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Essays in Banking

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Dedicated to my loving family.

Declaration

I certify that the thesis I have presented for examination for the PhD degree of the London School of Economics and Political Science is solely my own work other than where I have clearly indicated that it is the work of others (in which case the extent of any work carried out jointly by me and any other person is clearly identified in it).

Statement of Conjoint Work I confirm that Chapter 3 is jointly co-authored with Andra Smădu, and I contributed 50% of this work.

I declare that my thesis consists of approximately 19000 words.

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Abstract

In the first chapter I study the way in which monetary policy rates and capital and liquidity ratios are reflected into the prices of loans and deposits. I start from banks' profitability approach to disentangle two transmission channels: (i) through the cost of funds and (ii) through loan and deposit spreads. I use bank-level panel data to estimate these channels and then assess the correspondence with theoretical models of financial frictions, suggesting an extension to current DSGE models. When it comes to modelling the banking block, I suggest a simple extension that takes into account wholesale funding. The money-market rate banks pay on wholesale markets can simply be equal to the monetary policy rate. However, we can move a step closer to industry best practices and allow for it to be a function of capital and liquidity positions, in line with what counterparty credit risk assessments would suggest.

In the second chapter I show how liquidity constraints, coupled with banks' excessive government exposures lead to a negative feedback loop that reduces credit to the real economy because of deteriorating sovereign creditworthiness. Liquidity requirements improve banks' resilience when faced with liquidity shocks. However, they may also lead to a reduction in lending to the private sector.

The third chapter presents an estimation of the reversal rate, for both lending and deposit rates. Initially the idea of a reversal rate was introduced as the rate at which accommodative monetary policy becomes contractionary for lending. This is linked to the literature that has proposed low nominal rates can reduce and even reverse expansionary monetary policy. We find evidence of a threshold at -0.4%. Below this threshold, deposit rates stop responding to the monetary policy rate, while the sensitivity of lending rates to the policy rate changes sign, becoming negative.

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Chapter 1

Bank Profitability and Funds Transfer Pricing

1.1 Introduction

This chapter answers the following question: How can funds transfer pricing (FTP) help us understand banks' pricing decisions? In doing so, I am able to link how monetary and prudential policy matter with how bank profitability matters. Commercial banks seem to care more about FTP when profitability is decreasing or financial regulation changes. However, these issues should matter whenever we are interested in the pass-through of monetary policy, or impact of capital and liquidity regulation on interest rates faced by borrowers and depositors. In addition, not accounting for the cost of credit and liquidity risk and associated regulatory cost, even in normal times, might mean that banks are mispricing their products.

First, banks' pricing decisions for loans and deposits are affected by both monetary policy and prudential regulation. This is not new. A broad literature documents these, but a better understanding of the channels through which these policies affect banks' rate setting behaviour is important, especially since these are constantly changing and banks need to react to these changes. Second, downward pressure on bank profitability might reduce or even reverse monetary policy transmission as pointed out by Brunnermeier, Abadi, and Koby (2023) and as documented more broadly in chapter 3. An increasing literature has focused on this, especially when monetary policy rates have been on a decreasing trend worldwide and have even reached negative values in some countries. Balloch, Koby, and Ulate (2022) provides a literature review, summarising the theoretical channels through which negative rates affect banks, empirical findings, aggregate and general equilibrium effects. However, the net interest income channel is treated simplistically in most papers and the impact of capital and liquidity on banks' lending and deposit rates is not fully accounted for. This chapter tries to fill this gap.

The chapter overlaps with the literature on bank profitability. More importantly, it adds to the literature by decomposing the net interest income channel into two different channels: (i) the cost of funds channel and (ii) the loan and deposit spreads channels. Importantly, the insights from this chapter come from focusing on what banks should actually do in maximising their profit, based on industry best practices.

I show how banks' approach to measuring profitability at their business lines level provides a link between the impact of central banks' policy, profitability, and banks' rate setting decisions. Interestingly, this approach, called *funds transfer pricing* (FTP), has evaded the research spotlight, despite being commonplace in industry best practices and consulting advice [1]. FTP was introduced in the early 1980s to help firms better manage interest rate risk on a transactional basis during a period of high inflation and volatile interest rates. The 2007-2008 financial crisis made it clear that liquidity costs need to be considered and that bannks have previously done that in a heterogeneous way. Subsequent financial regulation through Basel III and liquidity management guidelines followed. As noted by BIS (2013), despite having adequate capital levels, many banks still experienced difficulties because they did not manage liquidity in a prudent manner [2]. Thus, Basel III addresses the management of liquidity risk through measures such as the Liquidity Coverage Ratio (LCR), aimed at promoting the short-term resilience of banks' liquidity profiles through ensuring they hold an adequate stock of liquid assets to meet their liquidity needs for a 30 calendar day liquidity stress scenario. In addition, capital regulation has been refined, increasing the overall quality and quantity of funds banks need to set aside. More recently, increasing pressures on bank profitability come in the context in which, precautionary savings driven by the COVID pandemic have pushed saving rates to record high, adding to the pressures of the zero lower bound for client deposit rates. At the same time, liquidity was once again put to the test in a generalised flight to highly-liquid assets and cash. Looking forward, bank profitability might face some short to medium-term respite,

[1] Figueiredo (2021), KPMG (2016) KPMG (2018), and developers of IT solutions aimed at FTP and Asset and Liability Management more broadly such as Oracle, Katalysys, Mors to name a few.

[2] As noted in BIS (2013), part of the issue was due to the fact that banks relied on markets where funding was readily available and at low cost. While this was true prior to the crisis, 2007 came with a rapid reversal in market conditions, in which liquidity evaporated quickly and illiquidity took hold for an extended period of time.

due to higher inflation that allowed interest rates to normalise. However, in the long-term, profitability might be affected by higher default rates. So, after a long period of calm, the importance of bank capital will increase. All these indicate that once again FTP should be understood better and potentially optimised to maximise banks' profits overall.

Banks use FTP as a part of their internal assessment of profitability. FTP methodologies are aimed at: (i) pricing risk into products, (ii) pricing regulatory cost into products and (iii) subsidising product lines according to management perception of businesses requirements and potential growth opportunities. FTP helps with the allocation of profit throughout the business lines of the bank. The bank's Treasury acts as a central hub for the bank and charges a cost to the lending business units, or rewards the funding (deposit taking) business units. Ultimately, each business unit considers all costs and revenues and prices then into the lending and deposit rates.

One helpful way of better understanding the channels in this chapter is to think of the banks' Treasury function as a "bank within a bank", as noted by Cadamagnani, Harimohan, and Tangri (2015). By focusing on FTP, we can distinguish two types of relationships that are fundamentally different. The first is between the Treasury function of banks, financial markets, and different business lines within the bank. The second is between the different business lines and non-bank customers: on the one hand, there is the lending spread channel and on the other hand there is the deposit spread channel. These channels involve fundamentally different decisions in terms of trade-offs and complexity and impose additional frictions *within* the net interest income channel. Accounting for them means that profit from banks' maturity transformation does not come by simply accounting for the difference between the interest rate that banks charge when issuing loans and the one that is paid to their depositors. Wholesale funding also plays an important role in profitability and the costs associated with raising funds on wholesale markets do not just reflect monetary policy decisions. They are a function of the creditworthiness of banks, in the sense that higher capital ensures a lower funding rate. In addition, the level of liquidity acts through two opposing forces: similar to capital, higher liquidity might ensure lower funding rates. However, holding liquid assets is costly. The net effect of liquidity on interest rates then depends on how strong each of these channels are.

One aim of this chapter is to complement the existing literature, focusing on the link between industry best practices, and empirical facts. These two then serve as a tool to inform a theoretical model.

In addition, I test how monetary policy rates and financial regulation explain the variation in deposit and lending rates. I find that the variation in lending and deposit rates is linked to regulatory constraints. The effect is non-linear and also shows interactions pointing to complementarity of capital and liquidity ratios. However, overall, the liquidity positions seem to exert a greater cost that mitigates beneficial effects of capital ratios. In light of these empirical findings, the chapter proceeds to show how the theoretical framework could be modified to account for FTP.

This chapter proceeds as follows: Section 1.2 presents the literature review, followed by the methodology in Section 1.3 and theoretical implications in Section 1.4. Section 1.5 concludes.

1.2 Literature review

Figueiredo (2021) and industry best practices suggest that in general FTP methodologies are based on the recognition that both lending and deposit activities should be economically viable for banks. FTP's objective is to calculate a single, or multiple rates, that charges users of liquidity (asset business units) and credits the liquidity providers (liability business units). Cadamagnani, Harimohan, and Tangri (2015) summarise the process of determining interest rates within the banks' Treasury departments [3]. Similar to the bank optimisation problem in Brunnermeier, Abadi, and Koby (2023) client deposit rates are below the transfer price with a spread that reflects the banks' market power. In addition, they reflect the costs associated with raising deposits, which is linked to the liquidity constraint. Client lending rates are above the transfer price with a spread that reflects market power and credit risk. This type of literature justifies more expensive lending (and hence lower lending volumes) as a result of an increase in the cost of lending induced by compliance with financial regulation.

Prior to the 2007-2008 financial crisis, banking regulation focused on capital requirements. The crisis unveiled new issues in our understanding, bringing further refinements of the capital regulation, but it is liquidity risk that came to the forefront of

[3] The Treasury function "borrows" deposits raised by deposit-taking units of the bank and "lends" to loan-originating units — hence the notion of a "bank within a bank". The transfer price is the rate at which the Treasury department provides funding to the business line and is the "actual" base interest rate, which can deviate from the monetary policy rate. More explicitly, taking the transfer price as a starting point, a business line will then usually decide the rate at which to extend loans or raise deposits. So in practice, monetary policy impacts client rates through this transfer pricing rate.

the Basel III accord. Allen and Gale (2017) point out that massive illiquidity in many markets, combined with an extreme exposure of financial institutions to liquidity risk calls for liquidity regulation indeed. However, Allen and Gale (2007) also point out that for most part of history, the development of financial regulation has been an empirical process, not necessarily driven by theory. Indeed our theoretical framework for thinking about financial regulation is still incomplete.

The FTP methodology suggests that the levels of capital and liquidity should matter for rate setting decisions not just when they are binding. It may be true that some banks care more about accurately measuring these components when their profitability is low, their constraints are more likely to bind in the future, or they need to account for some structural changes in the economy that affect the trends of inflation and interest rates. Liquidity constraints should matter just because banks need to hold liquid assets as a proportion of their assets as opposed to lending. In addition, at any moment, the liquidity position of the bank affects counterparty credit risks assessments on the wholesale market. The same is true for the total capital banks have; higher capital decreases the cost of funding in wholesale markets. In addition, the level of capital is linked to expected and unexpected losses and thus should be reflected in the spreads that banks charge their borrowers. These mechanisms are not fully captured by the literature. And finally, during uncertainties around the pandemic and dash-for-cash, a new issue occurred with buffer usability as pointed out in Mathur, Naylor, and Rajan (2023). Banks seemed reluctant to use their capital and liquidity buffers, even if they were far from binding, due to fear of market perceptions. That is banks' capital was perceived as a binding constraint at the onset of the pandemic faced with a prospect of lower profitability and higher credit losses, impairments, and provisioning. Similarly, banks seemed to hoard liquidity rather than trade it in money markets. So it seems that, particularly in stressed market conditions, banks treat their capital and liquidity requirements are binding, whatever the level relative to the regulatory minimum.

Brunnermeier, Abadi, and Koby (2023) study the interaction between monetary policy and financial regulation. First, it introduces the idea of a reversal rate, the rate at which accommodative monetary policy becomes contractionary for lending. Second, it enforces the idea that financial frictions in the form of capital and liquidity regulations introduce a wedge between monetary policy rates and the interest rates that banks charge for loans and pay for their deposits. While their contribution is welcome in explaining the limited impact of monetary policy when hitting a lower bound, their focus is on binding capital constraints. Still, it is noteworthy that their modelling approach mirrors empirical price-setting behaviour of banks through the FTP. Also, it is useful because it captures both the impact of regulation and competition on pricing, such that the potential explanations from empirical studies can be balanced within the same framework.

In Brunnermeier, Abadi, and Koby (2023) the existence of a reversal rate is guaranteed when, following a cut in the policy rate, the resulting capital gains are not enough to offset the fall in the net interest income of banks, which lower their profitability, thereby limiting banks' ability to lend. However, Brunnermeier, Abadi, and Koby (2023) attribute the reversal rate mainly to the effect of lower rates on bank profitability via capital constraints and choose to downplay the importance of liquidity constraints. In contrast, I opt to closely examine the role of liquidity constraints as they matter for the price-setting behaviour of banks. Related work by Repullo (2020) argues that, when the liquidity constraint binds, a fall in lending may not be related to the main mechanism in Brunnermeier, Abadi, and Koby (2023). Rather, a cut in the policy rate triggers a fall in deposits, that then results in a contraction of lending even if the equity is fixed. Further, they also abstract from the liquidity constraint and challenge the reversal rate focusing on the capital constraint only. Moreover, they argue no reversal would exist if lending is constrained by the current (exogenous) value of the bank's capital, as should be the case given how capital regulation is specified. Considering these remarks and in light with new findings on buffer usability at any level, my approach will not dismiss the liquidity constraint. This aims to match the price-setting behaviour of banks and to assess the possible interactions between both liquidity and capital constraints.

Following the empirically-driven motivation for the liquidity regulation, a considerable part of the literature presents empirical findings. Even prior to the introduction of LCR, policy makers have tried to assess its impact on funding costs and corporate lending. Bonner (2012) use a similar liquidity framework computed by Dutch banks and find that, from 2008 to 2011, banks that are just above/below their quantitative liquidity requirement do not charge higher interest rates for corporate lending. They argue that banks are not able to pass on their increased funding costs in the interbank market to private sector clients, implying that banks do not have pricing power. They conclude that LCR is unlikely to have a major impact on corporate lending rates. More recently, EBA (2017) assessment is based on the data submitted by banks on the LCR itself. They show that while the regulation may have a negative impact on lending *before* reaching the minimum requirements, highly liquid banks tend to increase the share of retail and non-financial corporate loans in their balance sheet.

1.3 Methodology

Details of the FTP methodologies are provided in Cadamagnani, Harimohan, and Tangri (2015), as well as consulting firms [4], but they are less frequent in the academic literature. I take them as a benchmark for industry best practices, look for empirical evidence of these best practices and then assess the correspondence with theoretical models of financial frictions.

Banks use FTP as a part of their internal assessment of profitability. FTP methodologies are aimed at: (i) pricing risk into products, (ii) pricing regulatory cost into products and (iii) subsidising product lines according to management perception of businesses requirements and potential growth opportunities. FTP helps with the allocation of profit throughout the business lines of the bank. The Treasury acts as a central hub to the bank and charges a cost to the lending business units, or rewards the funding (deposit taking) business units. Ultimately, each business unit considers all costs and revenues and prices then into the lending and deposit rates.

The Treasury will fund all other business lines by borrowing internally (from deposit-taking business lines) and externally (from money markets). The transfer price will reflect the marginal funding cost, which is the sum of a reference rate (an inter-bank short-term rate for short maturities, or a swap rate for longer ones) and an additional funding premium. The funding premium will reflect a combination of the bank's own credit risk premium and the liquidity risk premium. Banks may also add subsidies or charges to the transfer price, or 'management overlays', to drive desired behaviours in specific business lines based on expectations of future market developments. However, these are not transparent (observable) costs. A further component of the transfer price is the cost of holding a 'buffer' of liquid assets, which acts as an opportunity cost.

Taking the transfer price as a starting point, a business line will then usually decide the rate at which to extend loans or raise deposits: (i) a new loan is priced at a spread above its transfer price, while a (ii) new deposit is priced at a spread below its transfer price.

[4] KPMG (2016) KPMG (2018) Figueiredo (2021)

1.3.1 Mechanism

FTP rests at the core of the methodology behind this paper. By focusing on FTP, we can distinguish two types of relationships that are fundamentally different. The first is between the Treasury function of banks, financial markets, and different business lines within the bank. The second is between the different business lines and non-bank customers: on the one hand, there is the lending spread channel and on the other hand there is the deposit spread channel. These channels involve fundamentally different decisions in terms of trade-offs and complexity and impose *additional frictions within the net interest income channel*. Accounting for them means that profit from banks' maturity transformation does not come by simply accounting for the difference between the interest rate that banks charge when issuing loans and the one that is paid to their depositors.

As noted by Cadamagnani, Harimohan, and Tangri (2015), when determining the cost of funds, the treasury centre typically funds all assets originated by the bank's business lines by borrowing internally (from the bank's deposit-taking business lines) as well as externally (from wholesale funding markets) and assumes the associated liquidity, currency and interest rate risks. The interest rate at which the treasury charges business lines for extending new loans, or remunerates it for raising new deposits, is called the 'transfer price'.

The transfer prices reflects the banks' cost of funding and any strategic considerations (known as management overlays). The cost of funding is usually determined on a marginal basis. For instance, when a bank extends a new loan, it will consider the cost of raising additional funding to finance the loan. However, some risks such as interest rate risks are managed centrally for the entire bank. Also, determining the cost of funding can sometimes be more difficult as funding is actually a mix between retail deposits and wholesale funding. This provides some respite that even average rates might capture most of the channels from FTP.

