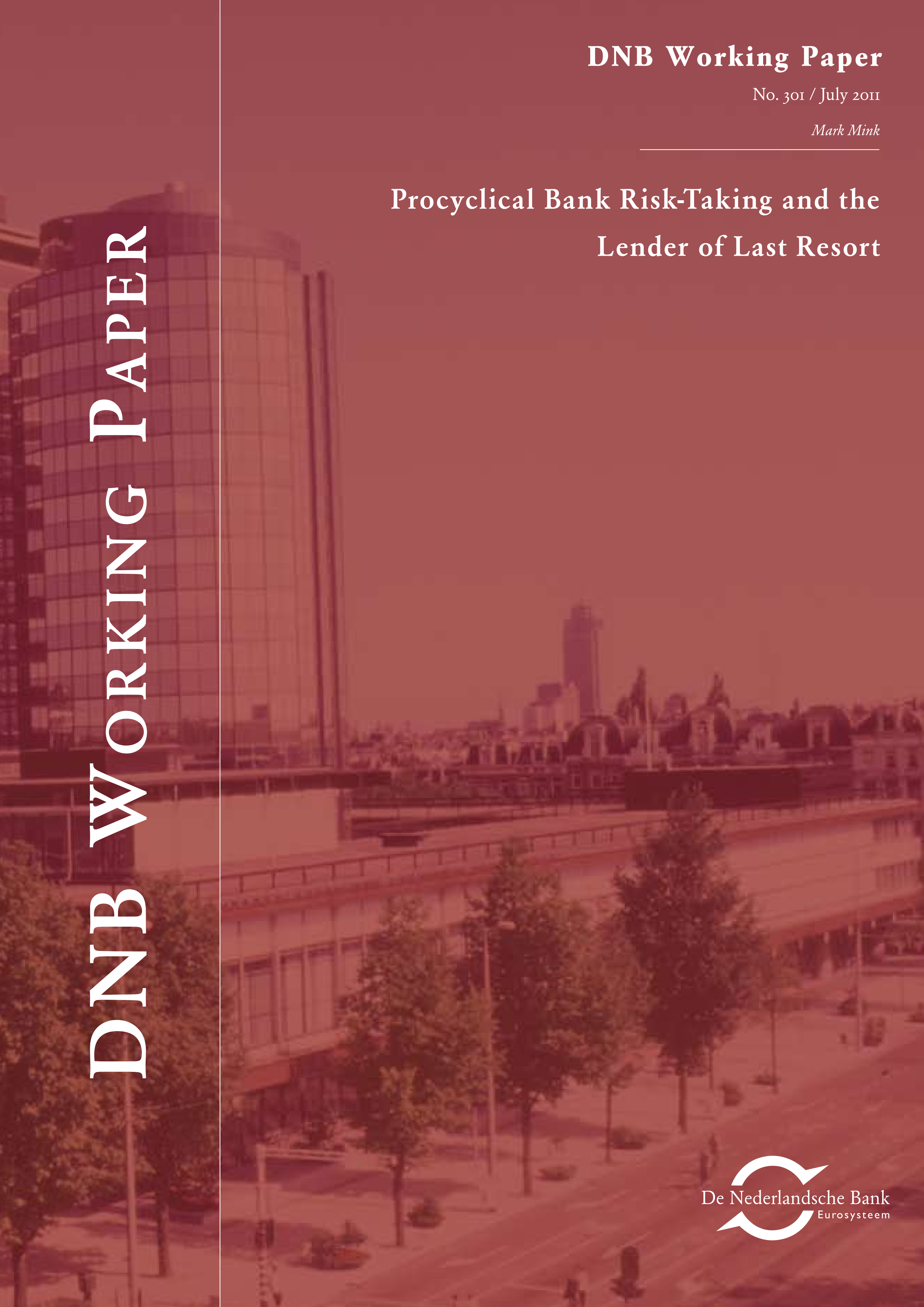

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Procyclical Bank Risk-Taking and the Lender of Last Resort

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De Nederlandsche Bank
Eurosysteem

Procyclical Bank Risk-Taking and the Lender of Last Resort

Mark Mink *

* Views expressed are those of the author and do not necessarily reflect official positions of De Nederlandsche Bank.

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Procyclical Bank Risk-Taking and the Lender of Last Resort

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Abstract

We show that through facilitating maturity transformation, the lender of last resort gives banks an incentive to lever, diversify, and lower their lending standards. Bank leverage increases shareholder value because maturity transformation effectively allows banks to borrow against lower interest rates than their shareholders. Bank diversification increases shareholder value by enabling banks to lever more. When the gains from maturity transformation are passed on to bank customers, lending standards deteriorate. This risk-taking intensifies when the term spread is steeper, and is thus procyclically related to the stance of the macro-economy. Regulatory liquidity requirements can reduce all forms of risk-taking examined.

