Intermediation Chains as a Way to Reconcile Differing Purposes of Debt Financing*

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Abstract

This paper provides an explanation for intermediation chains with stepwise maturity transformations, which have become a common form of financial intermediation (an example are banks with long-term assets that sell commercial paper with month-long duration to money market funds with daily demandable shares). Such chains can reconcile two theories of debt financing: debt as disciplining device and safe debt as 'money-like' claim. The paper shows that the two theories lead to conflicting predictions of the optimal level and optimal duration of bank debt. This conflict can be resolved by a partial separation of the two purposes of debt financing: the bank chooses a debt structure that optimizes the disciplining of its managers and it sells some of its debt to a fund, which provides safe, 'money-like' claims backed by the bank debt.

JEL codes: G21, G23

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1 Introduction

There are several explanations for maturity transformations by financial intermediaries. There is no explanation, however, for the fact that these maturity transformations are often divided into several steps which are performed by differing firms within an 'intermediation chain'. An important example is the investment of money market funds (MMFs), which issue shares that can be withdrawn daily, in commercial paper with durations of several weeks, which are issued by banks or other financial firms that hold long-term assets - a more detailed description is given in Covitz et al. (2013) and Kasperczyk & Schnabl (2010) for the period up to the crisis of 2007-08, or McCabe et al. (2013) and Chernenko & Sunderam (2014) for post-crisis periods.[1] Regulatory arbitrage can explain a shift of financial intermediation from banks to less regulated intermediaries (e.g. from bank deposits to MMFs, or from the balance sheets of banks to their SPVs). But regulatory arbitrage cannot explain why the intermediation subject to less regulation is performed in a chain with a stepwise maturity transformation as described above. For regulatory arbitrage it would have been sufficient, for instance, if the SPVs had sold asset-backed commercial paper with daily roll over to MMFs or directly to final investors. This paper addresses this issue and provides an explanation for intermediation chains that does not rely on regulatory arbitrage, but that rationalizes stepwise maturity transformations.
This paper rationalizes intermediation chains with stepwise maturity transformations as the reconciliation of two different purposes of debt financing of banks. On the one hand, Gorton & Pennacchi (1990) have pointed out that safe debt is 'informationally insensitive' and can serve as means of payment, for which its holders are willing to pay a premium. On the other hand, Calomiris & Kahn (1991) and Diamond & Rajan (2000) have argued that short-term debt can discipline the managers of a bank, because it can be quickly withdrawn if managers engage in costly misbehavior. Both theories are used as justifications for high levels of short-term bank debt.[2]. But is has not been analyzed so far whether these explanations of debt financing actually provide mutually compatible characterizations of the optimal capital structure of a bank. This paper provides such an analysis and obtain two results. First, it shows that, under plausible assumptions, the optimal disciplining of managers requires a higher debt level but a longer debt duration than the optimal provision of safe claims. Second, the paper shows that this conflict between the two objectives of debt financing can be resolved by means of intermediation chains with two links that issue different types of debt.

[1] While Covitz et al. (2013) and Kasperczyk & Schnabl (2010) focus on commercial paper, Krishnamurthy et al. (2014) focus on repos, which is a key source of funding for dealer banks. Although the majority of repos before the crisis were overnight, there has been a significant fraction of repos with longer duration, too. This is in line with the predictions in this paper that banks, which issue medium-term debt and are part of a chain, also issue large amounts of short-term debt next to the medium-term one.
Bluhm et al. (2016) indicate that such stepwise maturity transformations are not only observable for MMFs and their investment in commercial paper or repos, but also in interbank networks. They show that banks funded with deposits provide interbank credit with durations much longer than overnight.

[2] See e.g. Kashyap et al. (2008) and French et al. (2010), or DeAngelo & Stulz (2015) and Stein (2012).

If a bank with stochastically evolving assets wants to maximize the provision of safe claims, the level of safe claims is constrained by the worst possible decline that the bank value could experience before the debt becomes due. And since the possible decline is larger for longer time periods, the optimal duration for providing safe claims is the shortest duration possible, given the financial market is liquid.[3] Let me illustrate this for a case without interest rate risk and zero interest rate.[4] Every long-term debt with a safe payoff at its maturity date t_l can be substituted with short-term debt that has the same face value and is frequently rolled over, before it finally yields the same safe payoff at t_l. Consequently, each level of safe claims provided by long-term debt can also be provided by short-term debt. The inverse statement, however, is not true. Consider a level of short-term debt that is safe because the bank value cannot fall below the face value of the short-term debt before it matures at $t_s < t_l$. Long-term debt with the same face value can be risky, because the bank value can fall below the face value before the long-term debt becomes due at t_l. And this risk of the long-term debt is already relevant in the short run. Since the evolution of the bank value up to t_s changes the conditional probability of default of the long-term debt at t_l, this evolution affects the value of long-term debt at t_s, which is thus a risky claim already in the period up to t_s. To sum up, a shorter debt duration is always (weakly) better for providing safe claims than a longer duration.

Let us now consider that this bank with stochastically evolving assets has managers who can engage in privately beneficial, but inefficient behavior. A disciplining of these managers by the debt holders can be preferable to a disciplining by the equity holders, if equity holders are too 'soft' and tolerate the misbehavior of managers due to high 'liquidation costs' of stopping them, as suggested by Jensen (1986) and Diamond & Rajan (2000). Debt holders can discipline the managers by the threat to withdraw their funding in reaction to manager misbehavior. This threat is credible in spite of the costs that result from a liquidation, if the debt is served sequentially, as highlighted by Calomiris & Kahn (1991). A withdrawal in reaction to manager behavior only occurs, however, if the payoff of the debt claims is sensitive to this behavior. In order to be sensitive to it in more cases than just the worst possible evolution of the bank assets, the debt level has to be higher than the 'safe level' discussed above and it has to carry some risk.

Furthermore, the disciplining can only be effective, if the debt can be withdrawn before the managers have completed their misbehavior and have benefited from it. If this completion is possible before the bank assets mature, the debt has to mature before the assets mature. If a high level of debt has to be rolled over before the assets mature, then the bank faces a costly, premature liquidation in cases of relatively low asset value at inter-

[3]This means that the debt can be rolled over as long as the fundamental value of the bank is sufficiently large - i.e., there are no non-fundamental runs. Illiquidity due to coordination problems and run cascades in intermediation chains are discussed in a follow-up paper.

[4]Interest rates different from zero only change the accounting, but not the results. The presence of interest rate risk strengthens the result, since the value of long-term debt at intermediate dates is affected by this risk, while the repricing of short-term debt at roll over dates shift the interest rate risk from the short-term debt to more junior claims.

mediate dates. And such a premature liquidation becomes the more likely, the shorter the debt duration is. If the frequency of debt roll overs increases, it becomes less likely that the assets can recover from a negative shock before the debt becomes due. This cost of decreasing the debt duration has to be traded off against the benefit of decreasing the duration, which is a reduction of the time in which managers can misbehave before the debt holders can react to it. The optimal duration of disciplining debt thus depends on the bank characteristics like the costs of a premature liquidation or the time that managers need to complete the costly misbehavior. It is not possible to derive a generic statement as in case of the provision of safe debt. The paper shows, however, that the optimal debt duration for disciplining managers is an interior solution (i.e., it is shorter than the asset duration, but longer than the shortest duration possible) for a plausible range of parameters, which can be interpreted as: the costs that misbehaving managers can cause within a day are relatively small compared to the costs that they can cause in the course of weeks or months and compared to the costs of liquidating a bank. If this holds, debt with a duration of a few weeks can prevent the greatest part of potential costs from manager misbehavior, while the bank has a chance to recover from transitory shocks and to avoid a costly liquidation.