The main components of the cost of funding are:

- the reference interest rate - this is a variable money-market rate, or a swap rate with the relevant maturity to match the fixed period. Empirically, we expect this to be linked to the monetary policy rate, such that an increase in the monetary policy rate is associated with an increase in the cost of funds.

- additional funding premium - which is the spread between the bank's own cost of funding and the reference rate for the corresponding maturity. The funding premium will reflect a combination of the bank's own credit risk premium and the liquidity risk premium at the relevant maturity. This part should be linked to counterparty credit risk assessments that take place during wholesale funding. While the actual mechanism and metrics could potentially be complex, trying to simplify concepts we can at least expect that: higher capital is associated with lower funding costs and that higher liquidity is associated with lower funding costs.

- cost of holding a buffer of liquid assets - to meet the risk of unanticipated withdrawal of wholesale funding or retail deposits in a stress. Prior to the introduction of LCR, this was dependent on the banks' internal liquidity risk models. Currently, it is sensible to believe it is linked to the LCR [5]. So, one approach seems to be to look at the relationship between LCR and the cost of funds. We would expect a higher LCR ratio to be associated with a higher cost of funds.

- management overlays - that reflect charges or subsidies to encourage the expansion of a particular business line, or that reflect the risk appetite of the banks. Unfortunately, these are not observable, but could at least be approximated by bank fixed effects, as long as we believe that strategic decisions are slow-moving variables.

These sum up the essence of the cost of funds channel. We can link banks' cost of funding to the monetary policy rate, one comprehensive measure of capital risk and one of liquidity risk, with LCR as a proxy of overall liquidity standing, as well as a buffer in terms of stress. In a sense, this channel is more complex in terms of the ability of money markets to assess the credit and liquidity risk of commercial banks. Also, the mix of wholesale funding with retail deposits complicates matters and might dilute some of the effects such as the additional funding premium.

The second channel is that of loans and deposit spreads. That involves the relationship between banks and their non-bank customers. To that extent we might expect depositors to be less sophisticated and thus be less able to require a funding premium.

[5] One numerical example is provided in Cadamagnani, Harimohan, and Tangri (2015) For example, a bank may assess that 5% of its retail deposits would be at risk of sudden withdrawal in the event of stressed market conditions. As a result, suppose it raises an additional £5 million of funding (for example term wholesale funding with a maturity of five years) for every £100 million of retail deposit balances, and holds this £5 million in the form of liquid assets. If the yield on the liquid assets is 0.5% and the interest rate paid on the funding source is 1.0% then the bank will typically allocate a $0.5\% = (1.0\breve{~}0.5\%)$ cost of the buffer to its retail deposits to reflect their liquidity risk.

However, we do expect competition between banks to affect deposit rates. In terms of lending spreads, these should be related to expected and unexpected losses and thus be a measure of the borrowers' creditworthiness and should be linked to banks' capital through loan loss provisions and capital requirements. Here as well, banks' pricing power will impact how much of the cost of capital requirements can be passed on to customers. For lending rates, the spread above the transfer price will include the costs associated with any expected loss on the loan, the capital charge associated with the loan and other factors such as the bank's operating costs and margins (or mark-up).

Unlike loans, where the customer-facing business line pays the Treasury centre an internal price to originate the loan, the business line receives an internal rebate for acquiring deposit funding. This rebate reflects the value to the bank of deposits gathered. The final spread that the deposit-taking business units will earn is then the difference between the transfer prices and any costs they may face.

Alternatively, one can think of these pricing rules as a determinant of the profitability for each business line. In effect this is how commercial banks are using FTP; to allow them to decompose profitability by business line. Take the stylised example from Cadamagnani, Harimohan, and Tangri (2015) depicted below:

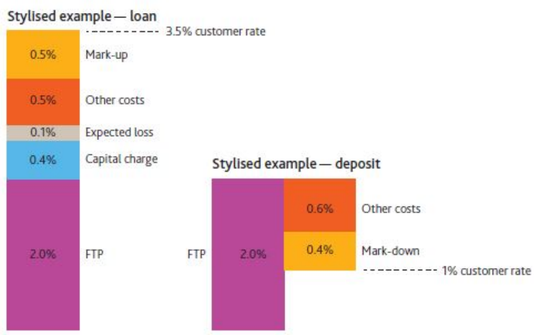


Figure 1.1: FTP example

, source Cadamagnani, Harimohan, and Tangri (2015)

The lending business line generates a 0.5% rate of return (mark-up). This return is the difference between the loan rate of 3.5%, the transfer price of 2% and additional costs of 1% that are related to capital charges and other costs (like operational costs). Similarly, the deposit-taking unit generates a return (mark-down) of 0.4%. This happens as it receives the transfer price of 2%, but pays the client only 1% and incurs 0.6% as other costs associated with their business.

For this chapter, I am interested in how the lending and deposit spreads vary as a function of capital and liquidity positions. On the one hand, I compute the simple spreads between lending rates and the cost of funds and, on the other, I compute the spread between the cost of funds and retail deposits. These are observable measures, as detailed in the next question.

1.3.2 Data

I use three main sources for this chapter to construct a bank-level panel dataset, similar to the dataset used for chapter 3.

At the bank level, the data comes from S&P Capital IQ Pro (formerly Global Market Intelligence). The data is observed at an annual frequency. The sample starts in 2006 and ends in 2020. The data covers operating companies only, either listed or non-listed. The data is downloaded at a consolidated level (the highest level of consolidation). The geographical coverage spans 19 countries: US, Canada, Japan, Australia and major economies in developed Europe (Austria, Belgium, Denmark, Finland, France, Germany, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK).

In addition to bank level data, I use policy rates collected from the Central Banks' websites, as well as short-term interest rates from OECD database.

The main variables are summarised below in Table 1.1 for the UK sub-sample. Summary statistics for the full (international) sample are in the Appendix, along with the list of variables and their description. Variables are winsorised at the 0.5% and 99.5% level, except for policy and short-term rates interest rates, in order to reduce the adverse effects of outliers. I first focus on the UK sample and then extend to the full international sample, but accounting for that many jurisdictions might complicate the different channels at play due to different country-level characteristics, different implementations of the Basel III international standards and different business models for banks that go beyond waht could be capture by firm-level fixed effects and time fixed effects. This level of complexity might require careful consideration in the future, but is nevertheless presented in the Appendix and could give some hints on the interpretation of some interactions, as well as a longer data set, which improves the precision of my estimates.

Table 1.1: **Summary statistics - UK sample**

Variable	Mean	Std. Dev.	Min	Max	N
Yield on Cust. Loans	4.88	2.82	0.38	15.03	860
Deposit Rate	1.35	1.29	0.00	6.76	902
Cost of Funds	1.36	1.16	0.00	7.23	1,237
Liquidity Coverage Ratio	273.12	180.64	71	841.27	357
Total Capital Ratio	26.69	23.94	7.84	156.49	1,089
Policy interest rate	2.45	2.19	0.23	5.97	3,332

Note: Winsorised variables at the 0.5% and 99.5% level, except for policy rates.

1.3.3 Estimation - UK sample

Based on the FTP methodology, I study the impact of policy rates, as well as that of the capital and liquidity constraints on lending and deposit rates. The contribution of this paper is to split the channel from the policy instruments into lending and deposit rates in two: (i) into the cost of funds and, subsequently, (ii) into the loan and deposit spreads. For comparability to other studies that do not use the FTP methodology, a simple assessment of the pass-though of monetary policy rates into lending and deposit rates directly is presented in the Appendix.

FTP would suggest that the monetary policy rate (MPR) would pass into the funds transfer price (FTP); additionally the funding premium adds to the FTP and finally so does the liquidity buffer. We would expect an inverse relationship between the level of capital and the funding premium; similarly, higher levels of liquidity should imply a lower funding premium. In contrast, the cost of holding a liquid buffer should be proportional to the level of liquidity.

$$(1) \quad FTP = \beta_{MP} MPR + premium(Capital, Liquidity) + buffer(Liquidity)$$

In order to quantify this relationship, I estimate a panel regression. A first step would be to assume linearity, but allow for interactions between capital and liquidity. The second step is to look into non-linear effects.

The linear specification is as follows:

$$(2) \quad FTP = \beta_0 + \beta_{MP} MPR + \beta_C Capital + \beta_L Liqudity + \beta_{Int} Capital Liquidty + \beta_X X_{b,t} + \alpha_b + \epsilon_{b,t}$$

where, *MPR* is the monetary policy rate *Capital* is measured by the total risk-weighted capital, *Liquidity* is measured by the LCR, $X_{b,t}$ are bank-level, time-varying observable controls, such as Assets, to control for the size of the banks and the Loan/Deposit ratio, to control for different business models in terms of funding on the money-markets versus retail deposits. We also allow for bank fixed-effects to control for any unobservable time-invariant characteristic, such as management overlays, different business models or higher market power.

For the UK sample, the estimation results from Table 1.2 point to a negative and significant correlation between capital and the cost of funds, with coefficients ranging from -0.018 to -0.014, based on specification (1 percentage point increase in the capital ratio is associated with a reduction in the cost of funds between 14 and 18 basis points). This is consistent with the idea that higher capital levels ensure a lower cost of funds through a lower funding premium. Liquidity has a negative, but insignificant association, suggesting that maybe the benefit of a lower funding premium that comes with higher levels of liquidity is offset by the cost of holding a liquid buffer. The sensitivity of the cost of funds to the monetary policy rate is roughly $0.5 - 0.6$ and is significant. Bank fixed-effects explain most of the variation between banks, slightly improved further by the loan to deposit ratio, while assets have mostly insignificant coefficients.

However, one plausible assumption would be that the effects of capital and liquidity are non-linear. To account for that, I discretise the capital and liquidity ratios by dividing the banks into quartiles, where the first one corresponds to the lowest level of capital and liquidity, respectively. I proceed by estimating the following regression:

$$(3) \quad FTP = \beta_0 + \beta_{MP} MPR + \sum_{n=2}^{4} \beta_{C,n} Q(n) Capital + \sum_{n=2}^{4} \beta_{L,n} Q(n) Liqudity +$$

$$\sum_{n=1}^{9} \beta_{Int,n} QCapitalQLiquidiy + \beta_X X_{b,t} + \alpha_b + \epsilon_{b,t}$$

For the UK, as shown in Table 1.3, when considering capital alone, levels of capital higher than the median are associated with a lower funding cost. For the third quartile, the cost of funds is lower by 0.143%, compared to that of banks in the lowest quartile, while for the fourth quartile, the reduction is 0.237%. When taken separately, the effects of liquidity alone are not significant. When added as a moderating variable to capital, they reduce the beneficial effect of higher capital on the cost of funds. However, the coefficients corresponding to liquidity are not significant, nor are the ones corresponding to the interaction terms, with the exception of the interaction term between the fourth quartiles for both capital and liquidity which is negative and significant at a 95% level of confidence. In some specifications, without the interaction terms, the fourth quartile of capital has negative and significant effect, similar to the linear specification. That might suggest that capital needs to be considerably higher than the median to be rewarded in terms of a decreased cost of funds. Also, the seemingly small impact from the linear specification might be small on average, but it is inherently non-linear and relevant only for high levels of capital, irrespective of liquidity.

Table 1.2: **Cost of funds channel - UK**

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Cost of funds						
β_{MP} : Policy Rate	0.530***	0.540***	0.539***	0.595***	0.592***	0.591***
	(16.36)	(25.08)	(27.81)	(5.72)	(5.68)	(5.70)
β_C : Capital				-0.0180***	-0.0143***	-0.0142***
				(-3.95)	(-3.92)	(-3.95)
β_L : Liquidity				-0.0004	-0.0002	-0.0002
				(-1.48)	(-0.78)	(-0.77)
β_{Int} : Capital x Liquidity				0.00		
				(1.36)		
Observations	1,237	1,236	1,064	303	303	303
R-squared	0.178	0.73	0.77	0.884	0.883	0.883
Controls						
Bank FE		Y	Y	Y	Y	Y
Assets			Y	Y	Y	
Loans/Deposits			Y	Y	Y	Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

Table 1.3: **Cost of funds channel - UK - non-linear effects**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: Cost of funds							
β_{MP} : Policy Rate	0.530***	0.540***	0.539***	0.536***	0.620***	0.631***	0.595***
	(16.36)	(25.08)	(27.81)	(27.26)	(5.25)	(5.36)	(5.65)
Capital 2nd quart.				-0.074		-0.111	-0.028
				(-1.23)		(-0.75)	(-0.23)
Capital 3rd quart.				-0.143*		-0.072	-0.095
				(-2.35)		(-0.45)	(-0.70)
Capital 4th quart.				-0.237*		-0.102	-0.108
				(-3.11)		(-0.49)	(-0.61)
Liquidity 2nd quart.					0.066	0.048	-0.090
					(0.86)	(0.24)	(-0.51)
Liquidity 3rd quart.					0.143	0.243	0.090
					(1.40)	(1.12)	(0.47)
Liquidity 4th quart.					0.139	0.018	-0.123
					(1.21)	(0.08)	(-0.63)
Interactions						Not sig.	Not sig.
Observations	1,237	1,236	1,064	955	338	323	303
R-squared	0.178	0.73	0.77	0.792	0.842	0.852	0.89
Controls							
Bank FE		Y	Y	Y	Y	Y	Y
Assets			Y				Y
Loans/Deposits			Y				Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

The second channel is that of the loan and deposit spreads.

Take the lending spread. That would be the difference between the lending rate and the cost of funds. According to the FTP methodology, this spread is composed of: capital charge, expected loss, other costs and mark-up. This would imply:

(4) $i_{loans} - FTP = mark - up + f(Capital)$

However, I allow for maximum flexibility and estimate the same regressions as before, but changing the dependent variable from cost of funds to lending spread. In this way I test if the monetary policy rate is relevant, or if the liquidity constraint matters, although FTP suggest that should not be the case.

Looking at the linear specifications, the results are based on the following regression:

(5) $i_{loans} - FTP = \beta_0 + \beta_{MP}MPR + \beta_C Capital + \beta_L Liqudity + \beta_{Int} CapitalLiquidity + \beta_X X_{b,t} + \alpha_b + \epsilon_{b,t}$

According to Table 1.4, there seems to be no effect from the monetary policy rate or LCR into the loan spreads. That is expected. However, there is no relationship between the capital ratio and the loan spreads either. This also holds true for the non-linear specification as documented in Table 1.5. Again, all the coefficients are not significant. This might mean that either the capital constraint is not binding, or that banks misprice their loans when accounting for credit risk.

(6) $i_{loans} - FTP = \beta_0 + \beta_{MP}MPR + \sum_{n=2}^{4} \beta_{C,n} Q(n) Capital + \sum_{n=2}^{4} \beta_{L,n} Q(n) Liqudity + \sum_{n=1}^{9} \beta_{Int,n} QCapitalQLiquidiy + \beta_X X_{b,t} + \alpha_b + \epsilon_{b,t}$

Similar to the previous regression, this latest specification just implies running the same non-linear specification as we did with the cost of funds. I just use the loan spread as dependent variable instead of the cost of funds.

Table 1.4: **Loan spread channel - UK**

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Loan spreads						
β_{MP} : Policy Rate	-0.169	0.0845	0.120*	0.4111	0.376	0.172
	(-1.57)	(1.28)	(2.12)	(0.98)	(0.91)	(0.42)
β_C : Capital				-0.0194	-0.0263	-0.009
				(-0.96)	(-1.59)	(-0.60)
β_L : Liquidity				0.0008	0.0004	0.0006
				(0.83)	(0.58)	(0.80)
β_{Int} : Capital x Liquidity				-0.0000		
				(-0.60)		
Observations	807	799	723	200	200	200
R-squared	0.003	0.774	0.804	0.886	0.885	0.881
Controls						
Bank FE		Y	Y	Y	Y	Y
Assets			Y	Y	Y	
Loans/Deposits			Y	Y	Y	Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

Turning to the the deposit spread, that would be the difference between the cost of funds and the rate that banks pay to their depositors. According to the FTP methodology, this spread is composed of: other costs and mark-down. Essentially, if the operating costs of the deposit taking unit are unobserved, this spread is a measure of the profit the unit makes, which will be proportional to its market power. This would imply:

$$(7) \quad FTP - i_{deposits} = mark - down$$

However, just as for the loan spread, I allow for maximum flexibility and estimate the same regressions as before. The dependent variable is the deposit spread. In this way I test if the monetary policy rate is relevant, or if the capital and liquidity constraints matter, although FTP suggest that should not be the case.