Keywords: bank risk-taking, procyclicality, lender of last resort, financial regulation
JEL codes: G01, G21, G28, G32

1 Introduction

Excessive bank maturity transformation, leverage, diversification, and lending standard deterioration can put at risk the stability of the financial sector. By engaging in maturity transformation, banks finance long-term assets with short-term debt, which makes them prone to bank runs and sudden illiquidity.[1] By levering their balance sheets, banks use less equity to finance their assets, so that a small decline in these assets' value can cause them to become insolvent. Portfolio diversification in turn reduces banks' exposure to idiosyncratic risks, but increases their exposure to systematic risks so that they are more likely to become

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[1]See for instance Diamond and Dybvig (1983) and Chen (1999).

insolvent simultaneously.[2] Finally, by lowering their lending standards, banks can inflate a credit bubble of which the bursting could trigger a financial crisis. Brunnermeier (2009) and Hellwig (2009) describe how this bank risk-taking intensified during the run-up to the 2007 financial crisis, which Borio (2008) points out went hand-in-hand with exceptionally strong performance of the financial system and the world economy in general.

This paper outlines a new incentive for banks to engage in maturity transformation, leverage, diversification, and lending standard deterioration. This incentive is stronger when macro-economic conditions seem the most prosperous, and arises solely from the illiquidity insurance provided by the lender of last resort. Notably, we establish this incentive within a stripped-down modeling framework based on Modigliani and Miller (1958), which is well-known for its implication that higher firm leverage and diversification do not create shareholder value (because shareholders can also lever and diversify themselves). By doing so we abstract from the incomplete markets and asymmetric information that in more fully fledged models justify banks' role as liquidity insurers and delegated monitors, see for instance Diamond and Dybvig (1983) and Calomiris and Kahn (1991). As a result, in our framework the impact of the lender of last resort on bank behaviour is the only market distortion, and can directly be interpreted as a deviation from the social optimum. An obvious limitation of this stylised approach is that we overlook any additional incentives that affect bank risk-taking, but on itself this does not invalidate the mechanism we highlight in our analysis.

It is well known in the literature that the lender of last resort gives banks an incentive to engage in maturity transformation, see for instance Bagehot (1873), Goodhart (2008) and Farhi and Tirole (2009).[3] At the same time, the consensus is that "where liquidity support clearly can be separated from the provision of risk capital, the moral hazard created will be limited to possible mismanagement of liquidity risk" (Freixas, Giannini, Hoggarth and Soussa, 2000, p.73). We aim to contribute to this literature by showing that through

[2]See for instance Allen and Jagtiani (2000) and Wagner (2010). Wagner (2008) points out how conglomeration leads to functional diversification, while consolidation via mergers and acquisitions fosters in particular geographical diversification. Financial innovation facilitates diversification by make more risks tradeable.

[3]Liquidity support can be substantial especially when multiple banks are illiquid at the same time. During the current crisis for instance, central banks provided not only emergency liquidity support to individual banks, but also massively increased the supply of liquidity to the banking sector as a whole. President of the ECB Trichet (2009) explains that "the Eurosystem's open market operations have, in addition to steering short-term interest rates, also sought to ensure that solvent banks have continued access to liquidity. [...] We are now providing - and this is quite exceptional - unlimited refinancing to the banks of the euro area for maturities ranging from one week to six months in exchange for eligible collateral. [...] In total, the Eurosystem's balance sheet rose by about EUR 600 billion since end-June 2007 and today, an increase of about 65%."

facilitating bank maturity transformation, the lender of last resort allows banks to save upon the spread between long-term and short-term interest rates when financing their activities. This borrowing cost advantage invalidates the assumption by Modigliani and Miller (1958) that firms borrow against the same interest rate as their shareholders. Bank leverage then increases shareholder value because banks can effectively borrow at a lower cost than their shareholders. Bank diversification increases shareholder value by reducing the risk on banks' assets, so that for any target level of default risk banks can increase their leverage further. Competitive pressures cause banks to translate their lower borrowing costs into lower lending standards, which can lead them to finance investment projects of negative net present value.

Our model connects micro-economic bank risk-taking with the stance of the macro-economy via the difference between long-term and short-term interest rates. This term spread is a leading indicator of the business cycle used in for instance the Conference Board's Leading Economic Index (see also Ang, Piazzesi and Wei 2006 and the references therein). Risk-taking increases when the term spread steepens since engaging in maturity transformation then provides banks with a larger borrowing cost advantage. To our knowledge this mechanism of procyclical bank risk-taking has not been modeled in the literature before. Bank risk-taking in turn could feed back into the term spread if maturity transformation and lending standard deterioration affect the (relative) price of long-term and short-term funds in the economy. While exploring this effect could shed further light on the interactions between the banking sector and the real economy, doing so is outside the scope of the present paper.

