full sample. Non-bank controls are market returns over the same window as bank returns, and the first two principal components of the changes in unemployment, GDP, CPI, HPI, and the level of the VIX. All regressions include indicator variables for the financial crisis period and the period where interest rates were <0.5%, bank control variables in levels, and uninteracted mps_t. Test statistics reported are obtained using Driscoll-Kraay standard errors.

3.5.5 Interpretation of results

The results reported so far provide evidence in support of Hypothesis 1, which posits that the role of bank transparency in the monetary transmission mechanism is conditional on the bank's reported asset quality. The separation of the sample of banks into those with non-performing assets above and below the sample median serves to test the role of η when the likelihood of signal s being informative, as measured by p, is high or low. The results show that transparency strengthens the effect of the monetary policy surprise on bank equity prices when bank assets are of lower quality.

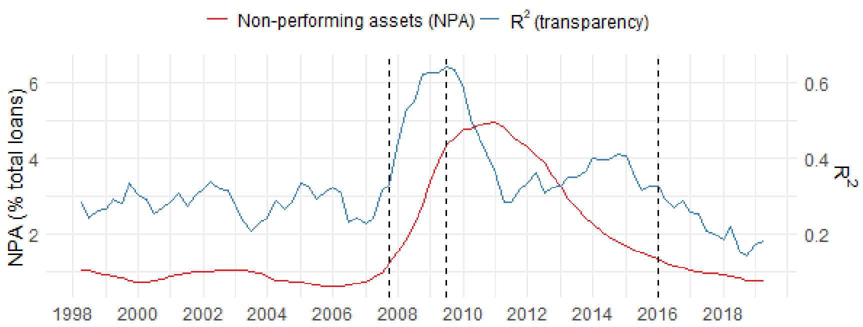
The evidence supports the idea that more transparent banks are more information sensitive. In this context, the monetary policy surprise constitutes a change in input costs for the bank, affecting intermediation activity. For banks that are both more transparent and have lower quality assets, the shock is more pronounced because outsiders can accurately assess the level of asset quality (η) and the potential for future endogenous changes due to the policy shock. This evidence supports research by Chen et al. (2022) on the stronger responsiveness of deposit rates of high transparency banks to income statement news, and by Altunbas et al. (2010) on the strength of monetary policy transmission through banks with lower quality assets.

The results also support the risk pricing channel of Kishan and Opiela (2012), suggesting that higher transparency may increase the spread on risk-sensitive deposits for banks with high levels of non-performing assets following a monetary tightening. In contrast, depositors of more opaque banks are less certain about future defaults, meaning they are less able to demand a premium. Additionally, Table 3.5.2 shows that the impact of the monetary policy surprise is larger for banks with higher shares of non-performing assets and a larger proportion of loans, suggesting that banks with lower quality assets may reduce lending by more.

3.6 The impact of monetary policy surprises over time

Hypothesis 2 asks whether the role of bank transparency varies with the operating environment of the bank. The sample period, which spans 1998 to 2019, includes periods of contrasting macroeconomic and financial conditions, such as the financial crisis and the subsequent era of low interest rates. Although the previous specifications controlled for the financial crisis and the low-interest rate period using indicator variables, it is possible that these controls do not fully capture the intertemporal differences of these periods in the role of bank transparency. Figure 3.6.1 illustrates variation over time of non-performing assets and R^2: each of these were relatively stable prior to the crisis, though increased quickly over 2008-9 followed by a gradual decline during the period of low interest rates.

Figure 3.6.1: Mean R^2 and mean non-performing assets over time



Note: The figure plots the average R^2 and average non-performing assets as a share of total loans over the sample period. The dashed vertical lines represent the sample splits according to 1) start of the financial crisis around 2007Q4, 2) end of the crisis period in 2009Q2 defined as the return to positive economic growth in the US, and 3) end of the lower bound period when the federal funds rate increased above 0.25% in 2016Q1.

To test Hypothesis 2 and account for differences across the periods, I estimate Equation 3.15 for four distinct periods: pre-GFC (1998Q1 to the first quarter before the crisis 2007Q3), GFC (2007Q4 to 2009Q2, which is when the US returned to positive economic growth), low rate (2009Q3 to 2016Q1 when the federal funds rate was below 0.25%) and post low rate (2016Q2 until the end of the sample in 2019Q4). The subsamples for high and low quality balance sheets are based on the period-specific medians of non-performing assets.