Table 1.5: **Loan spread channel - UK - non-linear effects**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: Loan spreads							
β_{MP} : Policy Rate	-0.169	0.0845	0.120*	0.087	0.139	0.279	0.561
	(-1.57)	(1.38)	(2.12)	(1.56)	(0.35)	(0.70)	(1.32)
Capital 2nd quart.				0.125		0.417	0.510
				(0.83)		(0.77)	(0.92)
Capital 3rd quart.				-0.114		0.139	0.185
				(-0.71)		(0.24)	(0.31)
Capital 4th quart.				-0.157		0.507	0.448
				(-0.79)		(0.45)	(0.40)
Liquidity 2nd quart.					0.064	0.455	0.594
					(0.23)	(0.70)	(0.90)
Liquidity 3rd quart.					-0.076	0.343	0.375
					(-0.21)	(0.51)	(0.55)
Liquidity 4th quart.					0.032	0.297	0.564
					(0.09)	(0.40)	(0.74)
Interactions						Not sig.	Not sig.
Observations	807	799	723	660	219	208	200
R-squared	0.003	0.774	0.804	0.831	0.888	0.899	0.901
Controls							
Bank FE		Y	Y	Y	Y	Y	Y
Assets			Y				Y
Loans/Deposits			Y				Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

Looking at the linear specifications, the results are based on the following regression:

(8) $FTP - i_{deposits} = \beta_0 + \beta_{MP}MPR + \beta_C Capital + \beta_L Liqudity + \beta_{Int} CapitalLiquidity + \beta_X X_{b,t} + \alpha_b + \epsilon_{b,t}$

As expected and shown in Table 1.6, there is no connection between capital and liquidity ratios and the deposit spread, However, in two specifications, there is a small positive correlation (0.1) between the monetary policy rate and the deposit spread, but that disappears if we account for all regressors. That means that at higher levels of the policy rate, banks are able to retain more profit from the deposit taking business line. In low interest rate environments, this is restricted by the zero lower bound on the deposit rates.

This also holds true for the non-linear specification as shown in Table 1.7: .

(9) $FTP - i_{deposits} = \beta_0 + \beta_{MP} MPR + \sum_{n=2}^{4} \beta_{C,n} Q(n) Capital + \sum_{n=2}^{4} \beta_{L,n} Q(n) Liqudity +$

$\sum_{n=1}^{9} \beta_{Int,n} QCapitalQLiquidiy + \beta_X X_{b,t} + \alpha_b + \epsilon_{b,t}$

Results documented in Table 1.7 show that coefficients are mostly not significant. One exception is the small positive correlation between the policy rate and deposit spreads, with the reasoning being the same as before. When not limited by the zero lower bound, banks' deposit spreads are higher, contributing to higher profitability overall. One non-linear effect, is related to the liquidity ratio. For banks that are in the lowest quartile in terms of capital and second lowest quartile in terms of liquidity, there is a negative effect between increasing liquidity and the deposit spreads (-0.53 to -0.56 percentage points lower). That is, banks that have both low capital and low liquidity need to sacrifice a part of their deposit spread. In other words, keeping the cost of funds fixed, they need to pay a higher deposit rate for their retail deposits, reducing their deposit spared and thus profitability. This seems to decrease as the level of liquidity is increasing, but the coefficients are no longer significant for higher quartiles. In the interaction terms, for banks that are in the second quartile in terms of liquidity, but in the second and third quartiles in terms of capital, there is a positive and significant effect on deposit spreads; banks that have below median liquidity, but have higher capital are rewarded with a higher deposit spread. This might be a sign that some retail clients do put a premium on riskier banks and require a higher compensation for their savings as a result and tend to reward a better capital position.

Table 1.6: **Deposit spread channel - UK**

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Deposit spreads						
β_{MP} : Policy Rate	0.0725	0.0689	0.102**	0.0815	0.125	0.151
	(1.56)	(1.79)	(3.15)	(0.55)	(0.85)	(1.04)
β_C : Capital				-0.00877	-0.00168	-0.0021
				(-1.49)	(-0.36)	(-0.48)
β_L : Liquidity				-0.0005	-0.0000	-0.0001
				(-1.45)	(-0.21)	(-0.41)
β_{Int} : Capital x Liquidity				-0.0000		
				(1.92)		
Observations	843	837	774	204	204	204
R-squared	0.003	0.515	0.547	0.873	0.869	0.868
Controls						
Bank FE		Y	Y	Y	Y	Y
Assets			Y	Y	Y	
Loans/Deposits			Y	Y	Y	Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

1.3.4 Estimation - international sample

Extending the analysis to the full international sample generally points into similar directions. Most of the coefficients align closer to the FTP predictions, but with greater significance, given the considerably increased sample size. There is however greater heterogeneity among countries, including in terms of monetary policy reactions, different implementations of capital and liquidity regulation, as well as other country-specific factors that might not be fully accounted for, which might induce some variation that is less obvious to interpret. It is still the case that controlling for bank fixed effects explains a significant part of the variation, with a smaller impact from loan-to-deposit ratios or asset size. These would account for different business models and funding profiles that the literature agrees are indeed important. In addition, adding capital and liquidity ratios improve R squared and are mostly in line with the predictions of the FTP methodology.

We estimate the same regression as the one estimated for the UK. Namely:

(10) $LHS = \beta_0 + \beta_{MP} MPR + \beta_C Capital + \beta_L Liqudity + \beta_{Int} CapitalLiquidty +$

Table 1.7: **Deposit spread channel - UK - non-linear effects**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: Deposit spreads							
β_{MP} : Policy Rate	0.0725	0.0689	0.102**	0.0731*	0.162	0.124	0.043
	(1.56)	(1.79)	(3.15)	(2.18)	(1.10)	(0.85)	(0.29)
Capital 2nd quart.				0.064		-0.072	-0.148
				(0.69)		(-0.35)	(-0.73)
Capital 3rd quart.				0.071		-0.060	-0.134
				(0.73)		(-0.27)	(-0.62)
Capital 4th quart.				0.187		0.288	0.205
				(1.56)		(0.51)	(0.35)
Liquidity 2nd quart.					0.043	-0.53*	-0.56*
					(0.41)	(-2.20)	(-2.40)
Liquidity 3rd quart.					0.154	-0.048	-0.158
					(1.16)	(-0.19)	(-0.66)
Liquidity 4th quart.					0.169	0.019	-0.0698
					(1.21)	(-0.07)	(-0.27)
Interactions						Not sig.	Not sig.
Observations	843	837	774	665	220	208	204
R-squared	0.003	0.515	0.547	0.497	0.864	0.884	0.892
Controls							
Bank FE		Y	Y	Y	Y	Y	Y
Assets			Y				Y
Loans/Deposits			Y				Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

$\beta_X X_{b,t} + \alpha_b + \epsilon_{b,t}$

$$(11) \quad LHS = \beta_0 + \beta_{MP} MPR + \sum_{n=2}^{4} \beta_{C,n} Q(n) Capital + \sum_{n=2}^{4} \beta_{L,n} Q(n) Liqudity +$$

$$\sum_{n=1}^{9} \beta_{Int,n} QCapitalQLiquidiy + \beta_X X_{b,t} + \alpha_b + \epsilon_{b,t}$$

where the LHS variables are in turn the cost of funds, the loan spreads and the deposit spreads.

The full results are presented in the Appendix. For instance, the results for the cost of funds estimation can be found in the Appendix in Tables 4.7 and 4.8 for the linear and non-linear specification respectively. Figure 4.1 in the Appendix also shows the regression coefficients, including the interaction terms that have been omitted in the tables due to space constraints, as well as the fact that most of them are not statistically significant.

For the cost of funds, the main results are still the same. The coefficient of the monetary policy rate is significant and around 0.4-0.5. In the linear specification, capital has a significant decreasing effect on the cost of funds through the premium, while the coefficient of liquidity is insignificant.

Some interesting insights arise, especially in terms of accounting for the non-linear effects. When taken separately capital has a decreasing and highly significant impact on the cost of funds. In isolation, the impact of liquidity is either insignificant or only slightly decreasing the cost of funds for the third quartile. In addition, the impact of capital on FTP is non-linear and moderated by the level of liquidity:

- Banks with low liquidity benefit from increased capital
- Banks with low capital pay higher rates to attract more liquidity initially
- The cost of higher liquidity dampens the benefit of higher capital

Turning to the lending spread, there is no significant impact from the policy rate (small and slightly significant coefficients decrease to 0 and/or become insignificant after accounting for regulatory ratios). Capital has a small negative effect in the linear specification as shown in Table 4.9, while liquidity or the interaction terms do not seem to matter. Turning to the non-linear effect in Table 4.10, capital has a positive effect and liquidity a negative one, but most of the coefficients become insignificant, apart from the fourth quartile of capital. Taken together, these are harder to interpret, but would point to a small decreasing effect on average from capital to lending spreads, suggesting that capital is a cost that slightly drags down on lending spreads. However, banks that hold a lot of capital seem to be able to gain a higher lending spread. All these are mostly in line with the FTP methodology which suggests that the lending spread should only be a function of market power and capital.

For deposit spreads, the results that we have observed for the UK sample become somewhat stronger. There is a small positive relationship between positive rates and deposit spreads that is now significant in all specifications, both the linear one in Table 4.11 and the non-linear one in Table 4.12. There is no connection between capital and liquidity and the deposit spread, and a small coefficient from capital quartiles becomes insignificant when also accounting for the liquidity ratio. All these are in line with the FTP methodology which suggests that the deposit spread should only be a function of market power.

1.4 Theoretical implications

1.4.1 Benchmark Model

The theoretical benchmark focuses on the banking block from Brunnermeier, Abadi, and Koby (2023). This is because their modelling framework enforces the idea that financial frictions in the form of capital and liquidity regulations introduce a wedge between monetary policy rates and the interest rates that banks charge for loans and pay for their deposits. These wedges are similar to the cost of financial regulation as implied by FTP, which is part of the banks' internal rate setting methodologies. I will then extend this framework to account for an even closer match with the FTP methodology.

On the asset side, banks extend loans L_t and purchase safe assets in the form of long-term government bonds B_t^L at the real price Q_t^B. This is funded by their net worth N_t and issuing deposits D_t. Thus, they face a budget constraint of the form:

$$L_t + Q_t^B B_t^L = N_t + D_t \qquad (BC)$$

Banks have market power in setting deposit and loan rates, as each household and bank-dependent firm is constrained to deal with a single bank. In each period, a bank sets a deposit rate i_D, a loan rate i_L and bond holdings B_t^L, taking as given the households' deposit demand $D_t(i_t^D, i_t)$, intermediate firms' demand $L_t(i_t^L)$, and the bond price Q_t^B.

We analyse the banks in a two-period banking model in partial equilibrium. That is, loan demand and deposit supply are constant, so that we can focus on the effect of monetary policy shocks and regulation on the supply of credit and demand for deposits.

Banks face two financial frictions that resemble capital and liquidity requirements.

First, bank lending is restricted by net worth, in the sense that lending is assumed to be a fraction ψ^L of net worth. $1/\psi^L$ could be he risk-weight associated with loans, which is always positive, since loans are risky. Since government bonds are assumed risk-free, they do not enter this constraint as they would have a risk-weight of 0:

$$L_t^*(i_t^L) \leq \psi^L N_t \qquad (CC)$$

Second, banks face a liquidity constraint of the form:

$$\psi^D D^*(i_t^D, i_t) \leq, Q_t^B B_t^L \qquad (LC)$$

where ψ^D is a positive number and is the proportion of deposits that are anticipated to run off. That is, this constraint is similar to the liquidity coverage ratios (LCR), that must insure that the banks have a sufficiently high liquidity buffer to cover the withdrawal of deposits over a 30-day period. The focus is on the LCR only, and not the NSFR, as LCR is more likely to interfere with the monetary policy rate, given the short-term horizon.

The bank chooses, long-term bond holdings B_t^L, as well as loan (i_t^L) and deposit rates (i_t^L) to maximise net interest income period-by-period. If loan demand and deposit supply curves are static, the net interest income in a period will depend on net worth N_t and the policy rate i_t. Taking all this into consideration, as well as the balance sheet constraint, the bank's problem becomes:

$$NII(N_t, i_t) = \max_{B_t^L, i_t^L, i_t^D} [i_t Q_t^B B_t^L + i_t^L L^*(i_t^L) - i_t^D D^*(i_t^D, i_t)]$$

subject to:

$$\begin{aligned} &L_t + Q_t^B B_t^L = N_t + D_t && (BC) \\ &\mathrm{L}_t^*(i_t^L) \leq \psi^L N_t && (CC) \\ &\psi^D D^*(i_t^D, i_t) \leq, Q_t^B B_t^L && (LC) \end{aligned}$$

The main objects of interest will be the FOC that I will match with the industry best practices for bank profitability:

$$\begin{aligned} &i_t^L = i_t + \tfrac{1}{\epsilon_t^L} + \lambda_t + \mu_t && (LR) \\ &\mathrm{i}_t^D = i_t - \tfrac{1}{\epsilon_t^D} + (1 - \psi^D)\mu_t && (DR) \end{aligned}$$

In these FOCs, ϵ_t^L and ϵ_t^D denote the semi-elasticities of loan demand and deposit supply with respect to i_t^L and i_t^D, respectively. λ_t is the Lagrange multiplier corresponding to the capital constraint and μ_t is the Lagrange multiplier corresponding to the liquidity constraint. When the constraints are slack, the two Langrange multipliers are zero. As a result, financial frictions in the form of regulatory constraints do not form a wedge between the monetary policy rate and loan and deposit rates. When the

CC binds, banks need to lend less, so the interest rate on loans increases. When the LC binds, banks need fewer deposits, as these represent potential outflows, so the deposit rate decreases proportional to the run-off coefficient ψ^D.

In Brunnermeier, Abadi, and Koby (2023) we do not get an intuition for why a binding liquidity constraint raises both the lending and deposit rate. Rearranging the terms, and thinking about FTP, this seems to be related to the cost of holding a liquid buffer. Thinking along these lines, if the liquidity constraint binds, the bank cannot currently raise more deposits, so in the budget constraint (BC) the whole right hand side is fixed, so we would need to lend less in order to allocate more funds into liquid assets. Hence, the lending rate needs to increase. This trade-off is reminiscent of the cost of holding a liquid buffer. In this sense, the first two terms of the FOC equation are equivalent to the cost of funding. So, the marginal cost of lending needs to take the liquidity constraint into account.

$$i_t^L = (i_t + \mu_t) + \frac{1}{\epsilon_t^L} + \lambda_t \qquad (LR)$$

$$\mathrm{i}_t^D = (i_t + \mu_t) - \frac{1}{\epsilon_t^D} - \psi^D \mu_t \qquad (DR)$$

Still, compared to the FTP methodology, we are missing the additional term that corresponds to the funding premium that is also part of the cost of funds. But, in order to capture that, we need to account for wholesale (money-market) funding. This is covered in the next section.

1.4.2 Extension

I expand the previous model by accounting for wholesale funding. This will modify the budget constraint, allowing banks to obtain an additional source of funding from the money markets MM_t:

$$L_t + Q_t^B B_t^L = N_t + D_t + MM_t \qquad (BCv2)$$

Money-market funding also impacts the net interest income of the bank, since we now face an additional cost on top of deposits i.e. $i_t^{MM} MM_t$. In addition to setting lending and deposit rates, the bank takes the money-market rate i_t^{MM} as given and chooses the level of funding MM_t to account for its funding needs. So the maximisation problem of the bank becomes:

$$NII(N_t, i_t) = \max_{MM_t, B_t^L, i_t^L, i_t^D} [i_t Q_t^B B_t^L + i_t^L L^*(i_t^L) - i_t^D D^*(i_t^D, i_t) - i_t^{MM} MM_t]$$

subject to:

$$L_t + Q_t^B B_t^L = N_t + D_t + MM_t \qquad (BCv2)$$
$$\mathrm{L}_t^*(i_t^L) \leq \psi^L N_t \qquad (CC)$$
$$\psi^D D^*(i_t^D, i_t) \leq, Q_t^B B_t \qquad (LC)$$

Taking FOCs again, we obtain:

$$i_t^L = (i_t^{MM} + \mu_t) + \frac{1}{\epsilon_t^L} + \lambda_t \qquad (LR)$$
$$\mathrm{i}_t^D = (i_t^{MM} + \mu_t) - \frac{1}{\epsilon_t^D} - \psi^D \mu_t \qquad (DR)$$

Essentially, the money-market rate replaces the policy rate. Either we adjust for an additional wedge between the money market rate and the policy rate, which would be a function of the capital and liquidity, or we assume a full pass-through from the monetary policy rate. Then, similar to the FTP, the lending rate, builds on a cost of funds that is linked to the bank's funding cost on the wholesale markets and the cost of holding a liquid buffer. Similarly, the deposit rate takes the cost of funds as revenue and then deducts the mark-down and any additional terms.

In this setup, the money-market rate i_t^{MM} can simply equal to the monetary policy rate i_t. However, we can move a step closer to the FTP methodology and allow i_t^{MM} to be a function of the capital and liquidity position. As counterparty credit risks assessments within banks' Treasury and Risk departments are unobservable, we can simplify the framework and simply assume a homogeneous function of degree one in total capital and LCR, in order to mimic the additional funding premium in a reduced-form way. So, the higher the capital ratio, the lower the money-market rate i_t^{MM} and the higher the LCR, the lower the money-market rate i_t^{MM}.

While the modelling approach from Brunnermeier, Abadi, and Koby (2023) is intuitive and tractable, I find that in the data regulatory constraints are less likely to bind. One alternative approach would be to model the cost of the regulatory constraints as a cost function that penalises deviations from the regulatory threshold. In this way the constraints do not need to bind to be relevant for the pricing of loans and deposits.