There is a conflict between the provision of safe debt with a very short duration and the disciplining of managers with a high level of risky, 'medium-term' debt. A bank thus has to trade off the two purposes of debt financing, when it chooses the level and the duration of its debt. This also holds true if the bank issues several debt tranches with different seniority and duration. Each of these tranches is a claim to the asset payoff with an unambiguous duration. And in choosing this duration, the bank has to decide between optimizing the disciplining of managers and optimizing the provision of safe claims. The conflict between the two purposes of debt financing can be resolved, however, in an intermediation chain in which the bank sells medium-term debt to a fund that is financed by selling short-term debt to the final investors. In such a chain, a claim to the same asset payoff can have two different durations: first, in the form of the fund's claim to the bank payoff, and second, in form of the investor's claim to the fund's claim to the bank payoff. The duration of the first claim (that directly refers to the bank) can be such that it optimizes the disciplining of the bank managers, while the duration of the second claim (held by investors with a demand for means of payment) can be such that it optimizes the provision of safe claims. An intermediation chain with stepwise maturity transformation can thus avoid a trade-off by separating the differing purposes of debt financing.

Besides resolving the conflict concerning the optimal capital structure, the intermediation chain can also resolve another tension between the two purposes of debt financing that concerns the information levels of debt holders. As pointed out by Admati & Hellwig (2013), the holders of bank debt must obtain detailed information about the bank operation, if they are supposed to react to potential misbehavior of the bank managers. This monitoring is in conflict with a demand for safe, 'informationally insensitive' claims that can be used as means of payment. In an intermediation chain, however, the debt of the bank is held by a fund which does not use the debt as means of payment, but which can perform the monitoring of the managers. If the incentives in the fund are appropriately aligned, it constitutes a delegated monitor on behalf of its investors. (A detailed discussion of the delegated monitoring and the alignment of incentives is given in Section 5.) Consequently, given an appropriate tranching of its payoffs, the fund can issue a senior, short-term tranche that is safe and informationally insensitive.

Additional related literature: I. There are papers about the optimal duration of debt financing, with Leland & Toft (1996) and Cheng & Milbradt (2012) as important examples. But these papers differ in two aspects from this one. First, they do not discuss how the optimal duration of debt depends on its purpose, but they focus on a certain type of risk-shifting and study which debt duration can prevent this specific case of risk-shifting most efficiently. Second, and most importantly, they do not study how different purposes of debt financing can be reconciled. II. There is a small literature about 'intermediation chains', like e.g. Glode & Opp (2016). But these papers describe the trading of assets along a chain of dealers in order to reduce problems of asymmetric information - they do not address maturity transformations or the choice of capital structure. III. The literature on financial networks, following Allen & Gale (2000) and Freixas et al. (2000), describes a certain type of 'intermediation chains' with maturity transformations. These networks studied, however, are systems of mutual liquidity insurance, and all nodes of the network engage in the same type of maturity transformation.

The **remainder of the paper** is organized as follows. Section 2 introduces the model and derives the debt structures that optimize the two purposes of debt financing, respectively. Based on this, Section 3 points out the conflict between these two purposes in the choice of capital structure. Section 4 explains how an intermediation chain can solve this conflict. Section 5 discusses how an intermediation chain allows for delegated monitoring of the bank managers. As a last step, Section 6 illustrates the robustness of the results to uncertainty about the timing of the shocks and to a staggered maturity structure of the debt.

2 Two Purposes of 'Short-term' Debt Financing

This section provides a simple model that illustrates how the choice of capital structure depends on the purpose of debt financing. There are four dates $t = 0, 1, 2, 3$ and two types of agents: a set of investors and an owner of a firm, which shall be called 'bank'. The bank has assets that yield either 1 or $1 - a$ at $t = 3$. At $t = 1$ and $t = 2$, there are public signals about the probabilities of the two potential payoffs. The expected payoff of the bank assets, conditional on the information available at t, is denoted as y_t. At $t = 1$, the uncertainty about the payoff at $t = 3$ is either resolved by a signal that the assets

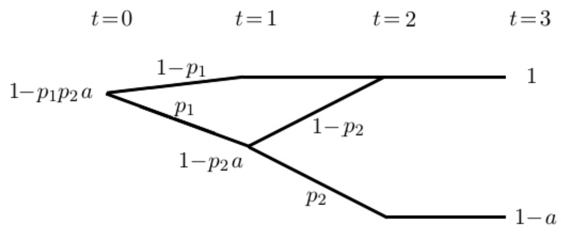


Figure 1: Event tree that represents the evolution of the expected payoff y_t of the assets.

will yield 1 with certainty (I refer to this as a 'good shock at $t = 1$'), or the uncertainty remains until $t = 2$ (denoted as 'bad shock at $t = 1$'). The respective probabilities of the two cases are $1 - p_1$ and p_1. In the latter case, the remaining uncertainty about the payoff at $t = 3$ is resolved by a signal at $t = 2$: there is either a signal that the assets will yield 1 (denoted as 'good shock at $t = 2$') or a signal that they will only yield $1 - a$ (denoted as 'bad shock at $t = 2$'). The respective probabilities are $1 - p_2$ and p_2. At $t = 3$, the payoffs are realized.

At $t = 0$, the initial owner of the bank sells debt and equity claims to the investors. Assuming that the initial owner wants to consume the revenue from this sale, her aim is to choose the capital structure that maximizes this revenue. For simplicity, assume that the investors are a continuum of risk-neutral agents who are willing to buy any security at $t = 0$, as long as its price equals the expected payoff of the security at $t = 1$. (This is equivalent to a risk-free interest rate $r = 0$.) Let us further assume that the bank has no outstanding debt at $t = 0$ and that after the initial choice of equity at $t = 0$ no new equity can be issued before $t = 3$. Besides choosing the level of the firm debt at $t = 0$, the bank chooses its duration, which can be short ($dt = 1$), medium ($dt = 2$) or long ($dt = 3$). The initial face values of short-term, medium-term and long-term debt are denoted as D_S, D_M and D_L, respectively. Short-term debt has to be rolled over at $t = 1$ and $t = 2$, while medium-term debt has to be rolled over once, at $t = 2$ (thereafter, it matures at $t = 3$).