The results are presented in Table 3.6.1, where Column 1 for the full time period replicates the previous results. The results for the GFC period align with the earlier analysis: a monetary policy surprise has a stronger effect on more transparent banks with higher levels of non-performing assets. For banks with lower levels of non-performing assets, the coefficient has increased in size and is negative, although it remains insignificant.

Interestingly, these results are reversed in the non-crisis periods. In Columns 2, 4, and 5 of Table 3.6.1, during the non-GFC periods, transparency tends to attenuate the impact of a monetary policy surprise for banks with higher quality assets. In the pre-GFC period, the equity price response of a bank with high quality assets and a high R^2 estimate (in the fourth quartile, around 0.76) to a 25bp monetary policy surprise is estimated to be 0.3pp higher than a bank with a low R^2 estimate (in the first quartile, around 0.02). This offsetting effect is more pronounced in the low rate period that followed the crisis, with the equivalent difference in equity prices around 0.9pp. The coefficients for banks with lower quality assets are more mixed, though they generally remain negative.

Table 3.6.1: Effect of a monetary policy surprise on bank equity returns across different periods

(a) Full sample

	(1) Full sample	(2) Pre-GFC period	(3) GFC period	(4) Low rate period	(5) Post low rate
$mps_t \times R^2_{it-1}$	-1.886	0.210	-2.749	5.170	-0.0785
	(-1.33)	(0.38)	(-1.08)	(1.10)	(-0.03)
Observations	54124	21842	6034	18848	7400
R^2	0.0875	0.0745	0.1859	0.0514	0.0875

(b) High shares of non-performing assets (above period median)

	(1) Full sample	(2) Pre-GFC period	(3) GFC period	(4) Low rate period	(5) Post low rate
$mps_t \times R^2_{it-1}$	-3.585**	-0.619	-4.821**	5.187	-2.529
	(-2.29)	(-0.87)	(-2.61)	(0.53)	(-0.60)
Observations	27533	11369	3190	9342	3620
R^2	0.0722	0.0664	0.1464	0.0449	0.0612

(c) Low shares of non-performing assets (below period median)

	(1) Full sample	(2) Pre-GFC period	(3) GFC period	(4) Low rate period	(5) Post low rate
$mps_t \times R^2_{it-1}$	-0.174	1.503**	-2.087	4.920**	4.693
	(-0.13)	(2.21)	(-0.55)	(2.23)	(1.09)
Observations	26502	10473	2844	9506	3780
R^2	0.1145	0.0923	0.2578	0.0853	0.1068

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: The dependent variable is the bank's stock return over the day of and day following the monetary policy announcement. The pre-GFC period is defined as the sample in 1998Q1 to the start of the crisis in 2007Q3, the GFC period is 2007Q4 to 2009Q2 (when the US returned to positive economic growth), the low rate period is from 2009Q3 to 2016Q1 when the federal funds rate was below 0.5%, and the post low rate period is from 2016Q2 until the end of the sample in 2019Q4. Subsamples for high and lower quality balance sheets are obtained using the median non-performing assets as a share of gross loans for the respective estimation periods. All estimates are made using the full set of controls as used in Column 11 Table 3.5.2, including uninteracted bank control variables and uninteracted mps_t. Test statistics reported are obtained using Driscoll-Kraay standard errors.

3.6.1 Interpretation of results

Overall, Table 3.6.1 supports Hypothesis 2. That is, the role of transparency in the response of bank equity prices to a monetary policy surprise is conditional on both asset quality and the broader financial and macroeconomic environment. The results indicate that in stable periods, a monetary policy surprise tends to improve depositor confidence for banks with higher quality assets. This aligns with the theory that the external finance premium for transparent banks reporting η_L is relatively lower, thus mitigating some of the shift in the loan supply curve caused by a monetary tightening. These banks are better able to insulate their lending activity from changes in the monetary policy stance, supporting evidence presented by Altunbas et al. (2010).