However, issues with buffer usability might point that in time of stress, capital and liquidity regulation can be perceived as binding even if far from the regulatory threshold. During uncertainties around the pandemic and dash-for-cash, a new issue occurred with buffer usability as pointed out in Mathur, Naylor, and Rajan (2023). Banks seemed reluctant to use their capital and liquidity buffers, even if they were far from binding, due to fear of market perceptions. That is banks' capital was perceived as a binding constraint at the onset of the pandemic faced with a prospect of lower profitability and higher credit losses, impairments, and provisioning. Similarly, banks seemed to hoard liquidity rather than trade it in money markets. So it seems that, particularly in stressed market conditions, banks treat their capital and liquidity requirements are binding, whatever the level relative to the regulatory minimum. In such a setup, taking liquidity and capital regulation into account all the time when pricing for lending and deposit rates might seem reasonable. In addition, both should be taken into account irrespective of being binding or not, due to the costs incurred, as shown by industry best practices.

1.5 Conclusions

The financial crisis of 2007-2008 led to an overhaul of banking regulation, with liquidity requirements being added to the regulatory package that followed. In addition, capital requirements have been refined and tightened. These factors overlap with a decades-old decreasing trend in nominal interest rates. Thus, assessment of bank profitability became topical, as well as the hypothesis that decreased profitability and increased regulation might reduce or reverse the impact of monetary policy.

With profitability in mind, I look at FTP, as the industry best practice in accounting for profitability at a business line level for banks. I find empirical evidence of the main channels though which policy instruments are reflected in interest rates set by commercial banks and assess the correspondence with theoretical models of financial frictions. I use panel data to estimate these channels and conclude that both monetary and macroprudential policies act mainly through the cost of funds channel. First, monetary policy rates feed into the cost of funds; there is also a positive relationship between monetary policy rates and the spreads on deposits. Second, banks with more capital pay a lower cost of funding. More liquidity has a small positive effect, as the cost of holding a liquid buffer dominates the decrease in the funding premium.

This chapter adds to the literature on how banks' liquidity and capital positions affect their lending and deposit rates. Capital and liquidity ratios, not just monetary policy rates, are relevant for the pricing of loan and deposit rates. Omitting these distorts the estimates of the pass-through of monetary policy. This also implies that prudential regulation and monetary policy should be integrated, in a bottom up approach at every step of the policy analysis.

One of the main contributions of the chapter is to show how funds transfer pricing helps disentangle the channels through which both monetary policy and prudential regulation affect rate setting behaviour. In light of this finding, policy makers can use their instruments to balance the trade-offs operating within net interest income optimisation. More specifically, monetary policy acts predominantly through banks' cost of funding. Prudential policy also acts through the banks' cost of funding, but also through lending spreads. On the other hand, loan and deposit spreads are less related to monetary policy, but there might be some non-linear effects, especially when approaching the zero lower bound. The effect of prudential regulation on spreads is less consistent and more non-linear over the sample. More research is needed in this respect.

This chapter overlaps with the literature on bank profitability. More importantly, it adds to the literature by decomposing the net interest income channel in two different channels: (i) the cost of funds channel and (ii) the loan and deposit spreads channels. Importantly, the insights from this chapter come from focusing on what banks should actually do in maximising their profit, based on industry best practices.

The theoretical benchmark I focus on starts from the banking block from Brunnermeier, Abadi, and Koby (2023). This is because their modelling framework enforces the idea that financial frictions in the form of capital and liquidity regulations introduce a wedge between monetary policy rates and the interest rates that banks charge for loans and pay for their deposits. I then suggest a simple extension that also takes into account wholesale funding. The money-market rate banks pay on wholesale markets can simply be equal to the monetary policy rate. However, we can move a step closer to the FTP methodology and allow it to be a function of capital and liquidity positions, in line with what counterparty credit risk assessments would suggest.

Chapter 2

Liquidity Regulation and Nexus between Banks and Bonds

2.1 Introduction

In response to the financial crisis of 2007-2009, the the Basel Committee on Banking Supervision (BCBS) updated its set of banking regulations, the result being Basel III. As noted by BIS (2013), despite having adequate capital levels, many banks still experienced difficulties because they did not manage liquidity in a prudent manner [1]. Thus, Basel III addresses the management of liquidity risk through measures such as the Liquidity Coverage Ratio (LCR), aimed at promoting the short-term resilience of banks' liquidity profiles through ensuring they hold an adequate stock of liquid assets to meet their liquidity needs for a 30 calendar day liquidity stress scenario.

Most empirical assessments conclude that the effect of LCR on banks' resilience has been beneficial, with a limited reduction in lending. However, the current implementation of the LCR may have unintended side effects, as I will show in this chapter. Moreover, there has been little consensus on the theory behind liquidity regulation so far. Allen and Gale (2017) point out it is not fully understood what market failure the regulation should address and why the markets choose not to provide sufficient liquidity in the first place.

I develop a theoretical model to show that one source of financial fragility is banks'

[1] As noted in BIS (2013), part of the issue was due to the fact that banks relied on markets where funding was readily available and at low cost. While this was true prior to the crisis, 2007 came with a rapid reversal in market conditions, in which liquidity evaporated quickly and illiquidity took hold for an extended period of time.

excessive government bonds holdings that interact with liquidity constraints. Favourable treatment of sovereign exposures has been acknowledged by the BIS as being a potential issue. BCBS (2018) summarises sovereign treatment throughout Basel III and invites further academic debate. However, there is still limited interest from academia in the matter. One notable contribution comes from Brunnermeier et al. (2016) who document a “diabolic loop” between sovereign and bank credit risk as the hallmark of the 2009–2012 sovereign debt crisis in the periphery of the euro area. While potential bank bailouts may be harder to implement in the current regulatory framework, the sovereign-bank nexus may be an issue moving forward for potentially different reasons, as detailed below.

This chapter builds on a simpler version of the model in Brunnermeier et al. (2016). In addition, when they are liquidity-constrained, banks that have accumulated a considerable amount of domestic sovereign bonds on their balance sheet become vulnerable to shocks affecting sovereign creditworthiness. These shocks lead to a fall in the price of bonds, which leads to mark-to-market losses that weaken banks’ balance sheets and restrict the ability to lend to the real economy. In turn, lower credit leads to lower economic growth and hence lower tax revenue for the government, weakening sovereign creditworthiness even further. The model here is similar to Brunnermeier et al. (2016) in terms of the setup, but the mechanism differs in the sense that a negative feedback loop is triggered by a shock to bond prices when liquidity constraints are in place. This could potentially amplify the previously documented diabolic loop.

This chapter proceeds as follows: Section 2.2 presents the literature review, followed by the modelling assumptions and potential extensions in Section 2.3. Section 2.4 concludes.

2.2 Literature review

Prior to the 2007-2008 financial crisis, banking regulation focused on capital requirements. The crisis unveiled new issues in our understanding more broadly, bringing further refinements of the capital regulation, but it is liquidity risk that came to the forefront of the Basel III accord. Allen and Gale (2017) point out that massive illiquidity in many markets, combined with an extreme exposure of financial institutions to liquidity risk calls for liquidity regulation indeed. However, Allen and Gale (2007) also point out that for most part of history, the development of financial regulation has been an empirical process, not necessarily driven by theory. Indeed our theoretical framework for thinking about financial regulation is still incomplete.

The aim of this chapter is to complement the existing literature, focusing on one unintended side effect of Basel III. I show a mechanism in which excessive accumulation of government bonds, as a result of favourable treatment of government exposures, leads to financial fragility. Following a repricing shock, banks face marked-to-market loses that decrease their perceived solvency and restrict their ability to lend to the real economy. This effect is amplified when faced with binding liquidity constraints that induce banks to increase their holdings of government bonds, crowding-out lending to the private sector. Lower lending, leads to lower output and thus lower tax revenue, decreasing the ability of governments to fully pay back debt. As a result, an initial shock that may just be one of confidence in sovereign creditworthiness ends up being self-fulfilling in the sense that the government defaults in some states of the world in which primary surplus is low.

Following the empirically-driven motivation for the liquidity regulation, a considerable part of the literature presents empirical findings. Even prior to the introduction of LCR, policy makers have tried to assess its impact on funding costs and corporate lending. Bonner (2012) use a similar liquidity framework computed by Dutch banks and find that, from 2008 to 2011, banks that are just above/below their quantitative liquidity requirement do not charge higher interest rates for corporate lending. They argue that banks are not able to pass on their increased funding costs in the interbank market to private sector clients, implying that banks do not have pricing power. They conclude that LCR is unlikely to have a major impact on corporate lending rates. A more recent and comprehensive assessment comes from the EBA (2017) and is based on the data submitted by banks on the LCR itself. They show that while the regulation may have a negative impact on lending before reaching the minimum requirements, highly liquid banks tend to increase the share of retail and non-financial corporate loans in their balance sheet. A similar framework to Basel III has been implemented in the US [2]. Evidence from the Fed (Roberts, Sarkar, and Shachar (2019)) highlight a trade-off between lower liquidity creation and greater resilience from liquidity regulation. Thus, financial institutions that need to comply with the LCR do lend less. However, they also find that LCR banks are more resilient as they contribute less to fire-sale risk, relative to non-LCR banks. All these are reduced-from empirical evidence. They point

[2] Whereas in Europe, the LCR is implemented for all banks, in the US the regulation applies only to banks that are considered big enough to have a significant impact on financial markets. These systemically important banks are the ones that have more than $250 billion in total consolidated assets or more than $10 billion in on-balance sheet foreign exposure.

out potential channels through which liquidity regulation may have an effect on the economy, but cannot always fully disentangle between potential explanations.

From a theoretical point of view, there is still much debate on the implications of and sometimes, even the motivation behind liquidity regulation. In terms of implication, interaction with the monetary policy transmission mechanism is most documented. Notable contributions are presented below. In terms of theoretical motivation, Allen and Gale (2017) conduct a survey paper that concludes there is no wide agreement on the rationale for liquidity regulation. I refer to some of the main ideas also.

Brunnermeier, Abadi, and Koby (2023) study the interaction between monetary policy and financial regulation. First, it introduces the idea of a reversal rate, the rate at which accommodative monetary policy becomes contractionary for lending. Second, it enforces the idea that financial frictions in the form of capital and liquidity regulations introduce a wedge between monetary policy rates and the interest rates that banks charge for loans and pay for their deposits. While their contribution is welcome in explaining the limited impact of monetary policy when hitting a lower bound, their focus is not on liquidity constraints. Still, it is noteworthy that their modelling approach mirrors empirical price-setting behaviour of banks through the *funds transfer pricing approach*. Also, it is useful because it captures both the impact of regulation and competition on pricing, such that the potential explanations from empirical studies can be balanced within the same framework. Cadamagnani, Harimohan, and Tangri (2015) summarise the process of determining interest rates within the banks' Treasury departments [3]. Similar to the bank optimisation problem in Brunnermeier, Abadi, and Koby (2023) client deposit rates are below the transfer price with a spread that reflects the banks' market power. In addition, they reflect the costs associated with raising deposits, which is linked to the liquidity constraint. Client lending rates are above the transfer price with a spread that reflects market power and credit risk. This type of literature justifies lower lending as a result of an increase in the cost of lending induced by compliance with financial regulation. Bech and Keister (2017) use a theoretical model of monetary policy implementation to document a similar regulatory premium in long-term assets that reflects each type of loan's value in satisfying the LCR regulation. However, when the LCR is in place, the overnight interest rate tends to decrease.

[3] The Treasury function "borrows" deposits raised by deposit-taking units of the bank and "lends" to loan-originating units — hence the notion of a "bank within a bank". The transfer price is the rate at which the Treasury department provides funding to the business line and is the "actual" base interest rate, which can deviate from the monetary policy rate. More explicitly, taking the transfer price as a starting point, a business line will then usually decide the rate at which to extend loans or raise deposits. So in practice, monetary policy impacts client rates through this transfer pricing rate.

This happens because banks worried about violating the liquidity regulation are more likely to seek term funding in the market. They also warn that controlling interest rates using open market operations (OMOs) may be more difficult when LCR is in place. Similarly, Berger and Bouwman (2017) examine the interplay among bank liquidity creation and financial crises and suggest that central banks should consider tools to control bank liquidity creation, such as capital and liquidity requirements, but their approach is less structural.

In addition to the interaction with monetary policy, there are also considerations involving the overlap of LCR with deposit insurance and the need for Lender of Last Resort (LOLR) interventions by the central bank. A useful reference point on the matter is a recent paper from the ECB. Hoerova et al. (2018) find that despite being beneficial, the implementation of LCR, along with the Net Stable Fudning Ratio (NSFR) is complementary to LOLR. These two liqudity regulations would have reduced banks' reliance on publicly provided liquidity during the global financial crisis, without removing such assistance altogether. In addition, they also study the costs and benefits of liqudity regulation in terms of output and conclude that output loss is small, such that overall benefits outweigh the cost. An extensive review of the LOLR can also be found in Allen and Gale (2017), although they point out that the majority of the literature in LOLR only sporadically addresses liquidity regulation as well. In terms of connection to deposit insurance, Diamond and Dybvig (2016) develop a rationale for liquidity regulation based on depositors having incomplete information about the bank's ability to survive a run. The model is an extension of the standard Diamond and Dybvig (1983) framework and they show that the implementation of liquidity regulations decreases the probability of bank runs.

In terms of identifying the market failures that call the need for liquidity regulation, prior to the financial crisis there was little interest in shaping such a theoretical framework. Bhattacharya and Gale (1987) set the building blocks for further models. In their work, individual banks face privately observed liquidity shocks and have private information about their own fraction of liquid assets. Even when there are no aggregate liquidity shock, banks have an incentive to under-invest in liquid assets. Central banks can improve the outcome, but not completely, because they can only imperfectly monitor banks' portfolios. Later, Allen and Gale (2004) show how the invisible hand leads to an efficient provision of liquidity without any intervention, but their model is assuming that financial markets are complete. In contrast to that, during the financial crisis, not only did we experience incomplete markets, but to some extent we experienced missing markets altogether. At some point, the interbank market was completely frozen. Such a complete breakdown of markets could be the result of counterparty credit risk as in Heider, Hoerova, and Holthausen (2009). In a model with asymmetric information, where banks have private information about the risk of their assets, three types of equilibria can arise: i) normal state with low interest rates; ii) turmoil state with adverse selection and elevated rates; and iii) market breakdown with liquidity hoarding. These market failures lead to an inability of interbank markets to distribute liquidity throughout the system and at some time may cease to function completely. In their model, requiring banks to hold a certain amount of liquidity can act as a coordination device and alleviate adverse selection. So, in a sense, there is some agreement on the need for liquidity regulation in the case in which markets are incomplete.

Moral hazard considerations have been also addressed. Berger and Bouwman (2017) argues the need for regulation arises because of moral hazard associated with deposit insurance and the discount window. One of the points they stress is the importance of the interaction between capital and liquidity regulation and the need for both to exist together. In terms of interactions with capital regulation, Heider, Hoerova, and Calomiris (2015) develop an interesting theory of liquidity regulation based on the substitution possibilities between liquidity and capital. They believe that it is much easier to verify the value of liquidity on a bank's balance sheet than that of other assets that contribute to its capital position. This allows liquidity regulation to supplement capital regulation in an effective way.

Lastly, Allen and Gale (2016) show that financial regulation in general and liquidity regulation in particular needs to be constructed taking into account the fact that there are incentives to innovate around it. On top of the points developed in Allen and Gale (2016), there is little transparency in what happens to the liability side of the LCR. The standards set in BIS (2013) provide very detailed specification in terms of what qualifies as a liquid asset - the high quality liquid asset (HQLA) defined by the regulation. However, there is much more freedom on the liability side. The fact that EBA (2017) documents that most of the adjustment to comply with the LCR was on the asset side may be an indication for this. In turn, the liability side remained broadly unchanged. In that respect, for instance, banks have discretion in modelling current and savings account. Because these elements do not have a contractual maturity, they generally use behavioural assumptions, i.e. modelling techniques to project future run-offs, so they may use creative techniques to underestimate outflows that count towards the LCR.

To sum up, the theoretical models that we have so far are quite simple and capture only a small part of the market failures that distort efficient liquidity provision. In my opinion, despite the beneficial effects of the LCR on banks' resilience when faced with liquidity shocks, there are potentially many loopholes, both in our understanding of how banks and financial markets interact, as well as the current banking regulation.

Therefore, this chapter shows one such unintended side effect of Basel III. I do not intend to dispute all numerical values implied by the LCR, although Allen and Gale (2017) warn that maybe market failures may not be such that the numerical values in the regulations are sensible. I do believe, however, that the current favourable treatment of sovereign exposures tends to favour an excessive accumulation of government debt. As reviewed in BCBS (2018), the favourable treatment refers to the facts that: (i) sovereign exposures are currently exempted from the large exposures framework, (ii) the risk-weighted framework includes a national discretion that allows jurisdictions to apply a 0% risk weight for sovereign exposures denominated and funded in domestic currency, regardless of their inherent risk, and (iii) there are no limits or haircuts that are applied to domestic sovereign exposures eligible as high-quality liquid assets in meeting the liquidity standards.