The mechanism of bank-risk taking we analyse differs from those that have been discussed in the literature.[4] However, it is closely related to the insights by Modigliani and Miller (1958) and Lewellen (1971) that firms obtain an incentive to increase leverage and diversification from the corporate debt tax shield. This is the case because the borrowing cost advantage banks obtain via the lender of last resort can be modeled in a similar way as the borrowing cost advantage that firms in general obtain from the tax deductibility of

[4] Calomiris and Kahn (1991) and Diamond and Rajan (2001) explain that maturity transformation serves to discipline bank managers by increasing the risk of a bank-run. Furlong and Keeley (1987) explain banks' high leverage from the existence of retail deposit insurance, which for too-big-to-fail banks implicitly extends to wholesale creditors as well. Bank-specific diversification incentives are not typically discussed in the literature, but Penati and Protopapadakis (1988) argue that retail deposit insurance gives banks an incentive to increase asset return correlation with each other deliberately, while Acharya and Yorulmazer (2007) attribute this incentive to implicit too-many-to-fail guarantees. Lending standard deterioration can be explained from short-sightedness or deteriorating ability of bank loan officers, see Rajan (1994) and Berger and Udell (2004).

interest expenses. This parallel also holds true for borrowing cost advantages that arise from insolvency insurances, such as capital support for banks which are too-big-to-fail. Insolvency insurances however neither provide banks with an incentive to engage in maturity transformation, nor can they explain why risk-taking builds up during good times. In fact, as such insurances predominantly reduce banks' borrowing costs during times of crisis, see Standard & Poor's (2011), their impact on risk-taking is countercyclical instead.

In our model, regulatory capital and liquidity requirements reduce bank risk-taking. While capital requirements do not affect maturity transformation and diversification, liquidity requirements limit all forms of risk-taking examined. International capital requirements were already in place at the start of the current crisis, while liquidity requirements will by 2018 be incorporated in international banking regulation (see Basel Committee on Banking Supervision 2010). Banks have opposed stricter capital and liquidity requirements by arguing that equity and long-term debt are both 'expensive' sources of funding. In our analysis this is only the case because these funding sources do not allow banks to benefit from the illiquidity insurance by the lender of last resort. While based on Modigliani and Miller (1958), our analysis thus supports the common assumption in theoretical banking models that equity is a costly funding source. At the same time, as also argued by Admati, DeMarzo, Hellwig, and Pfleiderer (2010), it shows equity is not expensive from the perspective of society as a whole.

Finally, our analysis suggests a relationship between bank risk-taking and monetary policy. First, lower policy rates translate into lower short-term interest rates and thus steepen the term spread directly. Second, when policy rates are low for a longer time, rising inflation expectations might drive up long-term interest rates and steepen the term spread further.[5] This relationship adds a new component to the 'risk-taking channel' of monetary policy discussed by Borio and Zhu (2008). Angeloni, Faia, and Lo Duca (2010) provide empirical evidence for the U.S. that lower policy rates increase bank leverage. That lower policy rates weaken bank lending standards is documented by Ioannidou, Ongena, and Peydró (2009), Jiménez, Ongena, Peydró, and Saurina (2010) and Maddaloni, Peydró, and Scopel (2010). These last authors also show that prolonging low policy rates weakens lending standards even further. These findings are in line with our analysis.

[5] Ellingsen and Söderström (2001) show the impact of monetary policy on long-term interest rates is not unambiguous.

2 Bank risk-taking under Modigliani-Miller

To facilitate interpreting the mechanism that drives banks to lever, diversify, and lower their lending standards, we use a simple, stripped-down model which consists of three components:

Investment projects There are two long-term bank investment projects. Both projects are identical in the sense that for long-term risk-free interest rate $r > 0$, they yield expected returns with mean $(1 + \pi)\, r$ and standard deviation σ (we omit project-specific subscripts for notational convenience). The premium $\pi > 0$ is required by banks to cover for the risk on their investment. The projects only differ in the sense that the correlation between their returns equals $\rho < 1$, which provides banks with the opportunity to diversify.

Banks There are two banks that both finance their assets A with debt D and equity E, so that for each bank $A = D + E$ with leverage $L = A/E$ (we omit bank-specific subscripts for notational convenience). The standard deviation of banks' equity returns is denoted by σ_E. The risk on assets is fully born by banks' equity holders, so that $\sigma_E = \sigma_A A/E$.[6] Banks can specialise in one investment project, or diversify by investing in both. When they diversify, the mean of the expected return on assets is still equal to $(1 + \pi)\, r$, but the standard deviation thereof declines from σ to $\sqrt{0.5\,(1+\rho)}\sigma$.

Shareholder There is one shareholder, out of many, that has an amount I to invest in one or both banks' equity, using borrowed funds B and own funds O so that $I = B + O$. The standard deviation of the return on the shareholder's own funds equals σ_O, which for low shareholder default risk equals $\sigma_O = \sigma_I I/O$. For a given risk preference σ_O, the shareholder aims to maximise his return on own funds.