In contrast, transparency does not appear to have a significant impact on banks with lower quality assets in the more stable periods. This result supports the idea that when $\underline{u}$ is closer to 0, it can operate to offset the effects of η_H for a more transparent bank, rendering the existence of lower quality assets less important for deposit holders. In reality, the risk of an adverse shock that might be exacerbated by high levels of non-performing loans is lower in stable periods. As depositors are less concerned about potential future defaults, wholesale funding remains generally available. In the post-GFC (low rate) period, the positive insignificant coefficient for banks with high NPA may capture the regulatory response following the financial crisis which supported a more stable banking environment (e.g., the Dodd Frank Act 2010, which increased capital requirements and introduced stress testing).

During the crisis period, the results show that transparency strengthens the bank equity price response to a monetary policy surprise for banks reporting lower quality assets. This finding is particularly significant in the context of the financial crisis, where systemic risk was a key concern and large withdrawals of funding by credit-sensitive, uninsured depositors contributed to a sharp increase in risk premia. This scenario was exacerbated by capital scarcity, as highlighted by He and Krishnamurthy (2013), which further heightened the sensitivity of banks to changes in monetary policy. At the same time, we can see that transparency as measured by R^2 increased, consistent with the theory which shows information revelation to be optimal during bad times (Bouvard et al., 2015).

During this period, the focus was on monetary loosening to support macroeconomic recovery. In this environment, the results imply that more transparent banks with lower quality assets responded more positively to a conventional monetary policy loosening compared to their more opaque counterparts.[24] This positive response may be attributed to two key factors. First, the direct impact of lower $(1+r_f)$ on lending rates, particularly in the presence of very high credit risk premia and a reduced willingness to lend (e.g., Diamond and Rajan, 2011). Transparent banks were able to leverage the monetary loosening more effectively, as outsiders had a clearer understanding of their risk profiles. Second, lower lending rates indirectly improved bank capital by reducing the likelihood of further loans becoming non-performing. This reduction in default risk induced by monetary loosening served to improve their equity prices.

Overall, this evidence is consistent with the notion that monetary policy is more potent during crisis periods (Mishkin, 2009). During these times, transparency plays a critical role in enabling efficient investments and ensuring efficient allocation of capital in response to a monetary policy surprise. Comparatively, outside of crisis periods, transparency acts to improve confidence in banks with higher quality assets, attenuating

[24] Note that the significance of this result holds even in the presence of relatively low variation in the FFR over this period.

some of the impact of a monetary policy surprise.

3.7 Discussion

This study highlights that bank transparency plays a key role in how banks respond to monetary policy, suggesting that accounting standards and disclosure practices are more important for monetary policy transmission than previously thought. While existing research mainly focuses on transparency's role in financial stability, this study demonstrates how transparency alters the sensitivity of the bank's external finance premium to changes in conventional monetary policy.

Disyatat's (2011) recasting of the bank lending channel represents a move away from the 'traditional' bank lending channel, which is based on reservable deposits (e.g., Bernanke and Blinder, 1988).[25] Subsequent empirical research has been based on the same principal: that the bank lending channel operates through monetary policy induced changes in access to finance faced by the bank. For instance, the response to monetary policy is shown to be weaker for larger and better capitalised banks who have better access to wholesale funding markets (e.g., Kishan and Opiela, 2000; Gambacorta, 2008; Altunbas et al., 2009) and those affiliated with multi-bank holding companies who have access to internal capital markets (Ashcraft, 2006). On the other hand, in each of these cases, access to finance may be viewed from the perspective of the recasted bank lending channel in that access to finance will be influenced by informational asymmetries and agency problems.

Here, and by Disyatat (2011), it is argued that perceptions of the bank's financial health are of primary importance in determining its response to monetary policy. These perceptions influence the external finance premium and its sensitivity to monetary policy induced changes, ultimately impacting its marginal cost of funding. While factors like capital and size offer some indication of a bank's health and influence information asymmetries, evolving regulatory requirements mean that the signal to take from these characteristics vary over time.

Previous research already shows that bank health is an important determinant of bank response to monetary policy. Altunbas et al. (2010) shows that banks with lower levels of expected default are better able to insulate lending from monetary policy changes; Halvorsen and Jacobsen (2016) finds a non-linear response to monetary policy shocks which depends on bank financial strength; while Kishan and Opiela (2012) find that the risk premia of banks with lower quality assets respond more strongly to an adverse policy shock. Additionally, Breitenlechner and Scharler (2021) demonstrates

[25] The role for reservable deposits as the driver for depressing lending following a monetary tightening has also been dismissed due to a reduction in the importance of reserve requirements, highlighted by Romer and Romer (1990).

that monetary policy impacts bank loans when it leads to changes in wholesale funding supply, but not in funding demand, reinforcing the importance of outsider perceptions in the transmission mechanism.