The model presented here rests on two key ingredients: liquidity requirements and large government exposures. While the former should remain in place, there might be a benefit in reducing the latter.

2.3 The Model

2.3.1 Baseline assumptions and solution

The model is a simplified version of the one in Brunnermeier et al. (2016). In addition banks face a liquidity constraint similar to the LCR and the aim of the paper is to trace the impact of this constraint. Moreover, as mark-to-market losses are proportional to the share of domestic sovereign bonds on their balance sheet, the bigger the share, the greater the losses, both in terms of equity and the induced lending contraction.

A high share of government bonds can be the result of the favourable treatment of sovereign exposures through all the channels mentioned in BCBS (2018). First, there is no limit to the actual holdings of domestic sovereign bonds, unlike other types of exposures that are subject to the large exposures regulation. Second, the risk-weight of domestic sovereign is 0% as opposed to any other exposure, meaning that in terms of capital requirements it is always cheaper to fund the government relative to the real economy. Third, in terms of liquidity risk, domestic government bonds have no limits or haircuts when being accounted for as liquid assets. However, taking into account the episode of market volatility from March 2020, even government bonds witnessed significant price corrections. Moving froward, government creditworthiness may be put to the test given the unprecedented spike in debt meant to alleviate the effects of the pandemic, putting downward pressure on bond prices in the future. All these point to the fact that the sovereign-bank dependence documented in this paper may be a growing concern.

Consider a simple model with four economic agents: the government, banks, households and investors in government bonds. The government faces a stochastic tax revenue, resulting in a high or low primary surplus ($\overline{S}$ and $\underline{S}$, respectively). Higher lending to the real economy, represented by households, leads to higher output, which then leads to higher tax revenue. Banks are endowed with a balance sheet structure and take the liability side as given with initial deposits D_0 and initial equity E_0. Bank equity is affected by capital gains/loses, based on their holdings of government bonds, but otherwise they cannot raise further equity or deposits in later periods. Banks' assets are adjusted to comply with a liquidity constraint, as well as any re-balancing triggered by marking-to-market of their bond portfolio. Loans granted to households are used for consumption and paying taxes. Both households and the government have a preference for higher loans, since higher loans lead to higher consumption and higher tax revenue respectively.

The choice of holding the liability side fixed is not random. It is not straightforward that LCR compliance is an asset-side policy [4]. On one hand, banks can treat liabilities as given and adjust their assets to ensure sufficient liquidity. On the other hand, they may adapt both the level and structure of liabilities to become compliant. The choice in this paper is motivated empirically, to match the results from the EBA monitoring exercise. EBA (2017) shows that between 2011 and 2016, the increase in the LCR can be attributed mainly to an increase in liquid assets. Since June 2011, banks have

[4] As per BIS (2013) the LCR builds on traditional liquidity "coverage ratio" methodologies used internally by banks to assess exposure to contingent liquidity events. The total net cash outflows for the scenario are to be calculated for 30 calendar days into the future. The standard requires that, absent a situation of financial stress, the value of the net outflows be no lower than 100% of liquid assets. Assets are assigned a percentage haircut representing the loss that would be incurred if sold during market turmoil. In particular, domestic sovereign bonds do not receive a haircut.

almost doubled their liquidity buffers. In contrast, net liquidity outflows have remained relatively stable. However good this may seem in terms of complying with the LCR, it raises concerns on a potentially harmful dependence of banks on sovereign exposures, as the shift towards liquid assets has also been one into government bonds.

The model has three dates: 0, 1 and 2. All consumption takes place in the final period. At $t = 0$ the government issues one unit of bonds at price B_0, which has a face value of $\underline{S}$. Absent of any shocks, the primary surplus is $\overline{S}$ with probability $(1 - \pi)$ and $\underline{S}$ with probability π . Let α be the share of government bonds that satisfy the banks' liquidity constraint, i.e. $\alpha B_0 = \phi_D D_0$ [5], where ϕ_D is a regulatory parameter [6]. That means that we restrict attention on the case in which the liquidity constraint binds initially. The resulting difference is granted to households as loans that satisfy the balance-sheet constraint: $L_0 = D_0 + E_0 - \alpha B_0$. The $(1 - \alpha)$ share of bonds that the banks do not need is bought by bond investors. For simplicity we assume that there is no discounting (the risk-free rate is zero) and all agents are risk-neutral.

This setup allows for multiple equilibria, two of which are interesting: there is an equilibrium in which there is no default, meaning that the government debt is repaid in full, and one in which there is default.

The first type corresponds to a world without any repricing shocks that could affect domestic government bonds. In that case, at $t = 2$, even the primary surplus from the low state ensures full repayment of the face value of debt. This type of equilibrium arises with probability $(1 - p)$.

However, if at $t = 1$ a repricing shock occurs with probability p, a second type of equilibrium unfolds as follows: at $t = 1$ an unanticipated shock occurs, maybe pessimism about the creditworthiness of the government, driving down the prices of government bonds from B_0 to B_1. This repricing of government bonds causes mark-to-market loses that drive down the value of equity from E_0 to $E_0 + \alpha(B_1 - B_0)$. Given that the liquidity constraint was binding initially with $\alpha B_0 = \phi_D D_0$ and given the that $\alpha B_1 < \alpha B_0$, the banks need to buy more government bonds (an extra share β) such that $\alpha B_1 + \beta B_1 = \alpha B_0$ and the liquidity constraint binds again. Thus, the resulting loss of equity is fully captured by a decrease in the balance of loans to households,

[5] This is a simple way of defining liquidity constraints similar to the LCR. The share of domestic sovereign bonds, deemed as high quality liquid assets, is meant to cover net outflows, that are assumed to be a faction ϕ_D of the current level of deposits.

[6] Notice that government bonds do not receive a haircut when entering the liquidity constraint. That is, when counting towards the liquidity constraint, the price of government bonds can be accounted for in full/ without a penalty.

meaning that a share ϕ of the initial loans cannot be rolled-over, leading to a loss of ϕL_0 in terms of consumption.

In equilibrium, the pessimism is justified, as the government can default in the state in which the primary surplus is low. For computational convenience, I restrict attention to the case in which default only happens when the repricing shock occurs and the primary surplus is low. So absent any shocks, in low state, the surplus is $\underline{S}$ is just enough to cover the face value of debt. However, if the shock occurs at $t = 1$, the lower loan balance leads to lower output, which in turn leads to lower tax revenue, such that the primary surplus is then $\underline{S} - \tau\phi L_0$, where τ is the tax rate. However, if the surplus is high, no default occurs, even after a repricing shock. That is $\overline{S} - \tau\phi L_0 > \underline{S}$, where the face value of debt is $\underline{S}$ (this will justify assumption A2).

This is best summarised by the diagram below:

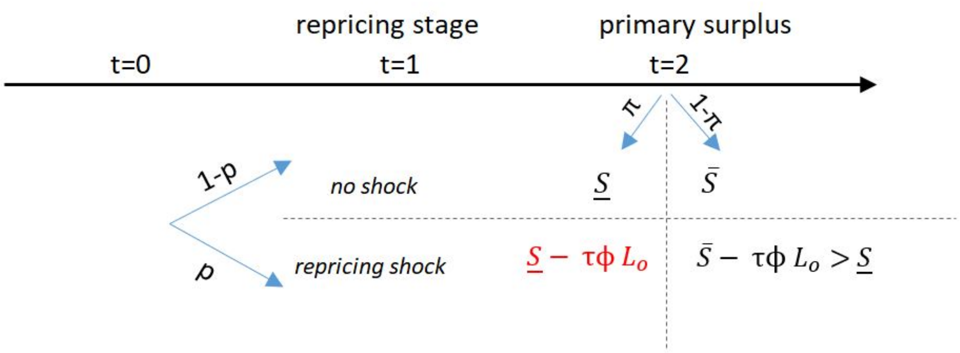


Figure 1: Types of payoffs to the government

If no shock occurs, then $B_0 = B_1 = \underline{S}$. Following a repricing shock, discounting the partial bond repayment to $t = 1$ justifies investors' pessimism in equilibrium. Thus, $\pi\tau\phi L_0$ ($p\pi\tau\phi L_0$) becomes a price discount at $t = 1$ ($t = 0$) relative to face value and is thus an endogenous cost of having to comply with the liquidity regulation.

$$B_1 = \pi(\underline{S} - \tau\phi L_0) + (1 - \pi)\underline{S} \tag{2.1}$$

$$B_1 = \underline{S} - \pi\tau\phi L_0 \tag{2.2}$$

discounting further to $t = 0$ gives:

$$B_0 = (1-p)\underline{S} + p(\underline{S} - \pi\tau\phi L_0) \tag{2.3}$$
$$B_0 = \underline{S} - p\pi\tau\phi L_0 \tag{2.4}$$

To summarise, the parametric assumptions needed for the loop to occur:

(A1) The liquidity constraint is in place at $t = 0$: $\alpha B_0 \geq \phi_D D_0$

(A2) If the surplus is high, the government can still repay the debt even after a repricing shock decreases tax revenue $\overline{S} - \underline{S} > \tau\phi L_0$

(A3) Banks are well capitalised, such that marked-to-market losses do not induce insolvency or runs on deposits $E_0 > \alpha(1-p)\pi\tau\phi L_0$

Thus, the main mechanism of the model unfolds - when liquidity constraints are in place and binding [7], worries about the ability of the government to repay debt triggers a self-enforcing loop. The fall in price of government bonds weakens banks' balance sheets thought mark-to-market losses that push down the value of equity. When liquidity constraints are binding, the re-adjustment needed to comply with the liquidity regulation reduces the ability to lend to the private sector, which in turn lowers the tax revenue and leads to default in the states in which the primary surplus is low.

The propagation mechanism is similar to Brunnermeier et al. (2016), where a sunspot equilibrium occurred at $t = 1$, leading to a similar fall in the value of government bonds. If the mark-to-market losses were high enough to bring equity into negative territory, then a similar credit crunch occurred (a fraction of loans ψL_0 could not be rolled-over), leading to government defaults in the low state. Here, equity can still be positive after the shock from $t = 1$. As long as the liquidity constraint binds at $t = 0$, mark-to-market losses and the readjustment of liquid assets from $t = 1$ are enough to result in a contraction for lending driven by the need to keep enough liquid assets on the balance sheet. Of course, this adjustment only happens if the fall in liquid assets cannot be absorbed by an increase in liabilities.

In contrast, Brunnermeier et al. (2016) need an additional layer of complexity such that a credit crunch leads to a reduction in primary surplus. Either equity needs to become negative, the assumption being that insolvent banks cannot roll-over maturing loans, or depositors need to run on banks that face a depreciation in assets, even if

[7] I analise the imapct of relaxing the contraint later.

that depreciation is not reflected in mark-to-market losses. Here instead I can focus on the case in which equity never becomes negative, so there is no need to think of bank runs and add another layer of complexity by dividing households into depositors and bank equity holders. But that means that as long as liquidity constraints bind, the loop in this paper cannot be avoided even if banks are well capitalised (this justifies assumption A3). That is the loop occurs, even if:

$$\alpha(B_1 - B_0) + E_0 > 0 <=>$$
$$\mathrm{E}_0 > -\alpha(\underline{S} - \pi\tau\phi L_0 - \underline{S} + p\pi\tau\phi L_0) <=>$$
$$\mathrm{E}_0 > \alpha(1-p)\pi\tau\phi L_0 \equiv \underline{E_0}$$

The mechanism described in this paper is similar to the real economy feedback loop in Brunnermeier et al. (2016) as presented in Figure 2. I have omitted the second feedback loop for two reasons. The first is to isolate the impact of liquidity constraints. The second, is that the regulation introduced after the financial crisis of 2007-2009 has made bail-outs less likely as central banks around the world have planned the end of too big to fail. For instance in Europe this have been triggered by the adoption of EU Bank Recovery and Resolution Directive in 2014.

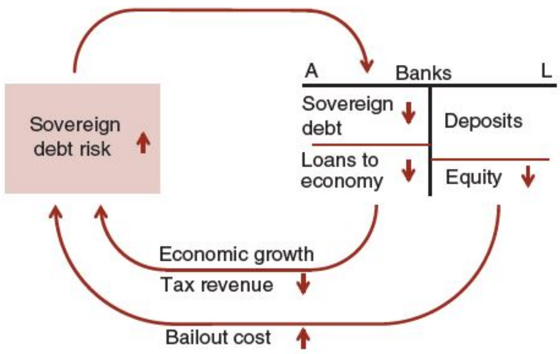


Figure 2: Two diabolic loops

source Brunnermeier et al. (2016)

As a result, as opposed to Brunnermeier et al. (2016), requiring banks to meet the minimum equity threshold $\underline{E}_0$ for a given size of their sovereign debt portfolio, does not stop the diabolic loop in this case. Here the trigger is the binding liquidity constraint. But can we do better if we start with a slack liqduity constraint at $t = 0$?

It turns out we cannot. As long as no extra capital is raised, there is no way in which this loop can be avoided without any loss in loans to the private sector. The only way to stop a loop in this setup (remember that we cannot increase the liability side) is to hold more liquid assets at $t = 0$ such that the liquidity constraint is slack: (i) either by holding more government bonds to begin with in order to compensate for mark-to-market losses: $(\alpha+\gamma)B_0 > \phi_D D_0$ and $\alpha B_0 = \phi_D D_0$ and $\gamma B_0 \geq (\alpha+\gamma)(B_1 - B_0)$ [8], or (ii) by holding other liquid assets that are not sensitive to sovereign creditworthiness, such as cash or reserves held at the central bank: $\alpha B_0 + other\_assets > \phi_D D_0$ and $\alpha B_0 = \phi_D D_0$ and $other\_assets \geq \alpha(B_1 - B_0)$. Thus, to avoid a loop at $t = 0$, less loans are issued, as the additional liquidity needs to be at least as big as $\alpha(B_1 - B_0)$. On the other hand, in the baseline scenario, when the liquidity constraint binds to begin with, the share of loans that cannot be rolled-over in period $t = 1$ is exactly equal to $\alpha(B_1 - B_0)$. This follows from the balance sheet identities. At $t = 0:$ $D_0 = \alpha B_0 + L_0 - E_0$. At $t = 1$, after re-balancing the liquidity constraint, $D_0 = \alpha B_0 + L_1 - (E_0 + \alpha(B_1 - B_0))$, where L_1 is the loan balance at $t = 1$. Thus, $L_1 = L_0 + \alpha(B_1 - B_0) = (1 - \phi L_0)$, meaning the reduction in loans is exactly equal to the mark-to-market losses.

Thus, whenever liquidity constraints are in place and no additional funding can be raised, there is no way to avoid a loss in loans to the private sector. Either we start with a slack liquidity constraint at $t = 0$, which means that the original amount of loans issued is smaller. Or, the constraint binds at $t = 0$, but that implies a re-balancing at $t = 1$ to compensate for the fall in bond prices. Thus a reduction in lending happens at $t = 1$ instead. This leads to the following proposition, which summarises this observation, along with the main mechanism of the model.

PROPOSITION: When liquidity constraints are in place, holding enough equity to remain solvent after a repricing shock affecting government bonds ($E_0 > \alpha(1 - p)\pi\tau\phi L_0$) cannot prevent a reduction in lending to the private sector. The reduction is proportional to the domestic sovereign bond holdings, assuming funding cannot increase after the shock. Even if the shock is unwarranted by fundamentals, the resulting re-balancing process triggers a self-fulfilling loop in which the government faces a partial default in states where the primary surplus is low.

Another way to look at the problem is to set aside more capital to begin with, accounting for potential capital loses driven by the bond portfolio. So, in a sense that means to assign a non-negative risk weight to domestic sovereign bonds when determining the capital requirement. Thus, given any level of bonds αB_0, an additional amount of equity (an equity buffer) could be raised at $t = 0$, such that in the event

[8]But then marked-to-market losses are bigger, since they increase proportionally with the extra share γ of bonds.

of shock this could account for the losses $\alpha(B_1 - B_0)$, where $B_1 = \omega B_0$ and ω is a haircut based on historical price volatility. Thus, given any starting amount of loans, no credit reduction will take place as long as the the equity buffer is not depleted. In addition, reducing the share of government bonds in the liquidity buffer, in favour of other assets that are not subject to price changes induced by volatility in sovereign creditworthiness, can also help to decrease the loss in lending. This is a mechanical consequence of the fact that mark-to-market losses are proportional to the share of government bonds. Imposing a haircut on domestic government bonds, as opposed to cash and central bank deposits can lead to such an outcome. Alternatively, a cap on the level of government bonds as a share of total liquid assets can also be imposed. All these measures would then alleviate the issues that arise from the favourable treatment of sovereign exposures.

Thus, even a simple and somewhat restrictive model that incorporates liquidity constraints may capture interesting effects. Namely, liquidity constraints may lead to a reduction in lending and a negative feedback loop between governments and banks, if sovereign creditworthiness shocks hit at a time when raising further funding is difficult. In a sense, we can argue this fits the behaviour documented by EBA (2017) in which between 2011-2016 a reduction in lending may have been a result of adjusting to the new LCR requirement, given that outflows were stable, while liquidity buffers almost doubled in size. Also, this could pose additional threats to financial stability, considering the current elevated levels of sovereign bonds that banks hold. On top of the favourable treatment of sovereign exposures in Basel III, a buildup of government bonds in banks balance sheets has been favoured by the long period of decreasing bond yields that generated mark-to market gains throughout the last decade. However, future shock to the creditworthiness of the governments, whether warranted by fundamental or not, could trigger a loop similar to the one presented here. In addition, an eventual reversal of the current accomodative stance of monetary policy could amplify contractionary shocks through similar mark-to-market losses (on top of the direct pass-through of higher monetary policy rates into higher lending rates).