As a benchmark case we follow Modigliani and Miller (1958) and assume that banks and shareholders borrow against the risk-free interest rate r. The shareholder can construct a

[6] This expression follows from taking into account that the risk on assets is proportionally born by debt and equity holders according to $\sigma_A^2 = \sqrt{(E/A)^2\,\sigma_E^2 + (D/A)^2\,\sigma_D^2 + 2\,(E/A)\,(D/A)\,\mathrm{Cov}\,(\sigma_E \sigma_D)}$, where we set the standard deviation of the return on debt σ_D equal to zero. In practice this standard deviation is somewhat larger than zero since banks' debt holders suffer a loss if the bank would go bankrupt. For clarity of exposition we assume that this bankruptcy risk is negligibly small, which does not qualitatively affect our results and seems in line with actual behaviour during non-crisis times.

diversified portfolio in two ways (diversification is optimal as it reduces risk while keeping returns unchanged). He either can equally spread his funds over two banks that each have specialised in a different investment project, or he can buy shares of one bank that has diversified and has equally spread his funds over both investment projects. The shareholder can also lever his portfolio in two ways. He can either lever himself by also using borrowed funds to buy the shares of unlevered banks, or he can let the banks lever while using only his own funds to buy these banks' shares. We thus distinguish four alternative scenario's based on whether the bank or the shareholder levers and/or diversifies.

We show in the Appendix that under all four scenarios the shareholder's return on own funds (ROO) is the same, and equal to

$$ROO = \left(1 + \frac{\sigma_O}{\sigma} \frac{1}{\sqrt{0.5\,(1+\rho)}} \pi\right) r, \tag{1}$$

which can also be written as $r + (A/O)\,\pi r$. The shareholder's return on own funds is thus equal to the interest rate on risk-free debt plus a reward required for the risk born on own funds. This reward is a function of risk premium π and of the combined total of bank and shareholder leverage A/O. When this ratio is higher, the shareholder has a more levered exposure to the investment projects, and thus earns a higher expected return on own funds as well.

As the shareholder's return on own funds is the same under all four scenario's examined, we obtain the well-known result that in the framework by Modigliani and Miller (1958) leverage and diversification at the level of the firm do not increase shareholder value. The reason for the absence of such an effect is that the shareholder can also lever and diversify his portfolio himself, so that there are no benefits associated with letting the bank do this for him. If we had allowed for (small) bankruptcy costs and economies of scale from banks investing in a single project, optimal bank leverage and diversification would be equal to zero. When banks lower their lending standards, and finance investment projects with expected returns below the cost-effective rate $(1+\pi)\,r$, shareholder value declines so that this strategy is not attractive either.

3 Bank risk-taking under illiquidity insurance

To analyse banks' incentive to lever, diversify, and lower their lending standards, we modify the set-up of the previous section by relaxing the assumption by Modigliani and Miller (1958) that banks and shareholders borrow against the same interest rate. In particular, we take into account that banks can engage in maturity transformation due to the illiquidity insurance provided to them by the lender of last resort.

A firm engages in maturity transformation when it finances long-term assets by rolling-over short-term debt. The advantage of doing so is that short-term interest rates are usually lower than long-term interest rates, so that the firm's financing costs decline. The disadvantage is that the firm runs the risk of illiquidity, since short-term funds can be withdrawn before the long-term investment projects mature. If this happens the firm has to liquidate these projects prematurely to repay its creditors, which can cause it to suffer large losses with insolvency as the potential outcome. Non-banks therefore do not typically aim to increase maturity transformation, as to them the advantage of cheaper funding is offset by the disadvantage of the higher illiquidity risk. For banks however, at least part of this risk is insured by the lender of last resort, which provides solvent banks with short-term funds when they are in imminent need of liquidity.[7] This insurance allows banks to engage in maturity transformation on a much larger scale than non-banks can.

We model bank maturity transformation by introducing a parameter $\tau > 0$, which indicates the fraction of short-term debt out of the total debt issued by the bank to finance its long-term investment projects. For simplicity we normalise the short-term interest rate to zero, so that the long-term interest rate r can be interpreted as the term spread, i.e. as the difference between short-term and long-term interest rates. The average interest rate banks pay on their issued debt is now equal to $(1 - \tau)\, r$. In addition to reducing banks' financing costs, maturity transformation increases banks' illiquidity risk. However, as this risk is born by the lender of last resort and does not affect bank or shareholder decision making, we do not explicitly include it in the model.[8] We thus model bank maturity transformation in a way

[7] The monthly liquidity provision to the banking sector as part of the monetary policy framework provides banks with some form of illiquidity insurance as well. See Freixas, Giannini, Hoggarth, and Soussa (2000) for a comprehensive review of the literature on the lender of last resort.

[8] Our approach to modeling maturity transformation is the mirror image of the one generally adopted in the literature. The literature often assumes banks fully funded their assets by means of short-term debt, with maturity transformation being modeled as the bank investing too much funds in long-term investment projects

that is observationally equivalent to the modeling of a corporate debt tax shield as discussed by Modigliani and Miller (1958), as becomes clear when we would interpret τ as the corporate income tax rate.