2.1 The Optimal Choice of Debt for Providing 'Money-like' Claims

This section focuses on the provision of 'money-like' claims and determines the capital structure that is optimal for that purpose of debt financing. The disciplining role of debt financing is addressed in Section 2.2. Based on Gorton & Pennacchi (1990) and the related literature, let us assume that the investors have a particular demand for financial claims with a safe value, because they can use these claims as means of payment. Consequently, they are willing to pay a premium for safe, 'money-like' claims.[5] For the questions ad-

[5] A microfoundation of the premium following Gorton & Pennacchi (1990) could be based on transaction needs that investors have between the dates, when some agents already receive the shocks about the assets. Given such transaction needs in presence of asymmetric information, safe claims are beneficial as means of payment, because they avoid costs of adverse selection. Such a microfoundation, however, would not

dressed in this paper, it is sufficient to represent the benefits of safe claims in a simple form: by assuming that the investors pay a fee λ per unit of safe claim per unit of time (similar to a fee for a deposit account). 'Unit of claim' refers to a unit of expected payoff at the maturity date of the debt, which is equal to the face value in case of safe debt. The fees are paid at the very end, after paying off the debt at $t = 3$,[6] and debt claims only earn a fee λ if they are already safe when they are issued at $t = 0$.[7]

The analysis starts with the case that the bank issues a **single debt tranche**. This means that the entire bank debt has the same duration $d \in \{S, M, L\}$ and the same seniority. The premium $\Lambda(D_d; d)$ that the bank can earn from providing safe claims depends on the debt level D_d and the debt duration d as follows:

$$\Lambda(D_L; L) = \lambda \cdot \begin{cases} 3\,D_L & \text{for } \; D_L \in [0, 1-a] \\ 0 & \text{for } \; D_L > 1-a \end{cases}$$

$$\Lambda(D_M; M) = \Lambda(D_M; L)$$

$$\Lambda(D_S; S) = \lambda \cdot \begin{cases} 3\,D_S & \text{for } \; D_S \in [0, 1-a] \\ (3-2p_1)D_S & \text{for } \; D_S \in (1-a, 1-p_2 a] \\ 0 & \text{for } \; D_S > 1-p_2 a \end{cases}$$

For $D_L \leq 1-a$, the long-term debt is safe from $t = 0$ until $t = 3$ and leads to a premium $\lambda \cdot 3\,D_L$. For $D_L > 1-a$, the long-term debt is risky and yields no premium. Given the simple structure imposed above, the premium for medium-term debt is the same as for long-term debt: for $D_M \leq 1-a$, the debt is safe from $t = 0$ until $t = 2$, when it can be rolled over without a change of the face value, since $r = 0$ and the payoff $1-a$ at $t = 3$ is safe. If the bank issues $D_M > 1-a$ at $t = 0$, in contrast, the debt is risky and yields no premium. In case of short-term debt, a claim with $D_d \leq 1-a$ is also safe until $t = 3$, and the roll-overs at $t = 1$ and $t = 2$ do not change the face value. If there is a good shock at $t = 1$, the same holds true for $D_S \in (1-a, 1-p_2\,a]$. But if there is a bad shock at $t = 1$ (which occurs with probability p_1), such a claim becomes risky from $t = 1$ onward. A roll-over is still possible for all $D_S \in (1-a, 1-p_2\,a]$ at $t = 1$, since the expected asset payoff $y_1 = 1-p_2\,a$ is weakly larger than D_S.[8] For $D_S > 1-p_2\,a$, the short-term debt is already risky at $t = 0$ and yields no premium.

Observation 1

The premium that can be earned by issuing a debt claim with short duration is larger than

change any results of this paper.

[6] This allows to ignore the tedious, but uninteresting effects of paid fees on the safety of the debt and on its repricing.

[7] I thus neglect the possibility that an initially risky claim, which becomes safe after an increase of the asset value, earns a fee from that point onward.

[8] The new face value $D^-_{S,1}$ is implicitly given by $D_S = (1-p_2)D^-_{S,1} + p_2\,(1-a)$.

the premium for issuing a debt claim with the same face value but longer duration:

$$\Lambda(D_S;S) \geq \Lambda(D_M;M) = \Lambda(D_L;L) \;\forall\; D_S = D_M = D_L \in \mathbb{R}^+$$

If a debt claim with face value D_d and $d \in \{M, L\}$ is safe, because the asset value y_t cannot fall below D_d until $t = 2$ or $t = 3$, then the asset value cannot fall below D_d until $t = 1$, either. This means that short-term debt with the same face value is safe, too. And given liquid markets, the short-term claim can be rolled over at $t = 1$ without a change of its face value and it remains safe until $t = 2$ and $t = 3$, too. The inverse relation, however, does not hold: short-term debt with $D_S \in (1 - a, 1 - p_2\, a]$ is safe until $t = 1$ (and until $t = 3$ in case of a good shock at $t = 1$), while medium- or long-term debt with the same face value is not safe, because the y_t can fall below that face value until $t = 2$.
The level of safe debt is constrained by the worst possible realization of the asset value y_t at different t. In order to study the choice of debt in presence of 'tail risk' – which means that the worst possible realization of y_t is low (i.e, a is large) but unlikely (i.e., p_1 and p_2 are small) – let us impose:

Assumption 1

$$\frac{(3 - 2\,p_1)(1 - p_2)}{p_1} > \frac{2\,(1 - a)}{a}\,.$$

Lemma 1
If Assumption 1 holds, the premium $\Lambda(D_d; d)$ has its unique maximum at $D_S = 1 - p_2 a$, which implies that short-term debt can generate a strictly larger premium than any level of debt with longer duration.

Proof: $\Lambda(1-p_2\, a; S) = \lambda \cdot (3-2\,p_1)(1-p_2\, a) > \lambda \cdot 3(1 - a) = \Lambda(1-a; M) = \Lambda(1-a; L)$, if Assumption 1 holds.

Short-term debt with $D_S = 1 - p_2\, a$ leads to a larger expected premium for safe claims than a debt level $1 - a$, which is safe in all possible states, if two conditions hold: first, the probability p_1 that the higher debt level $D_S = 1 - p_2\, a$ becomes risky after $t = 1$ is relatively small; second, the reduction $(1 - p_2)\, a$ of the debt face value, which would be necessary to achieve safety in all possible states, is relatively large.