This study goes further by examining how bank transparency interacts with asset quality to influence these perceptions. Importantly, bank transparency shapes outsider perceptions and influences the sensitivity of the bank's external finance premium. This raises two key questions: What is the role of accounting standards for monetary policy transmission? and How does bank transparency affect the monetary policy response to financial crisis? These questions are addressed briefly below.

Interaction of accounting standards and monetary policy transmission. There is limited research bridging these two strands of the economic literature. Notable exceptions for non-financial firms are Ozdagli (2018) and Armstrong et al. (2019), who respectively examine the role of firm ratings and accounting quality in equity price responses to monetary policy surprises. Additionally, Borio and Zhu (2012) acknowledge the importance of accounting for valuation perceptions within the risk-taking channel.

In this study, the R^2 transparency measure captures differences in how banks report defaults, non-performing loans, and loan loss provisions under prevailing accounting standards. Recently, new loan loss provisioning standards were adopted, which could alter outsider understanding of future defaults and alter transparency by the R^2 measure. The Current Expected Credit Loss (CECL) standard in the US requires banks to make provisions on expected losses at the time credit is granted, contrasting with the previous incurred loss approach which required a 'triggering' loss event before a provision was made. The CECL standard aims to reduce the procyclicality of loan loss provisions (Cohen and Edwards, 2017). However, because it relies on forecasted losses (which are inherently less certain) rather than actual events, it could reduce any transparency currently offered by loan loss provisions. On the other hand, encouraging early reserves may reduce the sensitivity of the bank's external finance premium to monetary policy induced changes as outsiders perceive the bank to be better prepared for adverse future shocks, akin to an improvement in $\dot{w}$. The overall effect will depend on whether any change in the level of transparency is offset by improvements in reserves relative to reported asset quality.

Bank transparency and monetary policy responses in financial crisis. Macroeconomic research suggests that monetary policy transmission is more effective during periods of financial stress when financing constraints are binding (e.g., He and Krishnamurthy, 2013; Ravn, 2014), and that financial uncertainty can dampen bank reactions to monetary policy (Baum et al., 2013). At the same time, theoretical research suggests that bank transparency optimally increases during financial stress (e.g., Bouvard et al., 2015). In such times, the benefits of opacity - especially for risk-sharing - are diminished, and rollover risk rises. Banks choose to become more transparent to reassure creditors about their financial health (Jungherr, 2018), as shown by the increase in transparency during the financial crisis (Figure 3.6.1).

During a crisis, policymakers adjust monetary policy to stabilise inflation and output. This study suggests that policymakers should include both the degree of information revelation in the financial system and the quality of bank assets in their reaction function. These factors, which influence bank responses to conventional monetary policy surprises, will also alter the broader macroeconomic response via bank lending channel.[26] Whilst it is not suggested that there should be an 'optimal' level of transparency for monetary policy transmission, the level of transparency will influence the bank's external finance premium and, consequently, the central bank's optimal policy path. As the distribution of non-performing assets and transparency levels evolve over time, the impact of these factors on overall monetary policy transmission will also vary.

3.8 Conclusions

Banks play a crucial role in the transmission of monetary policy. At the same time, asymmetric information between banks and their creditors means that their cost of funds are sensitive to their level of transparency and reported asset quality. The sensitivity of the bank's external finance premium, which determines cost of funds, is an important mechanism in the bank's response to a monetary policy surprise. This study demonstrates the role for transparency in the bank's external finance premium theoretically, and finds empirically that transparency is relevant for the bank's response to monetary policy.

The theory uses a version of Disyatat's (2011) recasting of the bank lending channel, which is modified to include a role for bank transparency in outsider perceptions of bank asset quality. The hypotheses of the model are tested using event study methods, which show that bank transparency can either strengthen or attenuate the bank's response to a monetary policy surprise, depending on the quality of the bank's assets and the prevailing operating environment.

[26] Information revelation in the financial system here is with regards to that between banks and its liability holders, rather than the regulator who may have superior knowledge.