When banks engage in maturity transformation, both leverage and diversification at the level of the bank affect shareholder value. To show this we again compare shareholders' return on own funds under the four scenarios discussed above. The scenarios where the shareholder levers (LS) yield a shareholder return on own funds equal to

$$ROO^{LS,DS} = ROO^{LS,DB} = \left(1 + \frac{\sigma_O}{\sigma} \frac{1}{\sqrt{0.5\,(1+\rho)}}\pi\right) r, \tag{2}$$

which does not depend on whether the shareholder diversifies (DS) or whether diversification is done by the bank (DB). Both returns on own funds are identical to the one in the previous section, since when the shareholder levers the ability of the bank to engage in maturity transformation is not put to use and thus does not affect the return on own funds. The returns on own funds do change when the bank levers (LB) instead of the shareholder. When the bank levers and the shareholder diversifies his return on own funds equals

$$ROO^{LB,DS} = \left(1 + \frac{\sigma_O}{\sigma} \frac{1}{\sqrt{0.5\,(1+\rho)}}\pi\right) r + \left(\frac{\sigma_O}{\sigma} - 1\right) \frac{1}{\sqrt{0.5\,(1+\rho)}}\tau r, \tag{3}$$

while when instead the bank diversifies this return becomes

$$ROO^{LB,DB} = \left(1 + \frac{\sigma_O}{\sigma} \frac{1}{\sqrt{0.5\,(1+\rho)}}\pi\right) r + \left(\frac{\sigma_O}{\sigma} - 1\right) \frac{1}{\sqrt{0.5\,(1+\rho)}}\tau r + \left(\frac{1}{\sqrt{0.5\,(1+\rho)}} - 1\right) \tau r. \tag{4}$$

This last expression can also be written as $(1-\tau)\,r + (A/O)\,(\pi+\tau)\,r$, which is equal to the average interest rate on risk-free debt, raised by a reward required for the risk born on own funds and by the benefits from engaging in maturity transformation τ. When $\tau > 0$, the second and third term of Equation (4) are always larger than zero, so that engaging in maturity transformation increases shareholder value. We discuss below what the composition of this return on own funds implies for the impact of leverage, diversification, and lending standard deterioration on shareholder value.

while holding too few short-term assets as a liquidity buffer. As the return on short-term assets is assumed to be equal to zero, higher maturity transformation increases the interest income the bank receives on its assets, while in our setup it reduces the interest expense to be paid on debt.

3.1 Bank leverage and shareholder value

Comparing the returns on own funds in Equations (2) and (3) shows that the gain for the shareholder from letting the specialised bank lever instead of doing so himself can be written as

$$ROO^{LS,DS} - ROO^{LB,DS} = \left(\frac{\sigma_O}{\sigma} - 1\right) \frac{1}{\sqrt{0.5\,(1+\rho)}} \tau r. \tag{5}$$

This gain is always positive as long as there is some leverage either at the level of the bank or at the level of the shareholder, since then $\sigma_O/\sigma > 1$. Letting the bank borrow instead of the shareholder thus always increases shareholder value. The intuition behind this result is that because of its ability to roll-over short-term debt, the bank can effectively finance its assets against a lower interest rate than the shareholder. The shareholder therefore receives a higher return on own funds when he lets the bank borrow instead of doing so himself. Going from left to right in Equation (5), the incentive for the bank to lever instead of the shareholder is stronger when:

Shareholders prefer more risk. When σ_O is higher shareholders prefer a more risky investment portfolio, and thus want to take a more leveraged exposure to the projects that banks invest in. This requires a larger amount of debt to be issued, which increases the gain from letting the bank doing so and exploit its borrowing cost advantage.

Banks invest in safer projects. When σ is lower banks invest in less risky projects. For a given level of shareholder risk preference this allows for a larger amount of debt to be issued, which increases the gain from letting the bank doing so to exploit its borrowing cost advantage.

Investment projects are less correlated. When the correlation ρ between investment projects is lower this leads to a smaller value for $\sqrt{0.5\,(1+\rho)}$. For a given of riskiness of these individual investment projects, the risk on the shareholder's own funds is then lower. Shareholders therefore need more leverage to align their portfolio's risk with their personal risk preferences, which increases the benefits from letting the bank borrow instead of doing so themselves.

Bank maturity transformation is higher. When τ is higher, banks finance themselves with a larger proportion of short-term funds, which increases the borrowing cost advantage they have over their shareholders. Shareholders are then more likely to prefer the bank to lever rather than doing so themselves.

The term spread is steeper. When r is higher, the term spread is steeper so that the difference between long-term and short-term interest rates is larger. The borrowing cost advantage stemming from banks' ability to engage in maturity transformation is then larger, so that bank instead of shareholder leverage becomes more attractive.