Let us now consider the possibility that the bank issues **debt tranches with different durations and different seniority levels**. Since any safe level of medium- or long-term debt can be substituted by the same level of safe short-term debt, different durations cannot improve the provision of safe claims relative to just issuing short-term debt. Different seniority levels, however, enable the bank to issue claims that remain safe and earn a fee even if more junior claims have become risky after bad shocks. For senior short-term debt with initial face value D_S^I and junior short-term debt with initial face value D_S^{II}, the premium is

$$\Lambda\left(D_S^I, D_S^{II}\right) =$$

$$\lambda \cdot \begin{cases} 3\left(D_S^I + D_S^{II}\right) & \text{for } D_S^I + D_S^{II} \leq 1-a \\ (3-2\,p_1) D_S^{II} + (3-p_1\,p_2)\,D_S^I & \text{for } D_S^I \leq 1-a \ \wedge \ 1-a < D_S^I + D_S^{II} \leq 1-p_2\,a \\ (3-2\,p_1)\left(D_S^I + D_S^{II}\right) & \text{for } 1-a < D_S^I \ \wedge \ D_S^I + D_S^{II} \leq 1-p_2\,a \\ (3-2\,p_1) D_S^I & \text{for } D_S^I \leq 1-p_2\,a \ \wedge \ 1-p_2\,a < D_S^I + D_S^{II} \leq 1 \\ 0 & \text{for } 1-p_2\,a < D_S^I \end{cases}$$

The key difference to $\Lambda(D_S; S)$ is the second interval that is defined by $D_S^I \leq 1-a \wedge 1-a < D_S^I + D_S^{II} \leq 1-p_2\,a$. For debt levels in that interval, the following holds. If there is a good shock at $t = 1$, both debt tranches are safe until $t = 3$ and earn a premium $\lambda \cdot (D_S^I + D_S^{II})$. If there is a bad shock at $t = 1$ (which occurs with probability p_1), the junior debt D_S^{II} becomes risky. This implies that its face value has to be increased to $D_{1,-}^{II} = \frac{1}{1-p_2}\left(D_S^{II} - p_2 \cdot (1-a-D_S^I)\right)$, so that investors are willing to roll over the claim.[9] But the senior debt D_S^I remains safe in spite of the bad shock (since $D_S^I \leq 1-a$) and it can earn a premium λ for an additional period. If there is a good shock at $t = 2$, the bank remains solvent owing to $D_{1,-}^{II} + D_S^I \leq 1$ (see Footnote 9), so that the bank can earn a premium λ for D_S^I in the last period, too. But if there a bad shock at $t = 2$ (which occurs with conditional probability p_2), the bank becomes insolvent due to $D_{1,-}^{II} + D_S^I > 1-a$. And I assume that no fees can be earned after the bank has become insolvent ('the deposit accounts become closed').

Lemma 2
a) Dividing the debt into tranches with different seniority increases the premium:

$$\Lambda(D_S^I, D_S^{II}) \geq \Lambda(D_S^I + D_S^{II}, S) \ \forall \ D_S^I, D_S^{II} \in [0,1].$$

b) If Assumption 1 holds, the unique maximum of $\Lambda(D_S^I, D_S^{II})$ is the combination of senior debt with $D_S^I = 1-a$ and junior short-term debt with $D_S^{II} = (1-p_2)a$. The resulting premium $\Lambda(D_S^I, D_S^{II})$ is strictly larger than any premium $\Lambda(D_d; d)$ that can be achieved by a single debt tranche.

c) Adding further debt tranches does not allow for a higher premium Λ.

The proof is given in Appendix A. As indicated above, a bank that sells a single debt tranche has to make the following choice: either, it chooses a relatively low level of debt (i.e., $1-a$) which remains safe in all states, or it chooses a relatively high level of debt (i.e., $1-p_2\,a$) which is initially safe and remains so in case of a good shock, but becomes risky

[9] A roll over is possible, since $D_{1,-}^{II}$ is weakly smaller than $1-D_S^I$ (the maximal possible payoff after a good shock): $\frac{1}{1-p_2}\left(D_S^{II} - p_2 \cdot (1-a-D_S^I)\right) + D_S^I = \frac{1}{1-p_2}\left(D_S^{II} + D_S^I - p_2 \cdot (1-a)\right) \leq \frac{1}{1-p_2}\left(1-p_2\,a - p_2(1-a)\right) = 1$.

in case of a bad shock. Selling two tranches, in contrast, allows for both: a relatively high level $D_S^I + D_S^{II} = 1 - p_2\, a$ of debt that earns a premium as long as there is no bad shock, and a senior tranche with $D_S^I = 1 - a$ that remains safe and continues to earn a premium, even if there is a bad shock at $t = 1$. Further tranches do not improve the provision of safe claims, since $D_S^I + D_S^{II} = 1 - p_2\, a$ is already the maximal level of safe debt up to $t = 1$ (and for the case that there is no bad shock), while $D_S^I = 1 - a$ is the maximal level of debt that is safe until $t = 2$ and $t = 3$ in case of bad shocks.

Let me briefly sum up the results of this section. First, issuing short-term debt is always weakly better for providing safe, 'money-like' claims than debt of longer duration, because a claim that is safe over a longer period of time is also safe over a shorter one. Second, short-term debt is strictly better for this purpose, if there is tail risk, which means that a strong decline of the asset value is possible, but unlikely. In that case, only a low level of debt would be safe in all possible states, whereas short-term debt allows for issuing a high level of debt that is safe initially and that will remain so in most states. Third, issuing more than one debt tranche allows for a higher premium, because the more senior tranche remains safe and continues to earn a premium, even when the more junior tranche becomes risky.

2.2 The Optimal Choice of Debt for Disciplining Managers

This section focuses on the disciplining of managers by means of debt financing. The characteristics of the bank assets and the bank's possibilities of financing are the same as described at the beginning of Section 2. I neglect the premium Λ in this section by setting $\lambda = 0$, before the next section will address the choice of debt in presence of both, $\lambda > 0$ and potential to discipline managers with debt. My analysis of the disciplining effect of debt follows Diamond & Rajan (2000), who combine the arguments of Jensen (1986) and Calomiris & Kahn (1991). Jensen (1986) argues that debt is a 'hard claim' that constrains the 'free cash flow' within a bank, which can be misused by its managers. And Calomiris & Kahn (1991) argue that the possibility to withdraw debt quickly can stop misbehaving managers and can thus prevent losses from such misbehavior. I extend this literature by studying the optimal shortness of the debt duration, given different types of misbehavior by managers.

Let us assume that the bank assets are operated by managers who obtain special skills in this operation, so that firing them at $t = 1$ or $t = 2$ reduces the asset payoff by l. While operating the assets, the managers can start inefficient activities at $t = 0.5$ which provides private benefits for them if they are able to complete them. Assume that the managers can either start a short activity (like inappropriate expenses on luxury equipment) or a long activity (like engaging in bad deals for the bank, which are privately beneficial for the managers). The short activity is completed at $t = 1.5$ and reduces the asset payoff by δ_s. The long activity, in contrast, is completed at $t = 2.5$ and reduces the asset payoff by

$\delta_l > \delta_s$. The respective private benefits from the completed activities are $\mu\delta_x$ for $x \in \{s, l\}$, with $\mu \in (0, 1)$. If the activities can be stopped before completion, the are no losses and no benefits from them. Let us assume that in case of zero probability of completing any activity, managers start no activity (i.e., they choose $\delta_0 = 0$). To sum up, the manager problem at $t = 0.5$ is $\max_{\{x=s,l,0\}} \mu\, \delta_x\, \phi_C(x) + \epsilon_x$, where $\phi_C(x)$ denotes the probability of completing the chosen activity. This probability will be discussed in the following. The parameter ϵ_x, which has an infinitesimally small, but positive value for $x = 0$ and is zero otherwise, only represents that the managers choose $\delta_0 = 0$, if they have no chance to complete the short or long activity.