2.3.2 Further discussion and extensions

The assumption of a flat liability structure, holding deposits D_0 and equity E_0 fixed may seem unrealistic. In fact, it seems to be the first assumption to relax in order to avoid the sovereign-bank feedback loop. If we want to maintain at least the level of loans that was issued at $t = 0$, while being able to replenish the stock of liquid assets back to αB_0, we can either raise more equity or more deposits. If the newly issued equity covers the mark-to-market losses, we do not need to face a reduction in lending. Similar results happen when raising additional deposits, but to a lower extent relative to equity, since for every unit of new deposits, a fraction ϕ_D needs to be held as liquid assets to comply with the LCR.

One further extension could refer to a different foundation for the repricing shock that happens at $t = 1$. In this chapter, the shock is similar to a sunspot equilibrium, where initially investors might become pessimistic for no fundamental reason, similar to Brunnermeier et al. (2016). Even if the shock itself does not affect the probability of ending up in a state with high primary surplus, the resulting mark-to-market losses trigger a self-fulfilling loop. Thus, as a result of the fall in equity and asset re-balancing, lower lending leads to lower tax revenue and lower surplus in the final period. One alternative could be to have an unanticipated increase in government spending. Then it would be rational to link that increase in government spending with a higher probability of default for the government. In our setup, that could mean that the probability of reaching a low surplus state increases from π to $\pi^{'}$. Thus, going back to equations (2) and (4), the cost of complying with the liquidity regulation increases to $\pi^{'}\tau\phi L_0 > \pi\tau\phi L_0$, such that the fall in prices for bonds become larger. As a result, the mark-to-market losses and the resulting credit crunch also increase. So the mechanism is similar, but the loses are greater in magnitude.

This model could also be extended to match more closely the setup from Brunnermeier et al. (2016) by considering the bail-out loop as well. On one hand, this would increase the endogenous reduction in bond prices caused by mark-to-market losses, as the government now has to bear the cost of negative equity. That is, following a repricing shock *and* bail-out, the primary surplus becomes $S - \tau(\phi + \psi)L_0 + E_0 + \alpha(B_1 - B_0)$, instead of just $S - \tau\phi L_0$, where S can either be high or low and ψ represents an additional share of loans that cannot be rolled-over whenever equity becomes negative. On the other hand, it comes with greater complexity. Strategic interaction between the government and depositors is also considered. Depositors run on insolvent banks that are not bailed-out by the government. Also, further parameter restrictions could be introduced to ensure that bailout is optimal following a repricing shock, given that the government has a preference for higher tax revenue.

Moreover, the assumption that insolvent banks cannot roll-over maturing loans fully can be modified into a constraint similar to capital constraints. If banks' equity goes below a critical level, this time positive (not zero), before inducing a credit crunch, that level could be interpreted as a minimum capital requirement.

Moving even further, the banks' problem can be fully endogenised and made to account for a more complex reaction to the liquidity shock in the intermediate period. In addition, the SVB failure showed that even in absence of a shock to government creditworthiness, mark-to-market losses can have a big impact on market and liquidity risk that might even convert into insolvency. Simply starting a rate-hike cycle after a low-for-long interest rate environment might expose banks to interest rate risk and accounting frictions might trigger fire-sales and bank failures quite suddenly. One of the issues in this case was that even selling one unit of a portfolio of HTM bonds converts the entire portfolio into one that needs to be marked-to-market, materialising all losses with immediate effect.

Thus, despite being simple, the model is very flexible in terms of accommodating further extensions. While, the ones discussed previously may seem to have small effects in this setup, we need to keep in mind these sovereign-bank loops are self-enforcing such that their effect gets compounded in time.

2.4 Conclusions

The financial crisis of 2007-2008 led to an overhaul of banking regulation, with liquidity requirements being added to the regulatory package that followed. These were driven mainly by empirical reasons, trying to prevent the massive illiquidity and lack of trust that froze many markets, including the interbank market. Also, in some sense the assessment of liquid assets was motivated by the behaviour of asset prices during the financial crisis. Particularly government bonds were deemed to be broadly risk-free, but subsequent events have showed that they are subject to market risk, as well as perceived deterioration of creditworthiness, such as that during the European sovereign debt crisis or the LDI episode.

Empirical assessments that followed reassured policy makers, to some extent, that the liquidity regulation has improved banks resilience when faced with liquidity shocks, without compromising too much on lending and economic growth. However, the debate among theorists on the role and motivation of liquidity regulation seems far from over. In addition, episodes such as the dash-for-cash during the pandemic, the LDI crisis and the failure of SVB have showed that liquidity crises can happen even in a world of abundant liquidity and that during some types of stress, only cash and central bank reserves are perceived as risk-free.

Among the theoretical models that address the market failures behind insufficient liquidity provision, there is yet little agreement. However, other models have achieved a somewhat widely accepted consensus on how the shadow cost of regulation impacts client rates, consistent also with the way that most banks set interest rates using the transfer pricing approach, as discussed in chapter 1. These advances are promising, but reveal there is much work yet to be done to fully understanding the theory behind liquidity regulation.

This chapter tries to inform the debate by pointing out an unintended effect that may decrease the beneficial impact of LCR on financial stability. It shows how liquidity-constrained banks that have accumulated an excessive amount of domestic sovereign bonds on their balance sheet become vulnerable to shocks affecting sovereign credit-worthiness. These shocks lead to a fall in the price of bonds, which leads to mark-to-market losses that weaken banks' balance sheets and restrict the ability to lend to the real economy. In turn, lower credit leads to lower economic growth and hence lower tax revenue for the government, weakening sovereign creditworthiness even further. Even if the initial shock was not related to fundamentals, mere pessimism becomes self-fulfilling when the government indeed defaults in the states of the world in which the primary surplus is low following the initial repricing shock driven by pessimism.

In addition, the SVB failure showed that even in absence of a shock to government creditworthiness, mark-to-market losses can have a big impact on market and liquidity risk that might even convert into insolvency. Simply starting a rate-hike cycle after a low-for-long interest rate environment that may have favoured an excessive reliance on government bonds might expose banks to interest rate risk and accounting frictions might trigger fire-sales and bank failures quite suddenly. Thus, looking forward as QT progresses and high interest rates linger, issues such as the ones presented in this chapter might still be relevant.

Chapter 3

An Estimation of the Reversal Rate

3.1 Introduction

A long tradition in macroeconomics has proposed the existence of a zero lower bound, but that has been highly untested on a broad scale until 2014, when negative rates became a reality for increasingly more central banks. Negative rates could in theory stimulate the economy by lowering credit spreads, but that might be limited or even reversed when deposit rates get closer to zero as seen in Figure 3.1. While there is some evidence of a pass-through into negative territory for corporate and wholesale deposits, retail deposit rates have mostly been affected by the zero lower-bound. This pushes down profitability, at a time where regulatory costs post-GFC drag profitability even lower. This begs the question of whether there is a limit to how much lending rates (and volumes) can react to expansionary monetary policy in this context. Evidence started to appear as we moved further into the low rates regimes prior to 2020, but it was not clear whether a zero lower bound would change or restrict expansionary monetary policy. In addition, some papers showed that low-for-long rates might be restrictive or less expansionary, even without hitting negative rates.

This chapter aims to test and estimate whether there is a threshold in the pass-through of monetary policy into lending and deposit rates at the zero lower bound or around it. We test this on a broad sample of countries, including the euro area, the US and other developed economies. Our bank-level data helps untangle some of the bank-specific characteristics that might be at play, as well as the relationship with capital and liquidity ratios.

We find that the variation in lending and deposit rates is linked to regulatory con-

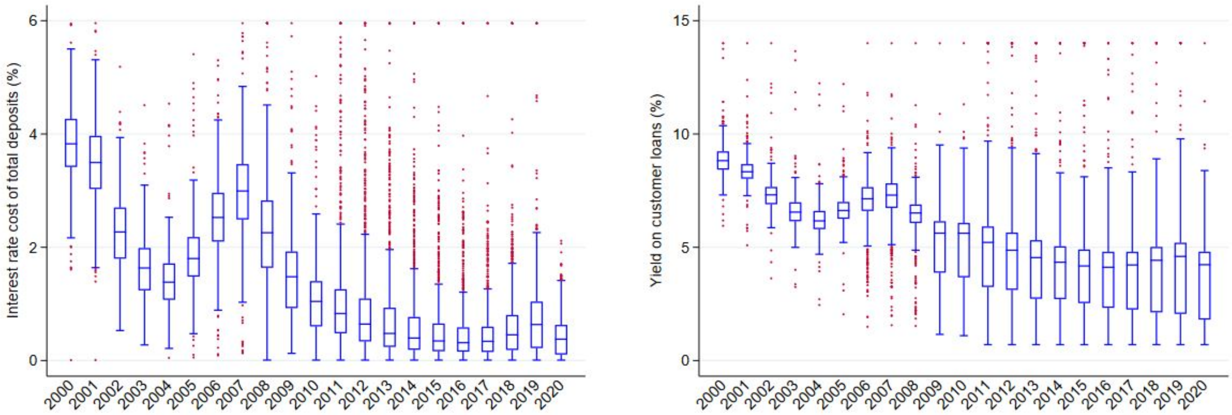
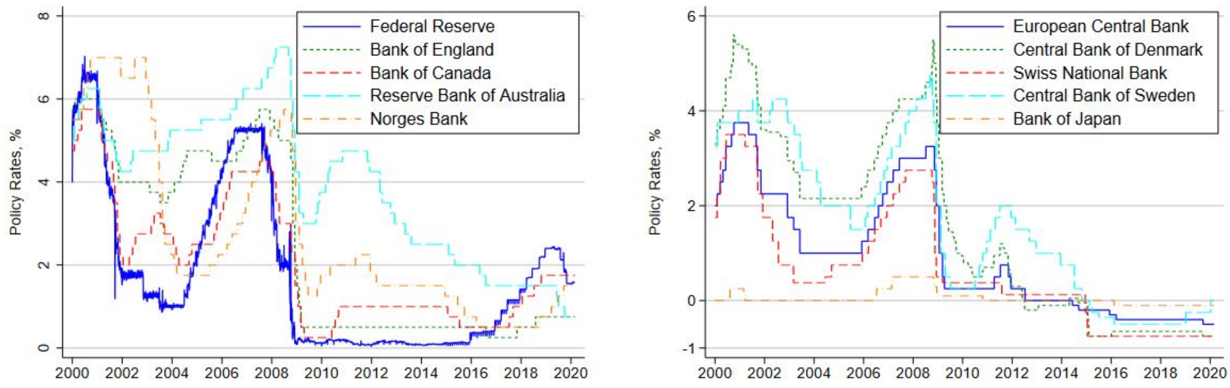


Figure 3.1: Deposit and lending interest rates across time

straints, but the impact is small. Further, we find evidence of a reversal rate, with a threshold at -0.4%. Below this threshold, the deposit rate stops responding to the policy rate, while for the lending rate, the response becomes negative, suggesting that there is evidence of a reversal rate.

Prior to 2020, interest rates have fallen steadily in most developed economies, as depicted in Figure 3.2 panel (a). This questioned the effectiveness of the bank lending channel to support lending and economic growth as interest rates approached the zero lower bound. In addition, this trend in interest rates decreased profitability for banks that rely on generating sufficiently high spreads between their return on assets and their cost of funds. Furthermore, as a response to the deep recession following the financial crisis of 2007-2009 (GFC), some central banks chose to decrease their policy rate even into the negative territory especially after 2014 as seen in Figure 3.2 panel (b). As a result, one additional concern was that profitability would be even more constrained, as deposit rates have been slow to follow central bank rates into negative territory. A growing literature has proposed that low nominal rates can reduce and even reverse an expansionary monetary policy through the profitability channel: Brunnermeier, Abadi, and Koby (2023), Ulate (2021), among others. Some papers do find that negative rates have a contractionary effect to lending or economic growth like Eggertsson et al. (2019). However, others claim that negative rates are not contractionary, due to some offsetting effects: Altavilla et al. (2019) , Demiralp, Eisenschmidt, and Vlassopoulos (2017). Further, Balloch and Koby (2020) study the effects of lower for longer interest rates, based on data from Japan.

In addition, the cost of financial regulation has also increased. In response to the GFC, the Basel Committee on Banking Supervision (BCBS) updated its set of bank-



(a) Positive rates (b) Negative rates

Figure 3.2: Policy interest rates across time and countries

ing regulations, the result being Basel III. As noted by BIS (2013), despite having adequate capital levels, many banks still experienced difficulties because they did not manage liquidity in a prudent manner.[1] Thus, Basel III addresses the management of liquidity risk through measures such as the Liquidity Coverage Ratio (LCR), aimed at promoting the short-term resilience of banks' liquidity profiles through ensuring they hold an adequate stock of liquid assets to meet their liquidity needs for a 30 calendar day liquidity stress scenario. Furthermore, capital regulation has been refined, increasing the overall quality and quantity of funds banks need to set aside. Taken together these additional regulatory constraints put even more pressure on already low interest rate margins that have been squeezed by decreasing and low-for-long interest rates, so papers that investigate the possibility of reversal rates should also take these into account.

This chapter proceeds as follows: section 3.2. goes through the literature review, which will inform our modelling approach and choice of data set, section 3.3. describes the data, section 3.4. goes through the methodology and results and section 3.5. concludes and presents some possible extensions.

[1]As noted in BIS (2013), part of the issue was due to the fact that banks relied on markets where funding was readily available and at low cost. While this was true prior to the crisis, 2007 came with a rapid reversal in market conditions, in which liquidity evaporated quickly and illiquidity took hold for an extended period of time.

3.2 Literature review

Brunnermeier, Abadi, and Koby (2023) is the foundational paper that introduces the idea of a reversal rate, the rate at which accommodative monetary policy becomes contractionary for lending. Second, it enforces the idea that financial frictions in the form of capital and liquidity regulations introduce a wedge between monetary policy rates and the interest rates that banks charge for loans and pay for their deposits. While their contribution is welcome in explaining the limited impact of monetary policy when hitting a lower bound, their focus is on binding capital constraints. Still, it is noteworthy that their modelling approach mirrors the empirical price-setting behaviour of banks through the *funds transfer pricing approach (FTP)* as defined in chapter 1. Also, it is useful because it captures both the impact of regulation and competition on pricing, such that the potential explanations from empirical studies can be balanced within the same framework.

In Brunnermeier, Abadi, and Koby (2023) existence of a reversal rate is guaranteed when, following a cut in the policy rate, the resulting capital gains are not enough to offset the fall in the net interest income of banks, which lower their profitability, thereby limiting banks' ability to lend. However, Brunnermeier, Abadi, and Koby (2023) attribute the reversal rate mainly to the effect of lower rates on bank profitability via capital constraints and choose to downplay the importance of liquidity constraints. In contrast, in this chapter we opt to also examine the role of liquidity constraints as they matter for the price-setting behaviour of banks. Related work by Repullo (2020) argues that, when the liquidity constraint binds, a fall in lending may not be related to the main mechanism in Brunnermeier, Abadi, and Koby (2023). Rather, a cut in the policy rate triggers a fall in deposits, that then results in a contraction of lending even if the equity is fixed. Further, they also abstract from the liquidity constraint and challenge the reversal rate focusing on the capital constraint only. Moreover, they argue no reversal would exist if lending is constrained by the current (exogenous) value of the bank's capital, as should be the case given how capital regulation is specified. Considering these remarks, our approach in this chapter will not dismiss the liquidity constraint. This aims to match the price-setting behaviour of banks and to assess the possible interactions between both liquidity and capital constraints.

On one hand, Eggertsson et al. (2019) empirically examine the effects of negative interest rates on Swedish banks, finding contractionary effects for lending for banks that rely heavily on deposit funding, suggesting proximity to the reversal rate. This is because retail deposit rates are subject to a lower bound and once that is met, the pass-through to lending rates and credit volumes is substantially lower and bank equity values decline in response to further policy rate cuts.