Appendix

3.A Model appendix

3.A.1 Derivation of the depositors external finance premium

Derivation of Equation 3.10 starts with the objective function of the depositor (Equation 3.9), which may be rewritten using Equations 3.6 and 3.8 as:

$$\begin{aligned}(1+r_f)L &= x(1+R)L + (1-x)(\psi^e - cL)\\ &= (1+R)L + (1-\theta)q(\psi^e - cL - (1+R)L)\\ &= (1+R)L - (1-\theta)qcL + (1-\theta)q\left[\dot{w}\left(1+\frac{1}{q}\int_{\underline{u}}^{u^*} ug(u)du\right) - (1+R)L\right]\end{aligned} \tag{3.16}$$

Where the third line uses the fact that $q = G(u^*)$, i.e. the conditional probability that the bank defaults. Using the critical shock to net worth u^* (Equation 3.4), this may be expressed as:

$$(1+r_f)L = (1+R)L - (1-\theta)qcL + (1-\theta)\dot{w}\int_{\underline{u}}^{u^*}(u-u^*)g(u)du \tag{3.17}$$

Which can be rearranged to obtain:

$$(R-r_f)L = (1-\theta)\left[qcL - \dot{w}\int_{\underline{u}}^{u^*}(u-u^*)g(u)du\right] \tag{3.18}$$

...and using the conditional probability of bank default q, may finally be rearranged to produce Equation 3.10 as in the text:

$$R - r_f = \frac{(1-\theta)}{L}\left[\int_{\underline{u}}^{u^*}\left[\dot{w}(u^*-u)\right]g(u)du + cL\int_{\underline{u}}^{u^*} g(u)du\right] \tag{3.19}$$

3.A.2 Equilibrium in the lending market

The solution of the model is characterised by equilibrium in the lending market for loans and is obtained from the zero profit conditions of the household and the firm. This section replicates the equilibrium for the household zero profit condition presented by Disyatat (2011), with the firm's production function and resulting profit function taken as given without loss of generality. We can obtain the households zero profit condition from Equation 3.17, where we can expand the integral to give:

$$(1+r_f)L = (1+R)L - (1-\theta)cqL - \frac{(1-\theta)w}{2}\left[\frac{(u^* - \underline{u})^2}{(\bar{u} - \underline{u})}\right] \tag{3.20}$$

Using q this simplifies to:

$$(1+r_f)L = (1+R)L - (1-\theta)cqL - \frac{w(1-\theta)(\bar{u} - \underline{u})}{2}q^2 \tag{3.21}$$

Then, using Equations 3.4 and 3.5 to substitute for $(1+R)L$ yields the household's zero profit condition as:

$$H \equiv \frac{\dot{w}(1-\theta)(\bar{u} - \underline{u})}{2}q^2 + [(1-\theta)cL - (\bar{u} - \underline{u})\dot{w}]q - \dot{w}(1+\underline{u}) + (1+r_f)L = 0 \tag{3.22}$$

A complication in the analysis arises from the role of q, which varies endogenously with the level of L. To simplify the exposition, consider the two situations where q equals 0 or 1:

$$q = 0 \quad \text{for} \quad L = \frac{\dot{w}(1+\underline{u})}{1+r_f} \equiv L_L \tag{3.23}$$

$$q = 1 \quad \text{for} \quad L = \frac{\dot{w}(1+\underline{u}) + \dot{w}(\bar{u} - \underline{u}) - \frac{\dot{w}(1-\theta)(\bar{u}-\underline{u})}{2}}{(1+r_f) + (1-\theta)c} \equiv L_H \tag{3.24}$$

Disyatat demonstrates that when c is restricted to a certain value, $L_H > L_L$ and $dq/dL > 0$ for $q \in (0,1)$. This implies that as the size of the loan increases, it becomes less likely that the bank will be able to repay creditors in the event of default. The conditional probability of default may be expressed as:

$$q = \begin{cases} 1 & \text{for } L \geq L_H \\ \min(q) : H = 0 & \text{for } L_L < L < L_H \\ 0 & \text{for } L \leq L_L \end{cases} \tag{3.25}$$

The non-linear loan supply schedule can be obtained from Equations 3.7 and 3.9 using the value for $(1 - x)$ in Equation 3.6:

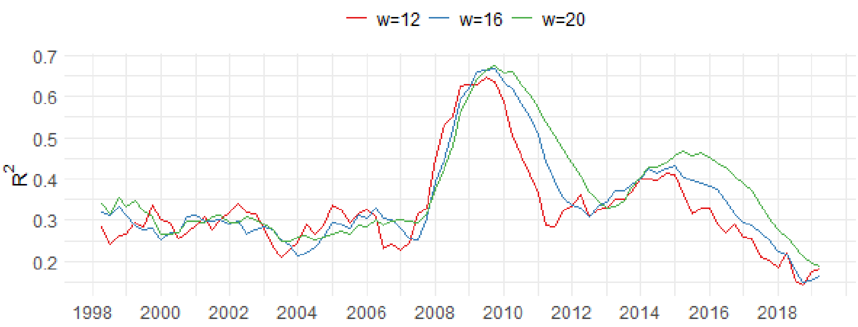
$$(1 + r_L) = \begin{cases} \frac{(1+r_f)}{\theta} + \frac{(1-\theta)c}{\theta} & \text{for } L \geq L_H \\ \frac{(1+r_f)}{\theta} + \frac{(1-\theta)c}{\theta}q & \text{for } L_L < L < L_H \\ \frac{(1+r_f)}{\theta} & \text{for } L \leq L_L \end{cases} \tag{3.26}$$

Where Figure 3.3.2 uses $\overline{(1 + r_L)} \equiv \frac{(1+r_f)}{\theta} + \frac{(1-\theta)c}{\theta}$ and $\underline{(1 + r_L)} \equiv \frac{(1+r_f)}{\theta}$ for the upper and lower bounds of bank lending rates. The upper bound represents the situation where it is inevitable that the bank will default ($q = 1$), whereas the lower bound is where banks are able to completely absorb lending risks so that $q = 0$, and the lending rate is a simple risk-discounted rate. The associated levels of lending are determined by the firm's profit function (see Disyatat, 2011).

3.B Supporting information for measuring R^2

3.B.1 R^2 estimated over different rolling regression windows

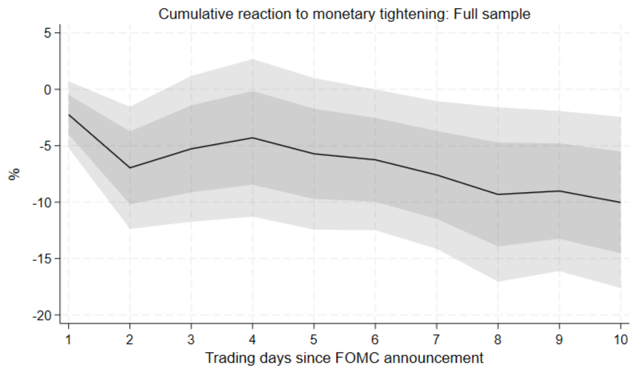
Figure 3.B.1: Mean R^2 estimated with varying window sizes



Note: The figure plots mean R^2 estimates when R^2 is obtained from rolling regressions of different window sizes (12, 16 and 20 quarters).

3.C Supporting results

Figure 3.C.1: Cumulative reaction to 100bps monetary tightening



Note: The figure plots estimates of β_h from the regression $ret_{i,t+h} = \alpha + \beta_h mps_t + u_i + \epsilon_{it}$ where $ret_{i,t-1+h}$ is the cumulative equity return to bank i between the close price on the day before the announcement $(t-1)$ and the days following the announcement $h = 1, ..., 10$ (i.e. $h = 1$ is the day of the announcement, $h = 2$ is the day following the announcement, and so forth). Standard errors are obtained using Driscoll-Kraay corrections for 68% and 90% levels of confidence.

Table 3.C.1: Effect of a monetary policy surprise on bank equity prices: responses to surprises in short-term and long-term rates

	(1)	(2)	(3)	(4)
mps_t	-8.589**	-8.674**	-7.780**	-7.863**
	(-2.21)	(-2.14)	(-2.27)	(-2.17)
mps_t^{10Y}		0.462		0.478
		(0.11)		(0.13)
R^2_{it-1}			0.00695	0.0216
			(0.11)	(0.35)
$mps_t \times R^2_{it-1}$			-2.492	-2.526
			(-1.30)	(-1.40)
$mps_t^{10Y} \times R^2_{it-1}$				0.0827
				(0.03)
Constant	0.0694	0.0826	0.0665	0.0749
	(0.71)	(0.85)	(0.71)	(0.81)
Observations	58783	58017	58783	58017
Banks	635	635	635	635
R^2	0.0171	0.0181	0.0175	0.0185

t statistics in parentheses
* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: Notes: The dependent variable is the bank's stock return over the day of and day following the monetary policy announcement. The sample comprises 181 events (announcements) and 635 banks. Test statistics reported are obtained using Driscoll-Kraay standard errors.