Assume that $l > \delta_l > \delta_s$ and that the bank is not able to write contracts at $t = 0$ which condition on the inefficient activities (for instance, because they are hard to distinguish from the normal operation of the firm). In this case, the equity holders tolerate if managers misbehave. If the equity holders notice at $t = 1$ or $t = 2$ that managers have started one of the two inefficient activities, they will not fire the managers, because that would lead to a larger loss (namely l) than keeping them and accepting their behavior (which costs either δ_l or δ_s). Consequently, $\phi_C(x) = 1$ for $x \in \{s, l\}$, as long as there is no disciplining by debt claims.

Let us start the discussion of debt financing with the case of a **single debt tranche** again, with D_d denoting the face value of this tranche and d denoting its duration. If all debt holders withdraw their debt at $t = 1$ or $t = 2$ and no investor is willing to buy the debt claims that have to be rolled over, then the bank has to be liquidated, which includes a replacement of the managers. A collective withdrawal of the debt can thus interrupt the manager activities before completion. In the following paragraphs, I explain how debt financing can discipline the managers, if they have to expect that the debt holders withdraw in response to activities they start. A necessary requirement is that they are 'less patient' than equity holders, which means that they have an incentive to withdraw in spite of the large loss l that the liquidation entails.

This is the case, if debt withdrawals are served sequentially, in order of their arrival, and if each debt holder holds a sufficiently small fraction α of the debt claims.[10] Let us assume that these two conditions apply. And consider the case $y_t - \delta_x < D_d$, where t is the maturity date of the debt with face value D_d and x indicates the activity started by the managers. If the other debt holders withdraw at t and there are no other investors buying bank debt instead, a single debt holder will also withdraw in order to receive $\alpha \cdot (y_t - l)$ on average instead of rolling over and receiving $y_r := \max\{0, y_t - l - (1 - \alpha)D_d\}$, which is smaller than $\alpha \cdot (y_t - l)$, since $D_d > y_t - l$. And no other investor will buy the fraction α of debt at a price larger than y_r, because the debt claim would only yield y_r, given that the others withdraw. But the income y_r is insufficient to pay out the withdrawing claim with face value $\alpha\, D_d$, so that that bank would still be liquidated. If the others debt holders

[10] The fraction α is sufficiently small, if $\alpha D_d < \min(y_t - l)$ with the latter being the lowest possible liquidation value of the assets.

did not withdraw, a single debt holder would still prefer to withdraw and to receive $\alpha\, D_d$ instead of rolling over and receiving $\alpha \cdot (y_t - \delta_x)$ on average.

For $y_t - \delta_x \geq D_d$, in contrast, the debt holders are willing to roll over their claim as long as the new face value $D_{d,t}$ of the claim is such that the expected payoff of the claim equals D_d.[11] This is possible for $y_t - \delta_x \geq D_d$, because $y_t - \delta_x$ is the expected payoff of the bank, and the payoff of the debt claim to the bank payoff equals D_d, if $D_{d,t}$ is set large enough. And neither the managers nor the equity holders have an incentive to offer another face value than $D_{d,t}$, because a smaller one would trigger withdrawals and the liquidation of the bank, while a larger one would shift expected payoffs to the debt holders without necessity.

To sum up, the optimal action of a holder of maturing debt is to withdraw if and only if the expected bank payoff $y_t - \delta_x$ is smaller than D_d. Withdrawals that occur in case of $y_t - \delta_x < D_d$ owing to $\delta_x > 0$ are key for the disciplining of managers, because the managers cannot expect to complete their inefficient activities. In this Section and the subsequent ones, I assume that investors can costlessly observe manager activities, before I comment on potential monitoring costs and the tension with the idea of safe claims as means of payment in Section 5. The implicit cost of debt as disciplining device is, however, that withdrawals and liquidations also occur in states with $y_t - \delta_x < D_d$ owing to a small value y_t of the assets. The relative benefits and costs can be represented by the 'agency costs' $\Delta(D_d; d)$, which is the sum of the expected loss due to liquidations and the expected loss due to manager activities. The agency costs depend on the level and duration of the bank debt as follows.

In case of long-term debt, there are no roll-overs, which implies: there are no withdrawals and costly liquidations, while the managers start the long activity, since they can always finish it. The agency costs for long-term debt are thus:

$$\Delta(D_L; L) = \delta_l \text{ for all } D_L \in [0, 1]\,.$$

In case of medium-term debt, there are no withdrawals and liquidations for $D_M \leq 1 - a - \delta_l$, because $y_t - \delta_x < D_M$ is not possible. For $D_M > 1 - \delta_l$, in contrast, the debt claims would be withdrawn at $t = 2$ in both states (i.e, for $y_2 = 1 - a$ and $y_2 = 1$), if the managers started the long activity. This implies $\phi_C(l) = 0$, so that the managers prefer to start the short activity, which can always be completed at $t = 1.5$ before medium-term debt has the chance to withdraw (i.e., $\phi_C(s) = 1$). One thus has to distinguish two cases for $D_M > 1 - \delta_l$: for $D_M \in (1 - \delta_s, 1]$, the debt claims will be withdrawn at $t = 2$ in both states (i.e, for $y_2 = 1 - a$ and $y_2 = 1$); for $D_M \in (1 - \delta_l, 1 - \delta_s]$, however, there are withdrawals and a liquidation at $t = 2$ only in case of $y_2 = 1 - a$, i.e. after two bad shocks which occur with probability $p_1\, p_2$. Similarly, for $D_M \in (1 - a - \delta_l, 1 - \delta_l]$, a withdrawal

[11] Since I consider liquid markets (by assuming that there is sufficient demand for fairly priced claims), I can neglect the problem of non-fundamental runs. They will be studied in a follow up paper.

only occurs after two bad shocks that lead to $y_2 = 1 - a$, even if the managers start the long activity. The managers thus start the long activity, if $(1 - p_1 p_2)\delta_l > \delta_s$, because their private benefit from a long activity (which can be finished with probability $1 - p_1\, p_2$) is larger than the benefit from a short activity. Assuming that this condition holds,[12] the agency costs Δ for medium-term debt are given as:

$$\Delta(D_M; M) = \begin{cases} \delta_l & \text{for } D_M \in [0, 1 - a - \delta_l] \\ (1 - p_1\, p_2)\, \delta_l + p_1\, p_2\, l & \text{for } D_M \in (1 - a - \delta_l, 1 - \delta_l] \\ \delta_s + p_1\, p_2\, l & \text{for } D_M \in (1 - \delta_l, 1 - \delta_s] \\ \delta_s + l & \text{for } D_M \in (1 - \delta_s, 1] \end{cases}$$

Given that $l > \delta_l$ and $(1 - p_1 p_2)\delta_l > \delta_s$, the agency costs $\Delta(D_M; M)$ are minimized either at $D_M \in [0, 1 - a - \delta_l]$ or at $D_M \in (1 - \delta_l, 1 - \delta_s]$. In the second case, there is a disciplining effect of medium-term debt (managers choose δ_s instead of δ_l), but there is also a costly liquidation after bad shocks. The first case, in contrast, implies neither any disciplining nor any liquidations.