On the other hand, Altavilla et al. (2019) studied the impact of the European Central Bank's negative interest rate policy on banks, and challenged the common view that conventional monetary policy becomes ineffective at the zero lower bound. They find that sound banks pass on negative rates to their corporate depositors without facing a decrease in funding and that the pass-through becomes stronger as rates move deeper into negative territory. Further, negative rates provide stimulus to firms through the asset re-balancing channel, as firms increase investments and decrease their cash balances to avoid costs associated with holding negative balances. They argue that a zero lower bound may still exist for retail deposits, as small household deposits can be easily withdrawn and held in cash at no cost. Similarly, Demiralp, Eisenschmidt, and Vlassopoulos (2017) estimate how negative interest rate policies influence bank lending in Europe, using bank-level data to identify differential effects based on banks' funding structures. They find that banks relying heavily on deposit funding adjust their balance sheets during the negative interest period by reducing their excess liquidity to fund more loans. Investment banks mainly use their excess liquidity to scale down their need for wholesale funding while some adjustment of these banks is also done through loans. Finally, wholesale-funded banks tend to react by increasing their government bond portfolios. Relatedly, Tan (2019) finds that banks most affected by negative rates through the retail deposits channel increase their lending relative to less affected banks. The response is limited to mortgage lending, and is driven by banks with high household deposit ratios and banks with high overnight deposit ratios. Overall, net interest margins are unaffected, which implies that the volume effect is large enough to offset the adverse impact on bank profitability (at least in the short-run). However, the positive effect dissipates as negative rates persist. This suggests that although the reversal rate has not been breached, it may creep up over time as banks become more limited in their options to maintain profit margins.

Our work from this chapter is closet in terms of data and methodology to that of Ulate (2021), which studies the effect of negative rates by building a DSGE model with a calibration informed by panel-data estimations. Ulate (2021) find that negative rates are between 60 and 90 percent as effective as positive policy rates.

3.3 Data

We use three main sources for this chapter to construct a bank-level panel dataset, similar to the dataset used for chapter 1. This is aimed at providing a micro-level dataset in a consistent reporting framework, over the longest available data span to cover low or negative interest rates in a wide range of countries around the world. The coverage is similar to that in Ulate (2021). Due to availability, the data does not go as far back as 1990, but we extend the analysis to 2020 (rather than 2017), in order to get a better coverage of the period of low and negative rates.

At the bank level, our data comes from $S\&P$ Capital IQ Pro (formerly Global Market Intelligence). The data is observed at an annual frequency. Our sample starts in 2006 and ends in 2020. The data covers operating companies only, either listed or non-listed. The data is downloaded at a consolidated level. The geographical coverage spans 19 countries US, Canada, Japan, Australia and major economies in developed Europe (Austria, Belgium, Denmark, Finland, France, Germany, Italy, Luxembourg, Netherlands, Norway, Portugal, Spain, Sweden, Switzerland, UK), covering both countries that have experienced negative rates (the Euro Area, Sweden, Switzerland, Denmark and Japan), as well as countries that have comparable characteristics, but have remained in the low, but positive territory (US, UK, Canada, Norway and Australia).

In addition to bank-level data, we use policy rates collected from central banks' websites, as well as short-term interest rates from the OECD database.

The main variables are summarised below in Table 3.1. Variables are winsorised at the 0.5% and 99.5% level, except for policy and short-term rates interest rates, in order to reduce the adverse effects of outliers.

Table 3.1: **Summary statistics**

Variable	Mean	Std. Dev.	Min	Max	N
Yield on Cust. Loans	4.57	2.17	0.38	15.03	16,252
Deposit Rate	1.06	1.12	0.00	6.76	17,001
Liquidity Coverage Ratio	185.15	140.93	37.02	841.27	4,252
Total Capital Ratio	18.79	15.62	7.84	156.49	19,297
Net Cust. Loans/ Deposits	87.30	39.21	0.12	254.75	21,240
Policy interest rate	0.84	1.48	-0.75	6.67	26,835
ST interest rate	1.17	1.66	-0.78	6.97	26,562

Note: Winsorised variables at the 0.5% and 99.5% level, except for policy and ST interest rates.

We focus on the yield on customer loans and deposit rates both for non-bank customers. While this cannot help disentangle sectoral differences between retail and corporate products, it does provide a wide and uniform coverage for all the countries in our sample. In contrast, data provided by each individual central bank would provide a better sectoral coverage, but is generally available as a country-level aggregate, rather than bank-level.

We use the liquidity coverage ratio (LCR) as a measure of liquidity policy post-GFC, as its short-term focus is more likely to interfere with monetary policy pass-through compared to other measures like the net stable funding ratios. That restricts our sample effectively to post-LCR implementation when regulatory ratios enter regressions, but it does offer the benefit of a coherent liquidity measure throughout the sample. Internal liquidity ratios would also be available in $S\&P$ Capital IQ Pro, but these would correspond to bank internal liquidity metrics which might be inconsistent across banks and subject to model risk. In a sense, this differential measurement backfired during the GFC and highlighted the need for a homogeneous measure of liquidity. To capture effects of capital regulation, we use the total capital ratio, as fundamentally we see no conceptual difference in terms of capital ratios or buffers and the way they are related to loan pricing.

In addition, variables such as the loans to deposit ratio and asset size help control for the effect of different business models, as the literature suggests that the type of bank and composition of bank funding has an impact on how affected the monetary policy pass-through is. Bank fixed effects help control further for any unobserved slow-moving differences in banks' business models and funding strategies.

3.4 Methodology and results

Brunnermeier, Abadi, and Koby (2023) introduce the idea of a reversal interest rate, defined as the interest rate at which accommodative monetary policy becomes contractionary for bank lending. Its existence is guaranteed when, following a cut in the policy rate, the resulting capital gains are not enough to offset the fall in the net interest income of banks, which lower their profitability, thereby limiting banks' ability to lend. Other papers, like Ulate (2021) use several independent approaches to test for more thresholds. The first, located around 0.5% is the one after which all banks set deposit rates to zero, while bank lending still functions normally and rate decreases are still transmitted to lending rates. After further decreases, a second threshold associated with disintermediation cannot be identified from his data, but might be around –2% for advanced economies, based on model predictions. This second threshold would be the one consistent with the reversal rate from Brunnermeier, Abadi, and Koby (2023). Between 0.5% and –2%, lowering the bank rate starts affecting banks differently, based on their profitability and pricing power, so rate cuts might still be transmitted but not fully; below –2% lowering rates would be contractionary.

We use a data set very similar in terms of geographical coverage to that of Ulate (2021), but our data provider is different and our sample is longer, increasing the probability of identifying a threshold in the data that indeed corresponds to the disintermediation, mimicking the reversal rate as defined by Brunnermeier, Abadi, and Koby (2023) .

The regressions that we use to test for the threshold have the following form:

(1) $i^D_{b,t} = \beta_1 i_{c,t} + \beta_2 \left(i_{c,t} - \bar{\imath}\right) 1(i_{c,t} \geq \bar{\imath}) + \beta_3 1(i_{c,t} \geq \bar{\imath}) + \beta_4 TightCapConstr_{b,t} TightLiqConstr_{b}$
$\beta_5 TightCapConstr_{b,t} + \beta_6 TightLiqConstr_{b,t} + \beta_7 X_{b,t} + \gamma_t + \alpha_b + \epsilon_{b,t}$

(2) $\mathrm{i}^L_{b,t} = \beta_1 i_{c,t} + \beta_2 \left(i_{c,t} - \bar{\imath}\right) 1(i_{c,t} \geq \bar{\imath}) + \beta_3 1(i_{c,t} \geq \bar{\imath}) + \beta_4 TightCapConstr_{b,t} TightLiqConstr$
$\beta_5 TightCapConstr_{b,t} + \beta_6 TightLiqConstr_{b,t} + \beta_7 X_{b,t} + \gamma_t + \alpha_b + \epsilon_{b,t}$

Where $i^D_{b,t}$ and $i^L_{b,t}$ are the deposit and lending rates, respectively, for bank b and time t, $i_{c,t}$ is the monetary policy rate in country c at time t. The dummy $1(i_{c,t} \geq \bar{\imath})$ is an indicator of whether the policy rate is above the threshold $\bar{\imath}$; the effect of the policy rate on lending and deposit rates is thus allowed to have a different magnitude above and below the threshold. $Tight_{b,t}$ is the tightness of either the capital or liquidity the constraint relative to regulatory cutoff. To account for different business models and funding structures, we use bank-specific time varying controls $X_{b,t}$ in the form of asset size and loan to deposit ratios. Further, bank fixed effects α_b control for any other business model or strategies that might be unobservable, but slow-moving, while γ_t are time fixed effects.

The coefficient on the policy rate, β_1, measures the slope below the threshold. β_2 the coefficient on $1(i_{c,t} \geq \bar{\imath})$ measures the difference in slope between the portion below and above the threshold.Thus, the sum $\beta_1 + \beta_2$ measures the slope above the threshold.

We run these regressions for values of the threshold between -0.5% and 0.5% and pick the specification that minimises the RMSE. This leads to a threshold of -0.4% for both lending and deposit rates. Ideally, we should be able to run a more rigorous identification of the threshold, using panel-threshold methods. However, these methods usually require a balanced panel, which would have restricted our sample size, especially due to low availability of lending and deposit rates. Thus, we continue with the grid search using an unbalaned panel.

Table 3.2 shows the results of the regressions for the lending rate. Above the threshold, the pass-through from the policy rate is positive and significant ranging from +0.31 to +0.34, similar in magnitude to the results from Ulate (2021) (+0.42), who does not control for regulatory ratios and uses a shorter sample. Below the threshold, either it changes sign, in column (4), without taking into account the regulatory constraints, or it does not react significantly, if we take into account the regulatory constraints (column (5)). This is different to Ulate (2021) who finds that the coefficient remains positive and significant. This might be due to a different sample size, as our sample includes 3 additional year in which policy rates continued to fall, or slightly different coverage in terms of entities, since we are using different data providers. In terms of regulatory constraints, only the tightness of the capital constraint matters for lending (similar to chapter 1 where only capital constraints should matter for loan pricing).

Table 3.3 delivers the results of the regressions for the deposit rate. The threshold is still identified at -0.4%, but the coefficients are less significant in comparison with those for lending. Above the threshold, the pass-through from the policy rate is positive and significant, ranging from +0.37 to +0.39, in line with the estimations from Ulate (2021), who finds a sensitivity of +0.44. Below, the threshold the deposit rate stops reacting to the policy rate, similar to the results from Ulate (2021). The effects from the regulatory constraints are not significant for the deposit rates.

Given that we do not work with exogenous variation in policy rates, these results are simply correlations that hold in the data and have the interpretation of general equilibrium outcomes that would hold in a theoretical model. Still, they can be informative of some of the mechanisms that operate in the real world and have been documented by the literature.

The results pertaining to deposit rates are broadly in line with the literature. It is interesting however, that the threshold falls below zero. This may be because we cannot disentangle between rates offered to households, which have been kept positive in most cases, albeit very close to zero, and corporate deposit rates, for which pass-through has

Table 3.2: **Pricing lending rates - threshold estimation**

	(1)	(2)	(3)	(4)	(5)
Dependent variable: Lending Rate; Threshold = -0.4 (grid search)					
β_1 :Policy Rate	0.33***			-1.81***	-1.29
	(11.70)			(-4.81)	(-1.79)
β_2 :(Policy Rate - Th) x $1(PolicyRate \geq Th)$		0.35***		2.15***	1.6*
		(12.3)		(5.71)	(2.21)
β_3 : $1(PolicyRate \geq Th)$			0.43***	0.20***	0.25*
			(4.61)	(2.00)	(2.51)
β_4 :Tight_CAP x Tight_LIQ					-0.00
					(-0.32)
β_5 :Tight_CAP					-0.012*
					(-2.12)
β_6 :Tight_LIQ					0.00
					(1.78)
$\beta_1 + \beta_2$				0.341***	0.314***
				(10.98)	(6.18)
Observations	15,359	15,359	16,212	15,359	2,528
R-squared	0.91	0.91	0.89	0.91	0.94
Controls					
Year FE	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y
Assets	Y	Y	Y	Y	Y
Loans/Deposits	Y	Y	Y	Y	Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

continued somewhat into the negative territory.

For lending rates, the literature has more mixed findings. Most papers agree that above a certain threshold pass-through from monetary policy remains unchanged. Actual results differ from sample to sample, and we attribute our findings in part due to a broader coverage of periods with negative and more persistent lower policy rates. However, we are among the few papers that document a true reversal rate, similar to the original proposal of Brunnermeier, Abadi, and Koby (2023). Some papers that document just a partial reduction of the effectiveness of expansionary monetary policy into negative rates, such as Ulate (2021) claim that that the overall effect is a combination of two different channels. On the one hand, falling policy rates push lending rates downwards. This is the classic bank lending channel. On the other hand, upward pressures come from the net worth channel. When profitability goes down, as deposit

Table 3.3: **Pricing deposit rates - threshold estimation**

	(1)	(2)	(3)	(4)	(5)
Dependent variable: Deposit Rate; Threshold = -0.4 (grid search)					
β_1 : Policy Rate	0.37***			-0.61	-0.38
	(10.16)			(-1.53)	(-1.24)
β_2 : (Policy Rate - Th) x $1(PolicyRate \geq Th)$		0.37***		0.98*	0.77*
		(10.14)		(2.48)	(2.44)
β_3 : $1(PolicyRate \geq Th)$			0.44***	0.03	0.11*
			(6.09)	(0.26)	(2.30)
β_4 : Tight_CAP x Tight_LIQ					0.00
					(0.08)
β_5 : Tight_CAP					-0.00
					(-0.08)
β_6 : Tight_LIQ					0.00
					(1.34)
$\beta_1 + \beta_2$				0.37***	0.39***
				(8.09)	(11.85)
Observations	16,078	16,078	16,974	16,078	2,363
R-squared	0.86	0.86	0.82	0.86	0.92
Controls					
Year FE	Y	Y	Y	Y	Y
Bank FE	Y	Y	Y	Y	Y
Assets	Y	Y	Y	Y	Y
Loans/Deposits	Y	Y	Y	Y	Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

spreads decrease, this leads to a decline in bank equity creating upward pressure on the lending rate. He argues that the efficiency of nominal negative rates is linked to the importance of bank equity in the economy, which differs across countries. We question whether this is also true for time variation and whether our results are also driven by the fact that our sample captures a more extended period of low or negative monetary policy rates, compared to other papers.

3.5 Conclusion

Decades of falling interest rates prior to 2020 questioned the effectiveness of the bank lending channel to support lending and economic growth as interest rates approached the zero lower bound and squeezed banks' interest rate margins. Further pressures on profitability rose with the overhaul of bank capital and liquidity regulation, following the Great Financial Crisis. In light of these the idea of a reversal interest rate, appeared as the interest rate at which accommodative monetary policy becomes contractionary for bank lending, as the traditional bank lending channel came under pressure of opposing effects from banks' net worth channel.

As a result, the main contribution of this chapter comes from the fact that we test for a threshold in policy rates, under which the reaction of client rates to the monetary policy rate changes. We show that the pass-through from monetary policy to lending and deposit rates decreases with the value of interest rates. In contrast to Ulate (2021), we find evidence of a single threshold, but in our case the threshold is negative, that is -0.4%. Below this threshold, deposit rates stop responding to the monetary policy rate [2], while the sensitivity of lending rates to the policy rate changes sign, becoming negative. The fact that the sensitivity of the lending rate to the monetary policy rate becomes negative is an indication that this is the disintermediation threshold, which is closer to the original idea of the reversal interest rate.

The results pertaining to deposit rates are broadly in line with the literature. It is interesting however, that the threshold falls below zero. This may be because we cannot disentangle between rates offered to households, which have been kept positive in most cases, albeit very close to zero, and corporate deposit rates, for which pass-through has continued somewhat into the negative territory.

For lending rates, the literature has more mixed findings. Most papers agree that above a certain threshold pass-through from monetary policy remains unchanged, but there is no consensus on whether lending is affected below that threshold. Actual results differ from sample to sample, and we attribute our findings in part due to a broader coverage of periods with negative and more persistent lower policy rates. However, we are among the few papers that document a true reversal rate, similar to the original proposal of Brunnermeier, Abadi, and Koby (2023).

Although another extended period of low or negative policy rates seems further away, following the protracted inflationary shocks that hit after 2020, further work might be needed in this area. First, it is unclear that the secular decline in interest rates is over. Second, after such a long period of low deposit rates it remains unclear if the pass-through of monetary policy rates into deposit rates has been affected for the longer-term, as early evidence from the most recent rate hiking cycle suggests an

[2] In Ulate (2021) this threshold is 0.5%.

incomplete response of deposits. Finally, as interest rates go up again, it would be interesting to know what other effects of the low-for-long era are yet to materialise, including in terms of impact on financial stability. These might offset partly the beneficial effects that low interest rates had on lending so far, or might surface some of the effects of yield seeking behaviour.

Chapter 4

Appendix to Bank Profitability and Funds Transfer Pricing

4.1 Data description

Table 4.1: **Summary statistics - international sample**

Variable	Mean	Std. Dev.	Min	Max	N
Yield on Cust. Loans	4.57	2.17	0.38	15.03	16,252
Deposit Rate	1.06	1.12	0.00	6.76	17,001
Cost of Funds	1.62	1.37	0.01	6.32	17,202
Liquidity Coverage Ratio	185.15	140.93	37.02	841.27	4,252
Total Capital Ratio	18.79	15.62	7.84	156.49	19,297
Policy interest rate	0.84	1.48	-0.75	6.67	26,835
ST interest rate	1.17	1.66	-0.78	6.97	26,562

Note: Winsorised variables at the 0.5% and 99.5% level, except for policy and ST interest rates.