Table 3.C.2: Effect of a monetary policy surprise on bank equity returns: full sample

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
$mps_t \times R^2_{it-1}$	-2.141	-1.527	-2.528	-2.134	-1.972	-2.511	-2.698	-2.633	-1.486	-1.702	-1.886	-2.233
	(-1.18)	(-1.06)	(-1.21)	(-1.15)	(-1.15)	(-1.18)	(-1.25)	(-1.23)	(-0.96)	(-1.16)	(-1.33)	(-1.60)
$mps_t \times \sigma(nco_{it-1})$	-1.313	-2.142	-1.281	-1.389	-1.862	0.931	-0.756	0.0577	-3.612	-1.765	-3.176	-1.510
	(-0.25)	(-0.43)	(-0.23)	(-0.26)	(-0.37)	(0.16)	(-0.13)	(0.01)	(-0.73)	(-0.33)	(-0.71)	(-0.33)
$mps_t \times equity_{it-1}$	-0.625*								-0.550	-0.649	-0.633*	-0.750
	(-1.75)								(-1.45)	(-1.08)	(-1.78)	(-1.24)
$mps_t \times size_{it-1}$		-2.534*							-2.545*	-3.448	-2.425	-3.391
		(-1.78)							(-1.66)	(-1.46)	(-1.60)	(-1.45)
$mps_t \times gap_{it-1}$			-0.919						-0.747	-1.182	-0.0833	-0.300
			(-0.75)						(-0.61)	(-0.85)	(-0.08)	(-0.23)
$mps_t \times loans_{it-1}$				-0.111**					-0.194***	-0.227***	-0.252***	-0.290***
				(-2.20)					(-2.83)	(-4.17)	(-3.91)	(-7.28)
$mps_t \times deposits_{it-1}$					0.161*				0.0557		0.112*	
					(1.72)				(1.10)		(1.95)	
$mps_t \times deposits^{unins}_{it-1}$						-0.137*		-0.114		-0.0935		-0.139**
						(-1.67)		(-1.47)		(-1.33)		(-2.17)
$mps_t \times deposits^{time}_{it-1}$							0.172*	0.154*		0.0976		0.105
							(1.93)	(1.84)		(1.10)		(1.15)
Observations	58777	58783	54126	58783	58783	42053	42405	42053	54124	40707	54124	40707
Banks	635	635	582	635	635	543	545	543	582	516	582	516
R^2	0.0225	0.0275	0.0234	0.0222	0.0225	0.0225	0.0224	0.0236	0.0307	0.0316	0.0875	0.0858
Non-Bank Controls											Y	Y

t statistics in parentheses

* $p < 0.10$, ** $p < 0.05$, *** $p < 0.01$

Notes: The dependent variable is the bank's stock return over the day of and day following the monetary policy announcement. The sample comprises 181 events (announcements) and 635 banks. Subsamples for high and lower quality balance sheets are obtained using the sample median non-performing assets as a share of gross loans across the full sample. Non-bank controls are market returns over the same window as bank returns, and the first two principal components of the changes in unemployment, GDP, CPI, HPI, and the level of the VIX. All regressions include indicator control variables for the financial crisis period and the period where interest rates were <0.5%, bank control variables in levels, and uninteracted mps_t. Test statistics reported are obtained using Driscoll-Kraay standard errors.

Conclusion

This thesis explores key topics within the literature on banking: the impact of earnings smoothing behaviour on bank value, the role of a low interest rate environment on bank stability, and the effects of transparency in the response of bank equity prices to a monetary policy surprise. By utilising different methodological approaches to address the research questions, the thesis enhances our understanding of these specific areas within the field and provides new contributions. This concluding section summarises the findings of the thesis, outlines the relevant policy implications, and identifies limitations which prompt avenues for further research.