The effects of short-term debt are similar to those of medium-term debt, but there are two important differences. First, the withdrawal of short-term debt can stop even the short activity. For $D_S \in (1 - \delta_s, 1]$, this would happen whenever managers start this activity, such that they refrain from it in that case. For $D_S \in (1 - \delta_l, 1 - \delta_s]$, however, managers start the short activity, because they can finish it in case of a good shock at $t = 1$ that implies $y_1 = 1$. Second, there can be withdrawals and a liquidation already at $t = 1$ in case of a bad shock, which occurs with probability p_1. This holds for short-term debt with $D_S > y_-$, where y_- denotes the expected payoff of the bank conditional on a bad shock at $t = 1$ (which constitutes the upper bound for the face value of short-term debt that can be rolled over in that state). For conciseness, I present y_- and $\Delta(D_S; S)$ here only for the case that $\delta_s < \delta_l < p_2(a+l)$, on which the following analysis will focus by imposing Assumption 2 b). Given $\delta_s < \delta_l < p_2(a + l)$, the critical value y_- is $1 - p_2\, a - p_2\, l - (1 - p_2)\delta_l$.[13] This is larger than $1 - a - \delta_l$ (so that no liquidations occur at $t = 1$ for $D_S \leq 1 - a - \delta_l$), but it is smaller than $1 - \delta_l$ (so that a liquidation occurs at $t = 1$ with probability p_1 for

[12] This condition also follows from $l > \delta_l$ and Assumption 2 a), which will be imposed later.

[13] The expected payoff of the bank equals $1 - p_2\, a - p_2\, l - (1 - p_2)\delta_l$ in case of a bad shock at $t = 1$, because: with a conditional probability $1 - p_2$, the bank value increases to $1 - \delta_l$; and with conditional probability p_2, the bank value decreases to $1 - a - l$ (since the assets will be liquidated after a second bad shock given a debt level higher than $1 - a$). [To prevent the loss δ_l in the good state, a debt level larger than $1 - \delta_l$ would be needed, which is larger than $1 - p_2\, a - p_2\, l$ and could not be rolled over in case of a bad shock at $t = 1$, either.]

$D_S > 1 - \delta_l$). Consequently, the agency costs for short-term debt are given as

$$\Delta(D_S; S) = \begin{cases} \delta_l & \text{for } D_S \in [0, 1-a-\delta_l] \\ \big(1 - \phi(D_S; S)\big)\, \delta_l + \phi(D_S; S)\, l & \text{for } D_S \in (1-a-\delta_l, 1-\delta_l] \\ (1-p_1)\delta_s + p_1\, l & \text{for } D_S \in (1-\delta_l, 1-\delta_s] \\ p_1\, l & \text{for } D_S \in (1-\delta_s, 1] \end{cases}$$

where $\phi(D_S; S)$ is the probability of a debt withdrawal at either $t = 1$ or $t = 2$ in case of short-term debt with face value D_S. The agency costs $\Delta(D_S; S)$ are minimized either at $D_S \in [0, 1-a-\delta_l]$ or at $D_S \in (1-\delta_s, 1]$, because of $\delta_l < l$ and $\delta_s > 0$. As for medium-term debt, the first case implies neither any disciplining nor any liquidations, whereas both effects are present in the second case. In contrast to the medium-term debt, however, the disciplining is stricter in that case (even the short activity with costs δ_s is suppressed), while liquidations occur more often (already after one bad shock, which occurs with probability p_1).

Having identified the relative minima of $\Delta(D_d; d)$ for the different debt durations, we can study which duration minimizes the agency costs. Consider a scenario in which the loss from either manager activity is relatively small compared to the loss from liquidating the bank. In addition, let us stay with the assumption of the previous section that the potential 'shocks' to the bank assets are large (i.e., a is large), but unlikely (i.e., p_1 and p_2 are relatively small). More precisely, let us impose the following assumption that accounts for these properties:

Assumption 2

a) $p_1\, p_2\, l < \delta_l - \delta_s$

b) $(1+p_2)\delta_l < p_2\,(a+l)$ *and* $\delta_s < p_1\,(1-p_2)\, l$

Lemma 3

If Assumption 2 a) holds, $D_M \in (1-\delta_l, 1-\delta_s]$ is the level of medium-term debt that minimizes the agency costs $\Delta(D_M; M)$. And the corresponding agency costs are strictly smaller than for any level of long-term debt:

$$\Delta(1-\delta_s; M) < \Delta(D_L; L)\ \forall\ D_L \in [0, 1].$$

If Assumption 2 b) holds in addition, medium-term debt with $D_M \in (1-\delta_l, 1-\delta_s]$ also leads to strictly smaller agency costs than any level of short-term debt:

$$\Delta(1-\delta_s; M) < \Delta(D_S; S)\ \forall\ D_S \in [0, 1].$$

Proof: The first statement holds, if $\delta_s + p_1\, p_2\, l$ (the value of Δ at $D_M \in (1-\delta_l, 1-\delta_s]$, which is one relative optimum of medium-term debt) is smaller than δ_l (the value of Δ for long-term debt and at $D_M \in [0, 1-a-\delta_l]$, which is other relative optimum of medium-term debt). This holds if Assumption 2 a) is true. And it also implies that the agency costs at $D_M \in (1-\delta_l, 1-\delta_s]$ are smaller than at the relative minimum $D_S \in [0, 1-a-\delta_l]$ of agency costs in case of short-term debt. The second relative minimum in case of short-term debt is $\Delta = p_1\, l$ at $D_S \in (1-\delta_s, 1]$. This is larger than $\delta_s + p_1\, p_2\, l$, if the second relation in Assumption 2 b) holds. Assumption 2 b) also implies that $\delta_s < \delta_l < p_2\,(a+l)$, which has been used in deriving the function $\Delta(D_S; S)$ stated above.

Choosing a high level of medium-term debt restrains managers form starting the long activity and it thus reduces the loss due to the misbehavior of managers. This reduction is losses can be larger than the expected loss from a liquidation in case of a low asset payoff, which the high level of debt entails. This holds, if the probability of bad shocks is small compared to the costs which are saved by preventing the long activity (as given by Assumption 2). In that case, medium-term debt is strictly better than long-term debt, which does not discipline the managers.
A high level of short-term debt can discipline the managers. But it does so in a less efficient way than medium-term debt, if two conditions stated in Assumption 2 b) apply. The first relation in Assumption 2 b) implies that the level of debt necessary to discipline managers (which is $D_S > 1-\delta_l$) is so high that a bad shock at $t=1$ leads to a withdrawal of the short-term debt due to $y_- < D_S$. This means that the bank would be liquidated at $t=1$ even if the decline in the asset value y_t is only 'transitory', which means that the value recovers at $t=2$ owing to a good shock. Medium-term debt, in contrast, allows for a recovery of the asset value after a transitory decline before the debt becomes due at $t=2$. This implies that the disciplining of managers with short-term debt leads to an expected liquidation loss which is larger than in case of medium-term debt by the amount $p_1(1-p_2)l$. This relative cost is larger than the relative benefit of short-term debt, which is the prevention of the short manager activity that causes a loss δ_s, if the second relation in Assumption 2 b) holds. In that case, short-term debt is a less efficient disciplining device than medium-term debt.