3.2 Bank diversification and shareholder value

If banks did not lever they also would not have an incentive to diversify, as follows directly from Equation (2). Having established however that bank shareholders gain from letting banks lever, banks obtain an incentive to diversify as well. The intuition behind this result is that for a given value of σ_E, the amount of leverage $L = A/E$ in the bank is constrained by $L\sigma_A = \sigma_E$, as was shown in Section 2. For any target standard deviation of equity, i.e. for any level of default risk preferred by the bank, the bank can thus only increase its leverage when it decreases the risk on its assets. This is exactly what it does by diversifying between investment projects. Comparing Equations (3) and (4) shows that bank diversification increases shareholders' return on own funds by

$$ROO^{LB,DS} - ROO^{LB,DB} = \left(\frac{1}{\sqrt{0.5\,(1+\rho)}} - 1 \right) \tau r, \tag{6}$$

which is always larger than zero. Going from left to right in Equation (6), the shareholder's gain from letting the bank diversify instead of doing so himself is larger when:

Investment projects are less correlated. When the correlation ρ between investment projects is lower the value of $\sqrt{0.5\,(1+\rho)}$ decreases. Diversifying between investment projects then leads to a larger reduction in the risk on assets, and thus creates more room for bank leverage to exploit the bank's borrowing cost advantage.

Bank maturity transformation is higher. When τ is higher, banks finance themselves with a larger proportion of short-term funds, which increases their borrowing cost advantage relative to their shareholders. Banks' incentive to diversify then increases, as doing so allows for more exploitation of this borrowing cost advantage.

The term spread is steeper. When r is higher, the term spread is steeper so that the difference between long-term and short-term interest rates is larger. The borrowing cost advantage stemming from banks' ability to engage in maturity transformation is then larger, so that bank instead of shareholder leverage becomes more attractive. In turn, this increases the gain from bank diversification as well.

3.3 Bank lending standard deterioration and shareholder value

Up to this point we have assumed that the gains from bank maturity transformation all accrue to the shareholder in the form of a higher return on own funds. This is however not necessarily the case, since in a competitive bank lending market, banks will also use these gains to lower the price of their loans. To allow for such lower lending tariffs we model bank lending rates as $(1 + \pi - \delta)\, r$, where $\delta > 0$ is a discount offered by the bank on the loan rate. The corresponding return on own funds when the bank levers and diversifies is obtained by replacing π in Equation (4) by $(\pi - \delta)$. Naturally, the bank cannot offer a discount that is so large that the return on own funds declines below the return required by the shareholder. Assuming that the shareholder requires a return at least equal to the one in Equation (2), the discount that the bank can offer is constrained by

$$\delta < \left(1 - \frac{\sigma}{\sigma_O}\sqrt{0.5\,(1+\rho)}\right)\tau, \tag{7}$$

which can also be written as $\delta < \left(1 - 1/L^{LB,DB}\right)\tau$.[9] The right hand side of this condition is always larger than zero, which indicates that by engaging in maturity transformation, the bank becomes able to offer a non-zero discount on the original lending rate. As a consequence, the bank can profitably finance investment projects even when they have a negative

[9]This result follows from noticing that when the bank levers and the shareholder does not, $\sigma_O = \sigma_E$ so that $\sigma_O/\sqrt{0.5\,(1+\rho)}\sigma = L^{LB,DB}$.

net present value.[10] Going from left to right in Equation (7), this discount increases when:

Shareholders prefer more risk. When σ_O is higher shareholders prefer a more risky investment portfolio, and thus want to take a more leveraged exposure to the projects that banks invest in. This allows banks to use more debt to finance their investment projects, which increases the gains from maturity transformation and allows for lower bank lending rates.

Banks invest in safer projects. When σ is lower banks invest in less risky projects. They can then use more leverage to finance these projects, and thus obtain a larger gain from their ability to engage in maturity transformation. As a result, they can give a larger discount on their lending rates.

Investment projects are less correlated. When the correlation ρ between investment projects is lower the value of $\sqrt{0.5\,(1+\rho)}$ decreases. Diversifying between investment projects then leads to a larger reduction in the risk on assets. This again allows for more leverage and a larger gain from maturity transformation, so that bank lending rates can be lower.

Bank maturity transformation is higher. When τ is higher, banks finance themselves with a larger proportion of short-term funds, which lowers their borrowing costs so that lending rates can be lower as well.

Equation (7) implies that when maturity transformation and leverage are high enough, the discount δ can even be larger than the risk-premium π. In this case banks finance risky investment projects even when they yield a return lower than the risk-free interest rate r. As an alternative, banks can use the gains from maturity transformation to invest in riskier projects against the same interest rate. Both cases imply a deterioration of bank lending standards and an expansion of credit supply into assets which yield lower risk-adjusted returns than the original investment projects.