Chapter 1 explores how earnings smoothing by banks affects their market value, and provides new insights into how market valuation looks positively upon earnings smoothing. The analysis is motivated by a theory of earnings smoothing, where a bank manager smooths their reported earnings to increase the equity holder's valuation. Analysis using dynamic panel regressions shows that banks use provisions to smooth their reported earnings in a non-linear fashion, and a positive earnings threshold exists beyond which the bank's provisioning approach changes. To test the effect of this behaviour on market valuation of the bank, proxies for earnings smoothing are constructed to measure the sensitivity of provisions to bank-level earnings over time. These proxies are estimated to have a positive effect on market valuation of the bank, measured by Tobin's Q and the market-to-book ratio, even when controlling for the earnings variability which the smoothing is targeting. This novel finding implies that markets place some positive value on bank opacity, supporting the role of opacity in enabling risk sharing in financial intermediation as banks are perceived to absorb some of the risks associated with lending.

While the results lend support to the idea that some level of bank opacity can be beneficial, they also lead to a question on the level of tolerable opacity for financial stability purposes. The use of loan loss provisions to smooth earnings implicitly means that the cumulation of reserves for loan losses does not wholly represent expected defaults: this presents a financial stability issue if it means that reserves under-represent expected defaults. Further research should look to understand if there is a point at which earnings smoothing becomes detrimental to bank health; equivalently, is there an optimal level of earnings smoothing? Evidence in this area is important against the context of the recent CECL implementation, which may have led to new patterns in discretionary provisioning and earnings smoothing behaviour.

Chapter 2 studies how bank stability responds to a monetary loosening, with a particular focus on the low interest rate period of 2009 to 2015. Monetary policy shocks are identified using high-frequency monetary policy surprises in a FAVAR, and these are projected onto different measures of bank stability. The chapter offers a new perspective on the risk taking channel of monetary policy, by demonstrating how bank stability does not necessarily decline following a monetary loosening when the policy rate is away from zero, as the macroeconomic environment acts to offset any increase in risk taking at the margin. The chapter also offers a new contribution to our understanding of heterogeneity in the transmission of monetary policy when rates are very close to zero, with the stability of high deposit banks worsening due to the deposit lower bound which impeded pass-through of changes in conventional monetary policy to deposit rates. The findings presents a conflict for monetary and financial stability policy makers: maintaining low rates may support the economy via asset prices, but they present a dilemma in respect of the traditional bank business model.

In this thesis, the dilemma is shown to materialise as a deterioration in financial stability for high deposit banks following a monetary policy shock. As discussed in the chapter, a prolonged period of low rates may entrench this deterioration as policy rates become ineffective on deposit rates. This, and the flatter yield curve, may induce banks to adapt their business models to achieve returns elsewhere. Further research is warranted to examine whether this happened over the low rate period, and whether it led to any longer lasting effects when policy rates moved back away from the lower bound. Additionally, the existing chapter may be strengthened by examining bank-level deposit rate data to improve identification of their role in bank funding costs and stability.

Chapter 3 examines the role of bank transparency in the bank lending channel of monetary policy transmission, supported by a theory of the bank lending channel which incorporates bank transparency. In line with the theory, the analysis shows that the response of bank equity prices to a monetary policy surprise is attenuated for banks with higher quality assets when economic conditions are stable, as transparency offers outsiders confidence in the bank's ability to respond to the shock. Conversely, during a crisis period, transparency acts to strengthen the response of equity prices for banks with lower quality assets. This result demonstrates the importance of the bank's external finance premium in the bank lending channel, the sensitivity of which to monetary policy induced changes is increased by transparency. To my knowledge, the role of bank transparency in the response to monetary policy surprises has not been studied elsewhere, and this chapter offers an important contribution to our understanding of the role for information frictions in monetary policy transmission.

Since transparency optimally increases during periods of crisis, the results put an onus on monetary policy makers to consider the quality of bank financial reporting as well as asset quality in determining their optimal policy response. Even outside of crisis periods, accounting standards, which govern transparency levels, serve to influence the pass-through of policy rate changes to rates on lending and deposits via the external finance premium. The chapter focuses on the response of bank equity prices, but would be strengthened by investigating the direct effect of transparency on the external finance premium, such as by analysis of rates on uninsured deposits or yields on market issued debt.

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