Table 4.2: **List of variables**

Variable	Description
Yield on Customer Loans	Return earned on customers loans, expressed as percent
Deposit Rate	Interest incurred on deposits as a percent of average deposits
Cost of funds	Interest incurred on liabilities as a percent of average non-interest-bearing deposits and interest-bearing liabilities
Liquidity Coverage Ratio (LCR)	High quality liquid assets as a percent of net cash outflows over a 30-day period as defined by local regulatory requirements
Total Capital Ratio	Total capital ratio as defined by the latest regulatory and supervisory guidelines. For US institutions, this will be transitional when applicable, and the lesser of the standardised and advanced approaches For non-US institutions, this may be transitional or fully loaded, depending on availability
Net Customer Loans / Deposits	Net customer loans as a percent of deposits
Total Assets	All assets owned by the company as of the date indicated , as carried on the balance sheet and defined under the indicated accounting principles

4.2 Wedges driven by regulatory constraints into the traditional lending and deposit channels

For comparability across other studies on the pass-though of monetary policy rates, I also study the correlation between the policy rates, as well as that of the capital and liquidity constraints and the lending and deposit rates. In contrast, Chapter 1 shifts this approach into decomposing the channel in two different parts: (i) first into the cost of funds, (ii) into lending and deposit spreads separately. However, this may also provide a benchmark against my main results.

The linear specifications are the following:

$$(1) \quad i_{loans} = \beta_0 + \beta_{MP} MPR + \beta_C Capital + \beta_L Liqudity + \beta_{Int} Capital Liquidity + \beta_X X_{b,t} + \alpha_b + \epsilon_{b,t}$$

$$(2) \quad i_{deposits} = \beta_0 + \beta_{MP} MPR + \beta_C Capital + \beta_L Liqudity + \beta_{Int} Capital Liquidity + \beta_X X_{b,t} + \alpha_b + \epsilon_{b,t}$$

where: b indexes banks, t is the time subscript, MPR is the policy rate, $Capital$ is the risk-weighted capital ratio and $Liqudity$ is the LCR, $X_{b,t}$ are bank-specific time-varying controls and α_b time-invariant bank-specific fixed-effects.

One thing to notice from the results in Table 4.3 is that, despite the fact that coefficients for capital and liquidity are not significant in the linear case, accounting for

Table 4.3: **Traditional lending channel - UK**

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Yield on customer loans						
β_{MP} : Policy Rate	0.354**	0.625***	0.659***	0.966*	0.947*	0.753
	(2.94)	(8.67)	(10.3)	(2.14)	(2.12)	(1.71)
β_C : Capital				-0.0308	-0.0346	-0.0183
				(-1.41)	(-1.95)	(-1.13)
β_L : Liquidity				0.0005	0.0003	0.0005
				(0.51)	(0.41)	(0.60)
β_{Int} : Capital x Liquidity				-0.0000		
				(0.30)		
Observations	860	853	772	205	205	205
R-squared	0.01	0.751	0.80	0.882	0.882	0.878
Controls						
Bank FE		Y	Y	Y	Y	Y
Assets				Y	Y	
Loans/Deposits			Y	Y	Y	Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

them does change the coefficient on the monetary policy rate considerably. Omitting the regulatory ratios thus seem to distort the pass-through of monetary policy. Also, either the linear specification biases the impact of capital and liquidity towards zero, or there might be some factors that work in different ways and simply cancel each other out. So, one way forward is to look at non-linear effects, but also be mindful of the split between the cost of funds and loan spreads, just as we accounted for in the main body of chapter 1.

Moving to the non-linear specification, I estimate:

$$(3) \quad i_{loans} = \beta_0 + \beta_{MP} MPR + \sum_{n=2}^{4} \beta_{C,n} Q(n) Capital + \sum_{n=2}^{4} \beta_{L,n} Q(n) Liqudity +$$

$$\sum_{n=1}^{9} \beta_{Int,n} QCapitalQLiquidiy + \beta_X X_{b,t} + \alpha_b + \epsilon b, t$$

When accounting for non-linear effects as showed in Table 4.4, it seems that moving above the median in terms of capital seems to decrease the lending rate, for the banks that have the lowest level of liquidity. However, in light with the main results of chapter 1, this seems to matter for the cost of funds and less so for lending rates. That means

Table 4.4: **Traditional lending channel - UK - non-linear effects**

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Yield on customer loans						
β_{MP} : Policy Rate	-0.354**	0.625***	0.659***	0.585***	0.679	1.147*
	(2.94)	(8.67)	(10.13)	(8.59)	(1.58)	(2.54)
Capital 2nd quart.				-0.190		0.581
				(-1.08)		(0.99)
Capital 3rd quart.				-0.553**		-0.00319
				(-2.86)		(-0.01)
Capital 4th quart.				-0.820***		0.319
				(-3.41)		(0.27)
Liquidity 2nd quart.					0.0517	0.515
					(0.17)	(0.73)
Liquidity 3rd quart.					-0.0123	0.501
					(-0.03)	(0.69)
Liquidity 4th quart.					0.102	0.411
					(0.25)	(0.51)
Interactions						Not signif.
Observations	860	853	772	698	225	205
R-squared	0.01	0.751	0.800	0.800	0.887	0.889
Controls						
Bank FE		Y	Y	Y	Y	Y
Assets						
Loans/Deposits			Y		Y	

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

that the main channel is that of the additional funding premium, while capital charges and expected loss play a smaller role.

Moving to deposit rates, I start from the linear specification as usual:

(4) $i_{deposits} = \beta_0 + \beta_{MP} MPR + \beta_C Capital + \beta_L Liqudity + \beta_{Int} CapitalLiquidity + \beta_X X_{b,t} + \alpha_b + \epsilon b, t$

In the case of deposit rates as shown in Table 4.5, the change in the coefficient corresponding to the monetary policy varies less when accounting for capital and liquidity ratios. In the linear specification, none of the coefficients corresponding to the capital and liquidity ratios are significant.

Table 4.5: **Traditional deposit channel - UK**

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Interest rate on deposits						
β_{MP} : Policy Rate	0.451***	0.469***	0.430***	0.428*	0.398*	0.381
	(8.49)	(11.40)	(12.37)	(2.30)	(2.16)	(2.10)
β_C : Capital				-0.0008	-0.0057	-0.0054
				(-0.11)	(-0.98)	(-0.93)
β_L : Liquidity				0.0002	-0.0001	0.0001
				(0.44)	(-0.31)	(-0.22)
β_{Int} : Capital x Liquidity				-0.0000		
				(-1.04)		
Observations	902	896	826	210	210	210
R-squared	0.074	0.61	0.695	0.872	0.871	0.871
Controls						
Bank FE		Y	Y	Y	Y	Y
Assets				Y	Y	
Loans/Deposits			Y	Y	Y	Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

Moving to the non-linear setup, I estimate:

(5) $i_{deposits} = \beta_0 + \beta_{MP} MPR + \sum_{n=2}^{4} \beta_{C,n} Q(n) Capital + \sum_{n=2}^{4} \beta_{L,n} Q(n) Liqudity +$

$\sum_{n=1}^{9} \beta_{Int,n} QCapitalQLiquidiy + \beta_X X_{b,t} + \alpha_b + \epsilon b, t$

Table 4.6: **Traditional deposit channel - UK - non-linear effects**

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Interest rate on deposits						
β_{MP} : Policy Rate	0.451**	0.469***	0.430***	0.448***	0.358	0.515**
	(8.49)	(11.40)	(12.37)	(11.73)	(1.97)	(2.81)
Capital 2nd quart.				-0.124		0.229
				(-1.24)		(0.91)
Capital 3rd quart.				-0.323**		-0.0611
				(-2.98)		(-0.23)
Capital 4th quart.				-0.465***		-0.615
				(-3.46)		(-0.89)
Liquidity 2nd quart.					-0.0253	0.498
					(-0.20)	(1.68)
Liquidity 3rd quart.					-0.122	0.301
					(-0.75)	(0.98)
Liquidity 4th quart.					-0.174	-0.0203
					(-1.01)	(-0.06)
Interactions					when both Q2: -0.891**	
					Not signif. otherwise	
Observations	902	896	826	706	227	205
R-squared	0.074	0.61	0.695	0.652	0.865	0.890
Controls						
Bank FE		Y	Y	Y	Y	Y
Assets						
Loans/Deposits			Y		Y	

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

Similar to the linear case, as seen in Table 4.6, the coefficient on the monetary policy rates changes less, compared to the case of the lending rate. Still, it is increasing when accounting for prudential regulation.

However, a few interesting aspects emerge. First, we would expect the liquidity ratios to impact deposit rates, not capital ratios. This is when the insight form the FTP matters.

First, the fact that capital is important makes more sense from the perspective of the cost of funds channel. Higher capital reduces deposit rates, when we move from the second to the third quartile (while still being in the lowest liquidity quartile in both cases). This also holds when moving from the first quartile to the fourth in terms of capital, while the liquidity is in the lowest quatiles for both cases.

Second, we would expect liquidity ratios to matter for deposit rates. The fact that the effect is not significant might be related to the different channels that offset each other: on the one hand, higher liquidity ensures a lower funding premium, but on the other hand, it increases the cost of holding a liquid buffer.

4.3 International sample

Table 4.7: **Cost of funds channel - full sample**

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Cost of funds						
β_{MP} : Policy Rate	0.498***	0.515***	0.474***	0.424***	0.424***	0.451***
	(87.64)	(124.40)	(120.08)	(46.95)	(46.96)	(49.15)
β_C : Capital				-0.0093***	-0.0088***	-0.0061***
				(-4.94)	(-5.82)	(-3.87)
β_L : Liquidity				0.0000	0.0000	0.0000
				(0.06)	(0.42)	(0.13)
β_{Int} : Capital x Liquidity				0.0000		
				(0.34)		
Observations	17,058	17,022	15,938	3404	3404	3404
R-squared	0.311	0.783	0.800	0.847	0.847	0.835
Controls						
Bank FE		Y	Y	Y	Y	Y
Assets			Y	Y	Y	
Loans/Deposits			Y	Y	Y	Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

Table 4.8: **Cost of funds channel - full sample - non-linear effects**

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Cost of funds						
β_{MP} : Policy Rate	0.498***	0.515***	0.474**	0.479***	0.454***	0.407***
	(87.64)	(124.40)	(120.08)	(115.68)	(48.32)	(42.81)
Capital 2nd quart.				-0.293***		-0.0381
				(-17.38)		(-0.73)
Capital 3rd quart.				-0.397***		-0.0541
				(-20.72)		(-0.95)
Capital 4th quart.				-0.531***		-0.256**
				(-22.98)		(-2.98)
Liquidity 2nd quart.					0.0664	0.291***
					(1.81)	(4.70)
Liquidity 3rd quart.					-0.084*	0.220**
					(-2.04)	(2.65)
Liquidity 4th quart.					-0.0407	0.176
					(-0.88)	(1.56)
Interactions						Negative**
Observations	17,058	17,022	15,938	15,134	3,663	3,404
R-squared	0.311	0.783	0.800	0.806	0.837	0.853
Controls						
Bank FE		Y	Y	Y	Y	Y
Assets			Y			Y
Loans/Deposits			Y			Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

	(1)		(2)
Dependent variable: Cost of funds - full sample			
β0: Constant	**4.616*** **	**β8: Q2 Capital*Q2 Liquidity**	**-0.247*** **
	(16.53)		(-3.50)
β1: Policy Rate	**0.407*** **	**β9: Q2 Capital*Q3 Liquidity**	**-0.234** **
	(42.81)		(-2.72)
β2: Q2 Capital	-0.0381	β10: Q2 Capital*Q4 Liquidity	-0.0999
	(-0.73)		(-0.88)
β3: Q3 Capital	-0.0541	**β11: Q3 Capital*Q2 Liquidity**	**-0.323*** **
	(-0.95)		(-4.31)
β4: Q4 Capital	**-0.256** **	**β12: Q3 Capital*Q3 Liquidity**	**-0.353*** **
	(-2.98)		(-3.98)
β5: Q2 Liquidity	**0.291*** **	**β13: Q3 Capital*Q4 Liquidity**	**-0.273* **
	(4.70)		(-2.36)
β6: Q3 Liquidity	**0.220** **	**β14: Q4 Capital*Q2 Liquidity**	**-0.276** **
	(2.65)		(-2.84)
β7: Q4 Liquidity	0.176	**β15: Q4 Capital*Q3 Liquidity**	**-0.299** **
	(1.56)		(-2.75)
Interaction terms	**neg** **	**β16: Q4 Capital*Q4 Liquidity**	**-0.177**
			(-1.34)
Observations	3404		
Adj R-squared	0.853		
Controls			
Year FE			
Bank FE	Y		
Assets	Y		
Loans/Deposits	Y		

Figure 4.1: Interaction terms

Table 4.9: **Loan spread channel - full sample**

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Loan spreads						
β_{MP} : Policy Rate	0.279***	-0.009	-0.000	0.009	0.009	0.021
	(22.39)	(-1.47)	(-0.09)	(0.60)	(0.59)	(1.46)
β_C : Capital				-0.0167***	-0.0147***	-0.0134***
				(-4.46)	(-4.95)	(-4.50)
β_L : Liquidity				0.000	0.000	0.000
				(0.99)	(2.22)	(2.17)
β_{Int} : Capital x Liquidity				0.0000		
				(0.60)		
Observations	12756	12660	12037	2443	2443	2443
R-squared	0.038	0.862	0.871	0.929	0.929	0.928
Controls						
Bank FE		Y	Y	Y	Y	Y
Assets			Y	Y	Y	
Loans/Deposits			Y	Y	Y	Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

Table 4.10: **Loan spread channel - full sample - non-linear effects**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: Loan spreads							
β_{MP} : Policy Rate	0.279***	-0.009	-0.000	0.006	0.0294*	0.021	0.019
	(22.39)	(-1.47)	(-0.09)	(0.92)	(2.00)	(1.34)	(1.19)
Capital 2nd quart.				0.013		0.050	0.054
				(0.52)		(0.57)	(0.62)
Capital 3rd quart.				0.134***		0.056	0.043
				(4.55)		(0.60)	(0.45)
Capital 4th quart.				0.216***		0.474***	0.440***
				(5.87)		(3.33)	(3.06)
Liquidity 2nd quart.					-0.264***	-0.151	-0.098
					(-4.48)	(-1.44)	(-0.93)
Liquidity 3rd quart.					-0.303***	-0.056	-0.016
					(-4.33)	(-0.39)	(-0.12)
Liquidity 4th quart.					-0.366***	-0.0872	-0.040
					(-4.58)	(-0.43)	(-0.20)
Interactions						Not sig.	Not sig.
Observations	12756	12660	12037	11625	2592	2538	2443
R-squared	0.038	0.862	0.871	0.870	0.930	0.930	0.929
Controls							
Bank FE		Y	Y	Y	Y	Y	Y
Assets			Y				Y
Loans/Deposits			Y				Y

t-statistics in parentheses

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

Errors are clustered at country and year level

Table 4.11: **Deposit spread channel - full sample**

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable: Deposit spreads						
β_{MP} : Policy Rate	0.0340***	0.0353***	0.0353***	0.0209***	0.0212***	0.0228**
	(7.71)	(11.10)	(13.01)	(4.22)	(4.28)	(4.72)
β_C : Capital				0.00223	0.00107	0.00123
				(1.89)	(1.09)	(1.27)
β_L : Liquidity				0.000	-0.000	-0.000
				(0.53)	(-0.90)	(-0.87)
β_{Int} : Capital x Liquidity				-0.0000		
				(-1.76)		
Observations	13289	13242	12806	2272	2272	2272
R-squared	0.004	0.683	0.656	0.812	0.812	0.812
Controls						
Bank FE		Y	Y	Y	Y	Y
Assets			Y	Y	Y	
Loans/Deposits			Y	Y	Y	Y

t-statistics in parentheses
* p<0.05, ** p<0.01, *** p<0.001
Errors are clustered at country and year level

Table 4.12: **Deposit spread channel - full sample - non-linear effects**

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Dependent variable: Deposit spreads							
β_{MP} : Policy Rate	0.034***	0.035***	0.035***	0.029***	0.019***	0.019***	0.018***
	(7.71)	(11.10)	(13.01)	(10.08)	(3.54)	(3.24)	(3.45)
Capital 2nd quart.				-0.042***		-0.008	-0.009
				(-3.50)		(-0.26)	(-0.31)
Capital 3rd quart.				-0.066***		-0.015	-0.019
				(-4.70)		(-0.43)	(-0.59)
Capital 4th quart.				-0.073***		-0.037	-0.058
				(-4.10)		(-0.64)	(-1.09)
Liquidity 2nd quart.					0.024	0.027	0.040
					(1.04)	(0.71)	(1.16)
Liquidity 3rd quart.					0.004	-0.014	0.012
					(0.14)	(-0.25)	(0.24)
Liquidity 4th quart.					0.016	-0.009	0.016
					(0.50)	(-0.11)	(0.21)
Interactions						Not sig.	Not sig.
Observations	13289	13242	12086	12048	2404	2343	2272
R-squared	0.004	0.683	0.656	0.679	0.870	0.874	0.814
Controls							
Bank FE		Y	Y	Y	Y	Y	Y
Assets			Y				Y
Loans/Deposits			Y				Y

t-statistics in parentheses

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

Errors are clustered at country and year level

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