[10] This result follows from noticing that the bank invests an amount A in a project that yields a return of $(1+\pi-\delta)\,r$, while given the project's riskiness the return required equals $(1+\pi)\,r$. The net present value of the project is then equal to $-\frac{A}{1}+\frac{A}{1+(1+\pi)r}+\frac{(1+\pi-\delta)rA}{1+(1+\pi)r}=-\frac{\delta}{1+\pi+1/r}$, which is smaller then zero.

3.4 Bank risk-taking under regulatory capital and liquidity requirements

To reduce bank risk-taking, bank regulators impose capital buffer requirements. In particular, regulators limit the ratio of banks' risk-weighted assets over their equity buffers. Since this ratio is equal to $\sigma_A A/E = \sigma_E$, these capital requirements can be modeled as regulators imposing an upper limit $\bar{\sigma}_E < \sigma_O$ on the standard deviation of banks' equity. As a result bank leverage declines from σ_O/σ to $\bar{\sigma}_E/\sigma$. Replacing σ_O in Equation (5) by $\bar{\sigma}_E$ shows that regulatory capital requirements limit shareholder gains from bank leverage, while doing the same in Equation (7) shows that they limit lending standard deterioration as well. Bank capital requirements however do not limit the incentive to diversify, since σ_O does not enter in Equation (6). The intuition behind this result is that the percentage decline in the capital requirement that can be achieved through diversification is independent of the strictness of this requirement itself.

In addition to imposing capital buffer requirements, the international banking regulation reforms set in motion since the 2007 financial crisis allow regulators to impose bank liquidity buffer requirements as well (see Basel Committee on Banking Supervision 2010). These requirements work to limit the maturity mismatch between banks' assets and liabilities, and can be modeled as regulators imposing an upper limit $\bar{\tau}$ on the amount of bank maturity transformation. Replacing τ by $\bar{\tau}$ in Equations (5), (6) and (7) shows that such a limit would reduce the gains from leverage and diversification, and would in addition reduce banks' ability to offer a discount on their loan rates. These effects of course come in addition to their primary objective of limiting maturity transformation.

In addition to reducing bank risk-taking, capital and liquidity requirements lead bank profits to be lower and cause banks loans to become more expensive. After all, in the extreme case where $\bar{\sigma}_E = \sigma_A$ and/or $\bar{\tau} = 0$, we are back in the world of Modigliani and Miller (1958). Banks then cannot afford to offer a discount on their lending rates, while to the extent that they used to pass on the gains from maturity transformation to their shareholders, profits will be lower as well. These effects are counterbalanced by a decline in expensive and distortional guarantees from the providers of bank insolvency and illiquidity insurances, which ultimately are the (inflation) tax payers. While banks thus will consider equity and long-term debt to be expensive sources of funding, this is not the case from the perspective of society as a whole (see also Admati, DeMarzo, Hellwig, and Pfleiderer 2010).

4 Conclusion

Excessive bank maturity transformation, leverage, diversification, and lending standard deterioration can put at risk the stability of the financial sector. This was illustrated by the outbreak of the 2007 global financial crisis, which has drawn renewed attention to the question why banks engage in these forms of risk-taking, and why this risk-taking intensifies when macro-economic conditions seem the most prosperous. We analyse these questions by outlining a mechanism in which providing banks with illiquidity insurance through a lender of last resort, which is the only market distortion in our model, is sufficient to give them an incentive to engage in maturity transformation, leverage, diversification, and lending standard deterioration. Our model connects micro-economic bank risk-taking with the overall stance of the macro-economy via the term spread, which is a well-known indicator of the business cycle. Bank risk-taking is shown to be procyclical as it becomes more profitable when the term spread steepens. In our model, risk-taking can be reduced via regulatory bank liquidity requirements, and to a lesser extent by regulatory capital requirements. While banks consider equity and long-term debt to be expensive sources of funding, our model shows both are not expensive from the perspective of society as a whole. The analysis also suggests a new risk-taking channel of monetary policy, as lower policy rates can steepen the term spread and thereby increase bank risk-taking. While we have adopted a fairly stylised modeling framework to establish these results, analysing them in more detail within the context of a general equilibrium model is a fruitful area for future research.

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Appendix

When the shareholder levers (LS) instead of the bank, the amount of the bank's equity is by definition equal to the amount of the bank's assets. In the scenario where the shareholder diversifies (DS) and chooses the bank to specialise, this implies that $E^{LS,DS} = A$. The bank's return on equity (ROE) then equals the income from investing in a single project divided by total shareholder equity:

$$\begin{aligned} ROE^{LS,DS} &= \frac{(1+\pi)\, rA}{E^{LS,DS}}, \\ &= \frac{A}{A}(1+\pi)\, r, \\ &= \pi r + r. \end{aligned}$$

The shareholder now equally spreads his funds over the shares of two specialised banks. His return on own funds (ROO) then equals the return on the investment in both banks' equity minus his interest expenditures on borrowed funds, divided by his amount of own funds:

$$\begin{aligned} ROO^{LS,DS} &= \frac{ROE^{LS,DS} I^{LS,DS} - r\left(I^{LS,DS} - O\right)}{O}, \\ &= \frac{I^{LS,DS}}{O}\left(ROE^{LS,DS} - r\right) + r, \\ &= \frac{\sigma_O}{\sigma}\frac{1}{\sqrt{0.5\,(1+\rho)}}\pi r + r, \end{aligned}$$

where for the last step we used the fact that $I^{LS,DS}/O = \sigma_O/\sigma_I^{LS,DS} = \sigma_O/\sqrt{0.5\,(1+\rho)}\sigma$. This result follows from the fact that as the bank does not lever, the standard deviation of his equity is equal to the standard deviation of his assets. Hence, when the shareholder spreads his investment equally over both banks' equity, the standard deviation of the resulting investment portfolio equals $\sigma_I^{LS,DS} = \sqrt{0.5^2\sigma^2 + 0.5^2\sigma^2 + 2\rho 0.5^2\sigma^2} = \sqrt{0.5\,(1+\rho)}\sigma$.

In the scenario where the shareholder levers and the bank diversifies (DB) by investing in both projects, the bank's return on equity equals

$$\begin{aligned} ROE^{LS,DB} &= \frac{(1+\pi)\, rA}{E^{LS,DB}}, \\ &= \frac{A}{A}(1+\pi)\, r, \\ &= \pi r + r. \end{aligned}$$

The shareholder now invests all his funds in the diversified bank's equity, in which case he earns a return on own funds equal to

$$\begin{aligned} ROO^{LS,DB} &= \frac{ROE^{LS,DB} I^{LS,DB} - r\left(I^{LS,DB} - O\right)}{O}, \\ &= \frac{I^{LS,DB}}{O}\left(ROE^{LS,DB} - r\right) + r, \\ &= \frac{\sigma_O}{\sigma} \frac{1}{\sqrt{0.5\,(1+\rho)}} \pi r + r, \end{aligned}$$

where for the last step we used the fact that $I^{LS,DB}/O = \sigma_O/\sigma_I^{LS,DB} = \sigma_O/\sqrt{0.5\,(1+\rho)}\sigma$.

Instead of levering his investment portfolio himself, the shareholder can also let the bank lever (LB). The shareholder then does not borrow himself, but only uses his own funds to buy banks' equity. As a result, the amount of shareholder own funds is by definition equal to the amount of shareholder investments. In the scenario where the shareholder diversifies and lets the bank specialise in a single investment project, this implies that $O = I^{LB,DS}$ in which case the bank's return on equity equals

$$\begin{aligned} ROE^{LB,DS} &= \frac{(1+\pi)\,rA - r\left(A - E^{LB,DS}\right)}{E^{LB,DS}}, \\ &= \frac{A}{E^{LB,DS}} \pi r + r, \\ &= \frac{\sigma_O}{\sigma} \frac{1}{\sqrt{0.5\,(1+\rho)}} \pi r + r, \end{aligned}$$

where in the last step we used the fact that $A/E^{LB,DS} = \sigma_E^{LB,DS}/\sigma = \sigma_O/\sqrt{0.5\,(1+\rho)}\sigma$. This result follows from the fact that when the shareholder does not lever, the standard deviation of his own funds equals the standard deviation of his investment portfolio, so that $\sigma_O = \sigma_I^{LB,DS} = \sqrt{0.5\,(1+\rho)}\sigma_E^{LB,DS}$. When the shareholder now spreads his funds over two specialised banks, his return on own funds equals

$$\begin{aligned} ROO^{LB,DS} &= \frac{ROE^{LB,DS} I^{LB,DS}}{O}, \\ &= \frac{O}{O} ROE^{LB,DS}, \\ &= \frac{\sigma_O}{\sigma} \frac{1}{\sqrt{0.5\,(1+\rho)}} \pi r + r. \end{aligned}$$

Finally, in the last scenario the bank both levers and diversifies instead of the shareholder, so that it's return on equity equals

$$
\begin{aligned}
ROE^{LB,DB} &= \frac{(1+\pi)\, rA - r\left(A - E^{LB,DB}\right)}{E^{LB,DB}}, \\
&= \frac{A}{E^{LB,DB}} \pi r + r, \\
&= \frac{\sigma_O}{\sigma} \frac{1}{\sqrt{0.5\,(1+\rho)}} \pi r + r,
\end{aligned}
$$

where in the last step we used the fact that $A/E^{LB,DS} = \sigma_E^{LB,DS}/\sigma = \sigma_O/\sqrt{0.5\,(1+\rho)}\sigma$. The return on own funds for the shareholder who invests in the levered diversified bank then equals

$$
\begin{aligned}
ROO^{LB,DB} &= \frac{ROE^{LB,DB} I^{LB,DB}}{O}, \\
&= \frac{O}{O} ROE^{LB,DB}, \\
&= \frac{\sigma_O}{\sigma} \frac{1}{\sqrt{0.5\,(1+\rho)}} \pi r + r.
\end{aligned}
$$

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