Let us now consider the possibility that the bank issues several **debt tranches with differing durations and different seniority levels**. The face values of the different tranches shall be denoted as D_d^i with $i = I, II, ...$ increasing with decreasing seniority. Tranches with different seniorities are compatible with a sequential servicing of withdrawals, if this sequential servicing applies to each tranche separately. This means that a withdrawing holder of an infinitesimal fraction of the tranche j is only paid off as long as $y_t - \delta_s^c - l - \sum_{i=1}^{j-1} D_d^i - w_j \geq 0$, where w_j is the sum of previous withdrawals in that tranche and δ_s^c equals δ_s if the short manager activity has been completed before the tranche j has the chance to withdraw, otherwise $\delta_s^c = 0$. Given this implementation of the sequential servicing, debt holders only have an incentive to withdraw their short- or medium-term debt tranche D_d^j in response to an ongoing short ($x = s$) or long ($x = l$) activity of man-

agers, if $y_t - l - \sum_{i=1}^{j-1} D_d^i > 0$ and $y_t - \delta_x - \sum_{i=1}^{j-1} D_d^i < D_d^j$. The first condition ensures that the debt holder who withdraws first will receive a non-vanishing payoff, so that she has an incentive to withdraw at all; and the second condition means that the expected payoff after a roll-over is smaller than D^j due to δ_x and a low y_t, so that the investors prefer to withdraw rather than to roll over. This implies that the disciplining mechanism only works, if there is at least one tranche for which both conditions hold.
In discussing the duration of the different debt tranches, I focus on combinations of short- and medium-term debt, since long-term debt is equivalent to equity with respect to the disciplining of managers. And as indicated in the previous paragraph, two or more tranches with the same duration do not lead to a better disciplining of the managers than just one tranche with the same duration and a face value that equals the sum of the face values of the tranches. Consequently, there is only one interesting case to study: the combination of one tranche of short-term debt (with face value D_S^I) and one tranche of medium-term debt (with face value D_M^{II}). (The indices assign seniority to the short-term debt, but I will briefly comment on the inverse case, too.)
The disciplining of managers by short- or medium-term debt is restricted to cases with $D_S^I + D_M^{II} > 1 - \delta_l$. The managers only refrain from starting the long activity, if they have to expect that the activity would always be interrupted by withdrawals at $t = 1$ or $t = 2$. Given a debt level $D_S^I + D_M^{II} > 1 - \delta_l$, the probability of a liquidation of the assets is at least $p_1\, p_2$, which is the probability of the asset value $1 - a$ at $t = 2$. This means that any disciplining entails a liquidation loss of at least $p_1\, p_2\, l$. The agency costs in case of a single tranche of medium-term debt with $D_M \in (1 - \delta_l, 1 - \delta_s]$ are $p_1\, p_2\, l + \delta_s$. This implies that the two debt tranches can only achieve smaller agency costs than a single tranche of medium-term debt, if they prevent the short manager activity. The managers only refrain from starting a short activity, if they have to expect that this activity will be stopped by a withdrawal at $t = 1$, even in case of a good shock. This is only the case for, either, senior short-term debt with $D_S^I > 1 - \delta_s$, or for junior short-term debt with $D_S^{II} + D_M^I > 1 - \delta_s$. In both cases, the disciplining effect of the tranches as well as the probability of a liquidation would be same as for just one tranche of short-term debt with $D_S > 1 - \delta_s$. This leads to the result:

Lemma 4

Issuing debt tranches with different durations or seniorities does not decrease the agency costs Δ relative to just issuing one tranche of debt:

$$\forall\ j \in \mathbb{N} :\ \forall\ \left\{D_{d^i}^i\right\}_{i=I}^{j}\ \textit{with}\ D_{d^i}^i \in [0,1]\ \textit{and}\ d^i \in \{S, M, L\}\ \textit{for}\ i = I, II, ..., j :$$
$$\exists\ (D_d; d) \in [0,1] \times \{S, M\} :\ \Delta(D_d; d) \leq \Delta\left(\left\{D_{d^i}^i\right\}_{i=I}^{j}\right)$$

If Assumption 2 holds, the agency costs Δ are thus minimized by medium-term debt with $D_M \in (1 - \delta_l, 1 - \delta_s]$, even if the bank can issue different debt tranches.

The proof is implicitly given in the paragraph that leads to this lemma. Let me briefly sum up the results of this section. The optimal capital structure for the purpose of disciplining managers depends on the characteristics of the bank. If managers can cause large losses by long-lasting misbehavior, while the risk of the bank assets is relatively small, then it is efficient to restrain managers from such misbehavior by a large level of debt that can be withdrawn at intermediate dates in response to potential misbehavior by managers. And it is more efficient to issue medium-term rather than short-term debt for this purpose, if there might be a transitory shock (to which short-term debt is more sensitive than medium-term debt), while misbehaving managers can only cause relatively small losses in the short run.

3 The Trade-Off between the Disciplining of Managers and the Provision of Safe Debt

Let us now study the decision problem of the initial bank owner in presence of both, the agency costs Δ due to misbehaving managers as well as the premium Λ from providing money-like claims. This section focuses on the trade-off between the two purposes of debt financing with respect to the choice of capital structure. The conceptual tension between the monitoring of bank managers and the demand for safe claims as means of payment is addressed in Section 5. Let us thus assume in this section that the manager behavior can be observed costlessly by all agents at the dates $t = 1$ and $t = 2$. And to simplify notation, let us set $\delta_s = 0$.

3.1 The Functional Form of Δ and Λ in Presence of Both Frictions

If one simultaneously accounts for both, the agency problem and the premium for safe claims, the form of Δ and Λ as functions of $(D_d; d)$ or $\{D^i_{d^i}\}_i$ remains almost the same as stated above, given the assumptions imposed in the previous sections. Since the fee λ is paid at the very end, after the payment of the debt, it has no impact on the withdrawal decisions of the investors or on the manager decisions – this means it has no impact on Δ. Vice versa, the losses δ_l and l from manager activities and liquidations only shift the boundaries of the intervals in Λ. The occurrence of these losses depending on the debt structure has been described in the previous section. Staying with $\delta_l < p_2(a + l)$ (which is given by Assumption 2 b), the premium $\Lambda \left(D^I_S, D^{II}_S\right)$ for two tranches of short-term debt, for instance, is given as:

$$\Lambda\big(D_S^I, D_S^{II}\big) = \lambda \cdot \begin{cases} 3\,\tilde{D}_S & \text{for } \tilde{D}_S \leq 1-a-\delta_l \\ (3-2\,p_1) D_S^{II} + \big(3-p_1\,p_2\big)\, D_S^I & \text{for } D_S^I \leq 1-a-l \;\wedge\; 1-a-\delta_l < \tilde{D}_S \leq y_- \\ (3-2\,p_1)\,\tilde{D}_S & \text{for } 1-a-l < D_S^I \;\wedge\; 1-a-\delta_l < \tilde{D}_S \leq y_- \\ (3-2\,p_1) D_S^I & \text{for } D_S^I \leq 1-p_2\,a-l \;\wedge\; y_- < \tilde{D}_S \leq 1 \\ 0 & \text{for } 1-p_2\,a-l < D_S^I \;\wedge\; y_- < \tilde{D}_S \leq 1 \end{cases}$$

where $\tilde{D}_S := D_S^I + D_S^{II}$ denotes the joint face value of the two tranches. And as introduced above and derived in Footnote 13, $y_- = 1 - p_2\,a - p_2\,l - (1-p_2)\delta_l$ is the largest possible face value of short-term debt that can be rolled over at $t = 1$ in case of a bad shock. A more detailed explanation of the small shifts in the interval boundaries of $\Lambda\left(D_S^I, D_S^{II}\right)$ is given in Footnote[14].
The analysis in the previous section has imposed Assumption 1 in order to discuss the provision of safe debt in presence of 'tail risk', which means that the potential decline of the asset value is relatively large, but unlikely. Let us now impose an analogue to this assumption which accounts for the potential losses from the agency problem:

Assumption 3

$$\frac{(3-2\,p_1)(1-p_2)}{p_1 \cdot p_2} - \frac{3p_2 + 2p_1(1-p_2)}{p_1 \cdot p_2}\,\frac{l-\delta_l}{a} > \frac{1-a-l}{a}.$$

Lemma 5
If Assumptions 2 and 3 hold, the unique maximum of the premium $\Lambda(D_S^I, D_S^{II})$ is the combination of senior short-term debt with face value $D_S^I = 1 - a - l$ and junior short-term debt with face value $D_S^{II} = (1-p_2)(a + l - \delta_l)$. Adding further tranches does not allow for a higher premium Λ.

The proof is given in Appendix B. The lemma holds for the same reasons as Lemma 2, because it is just a generalization of that lemma for non-vanishing δ_l and l.

3.2 The Optimal Capital Structure of the Bank

Having determined the choices of debt that optimize Λ and Δ respectively, we can now proceed to the overall bank problem. As mentioned, I assume the initial owner of the bank wants to maximize the expected payoff of the equity and debt claims that she sells at $t = 0$. The expected payoff of the sum of these claims is equal to the expected payoff

[14] For $D_S^I + D_S^{II} \leq 1 - \delta_l$, the managers start the long activity which reduces the bank payoff in the low state to $1 - a - \delta_l$. For debt levels larger than $1 - a - \delta_l$, the activity will be interrupted in the low state, which causes the loss l instead of δ_l. The highest possible face value of short-term debt that can be rolled over at $t = 1$ in case of a bad shock is no longer $1 - p_2\,a$, but $y_- = 1 - p_2\,a - p_2\,l - (1-p_2)\delta_l$. For debt levels $D_S^I + D_S^{II}$ larger than y_-, there will be a liquidation and a loss l at $t = 1$ in case of a bad shock, so that the face value of a safe claim cannot be larger than $1 - p_2\,a - l$.

$y_0 = 1 - p_1\, p_2\, a$ of the bank assets, minus the expected agency costs Δ, plus the expected premium Λ. The initial owner thus solves

$$\max_{j \in \mathbb{N}\,,\, D^i_{d^i} \in [0,1] \text{ and } d^i \in \{S,M,L\} \text{ for } i=I,..,j} \quad y_0 + \Lambda\left(\{D^i_{d^i}\}^j_{i=1}\right) - \Delta\left(\{D^i_{d^i}\}^j_{i=1}\right) .$$

Since y_0 is fixed, the problem consists of maximizing the expression $\Lambda - \Delta$. The analysis presented in previous sections leads to:

Proposition 1

If Assumptions 2 and 3 hold, the bank faces a conflict between providing safe claims and disciplining the managers efficiently. There is no debt structure that simultaneously maximizes Λ and minimizes Δ:

$$\Lambda\left(\left\{D^{I*}_S, D^{II*}_S\right\}\right) - \Delta\left(\{D^{I\,*}_M\}\right) > \Lambda\left(\{D^i_{d^i}\}^j_{i=1}\right) - \Delta\left(\{D^i_{d^i}\}^j_{i=1}\right)$$
$$\forall\, j \in \mathbb{N},\ D^i_{d^i} \in [0,1] \text{ and } d^i \in \{S, M, L\} \text{ for } i = I, .., j\,,$$

where $\left\{D^{I*}_S, D^{II*}_S\right\} = \{1 - a - l, (1 - p_2)(a + l - \delta_l)\}$ *is the maximum of* $\Lambda\left(\{D^i_{d^i}\}^j_{i=1}\right)$ *and* $D^{I\,*}_M \in (1 - \delta_l, 1]$ *is the minimum of* $\Delta\left(\{D^i_{d^i}\}^j_{i=1}\right)$.

Proof: The proposition follows directly from the results in the Lemmas 4 and 5 . As shown in Lemma 5, any set of debt tranches that maximizes the premium $\Lambda\left(\{D^i_{d^i}\}^j_{i=1}\right)$ must include two senior tranches of short-term debt with face values $D^{I\,*}_S$ and D^{II*}_S. And as shown in Lemma 4, any set of tranches that minimizes the agency costs $\Delta\left(\{D^i_{d^i}\}^j_{i=1}\right)$ must have the same disciplining effect as medium-term debt with face value $D^{I\,*}_M$. This implies that there must a set of debt tranches with short or medium duration and a joint face values larger than $1 - \delta_l$. Consequently, the only possibility to simultaneously maximize Λ and minimize Δ would be to add a third, junior tranche of debt to the set $\left\{D^{I\,*}_S, D^{II*}_S\right\}$ and choose the face value D^{III}_d such that $D^{I\,*}_S + D^{II*}_S + D^{III}_d > 1 - \delta_l$. But this debt structure does not minimize the agency costs, as I will explain in the following. This result also holds for a subdivision of D^{III}_d into different tranches.
Let me start with the case of medium-term debt (i.e., $d = M$). The debt level $D^{I\,*}_S + D^{II*}_S + D^{III}_M > 1 - \delta_l$ implies $D^{III}_M > p_2 \cdot (a + l - \delta_l)$. And it implies that the managers do not start the long activity. The loss due to manager activities is thus as small as for $\{D^{I\,*}_M\}$. But the overall costs Δ are still larger than $\Delta\left(\{D^{I\,*}_M\}\right)$, because the high debt level leads to a liquidation of the bank in case of a bad shock at $t = 1$, which occurs with probability p_1. This leads to an expected loss $p_1\, l > p_1\, p_2\, l$.[15] The reason is as follows: The short-term debt with intermediate seniority and face value D^{II}_S becomes risky in case of a bad shock at $t = 1$, since the conditional probability of $y_2 = 1 - a < D^{I\,*}_S + D^{II*}_S$ is larger than zero in that state. The debt claim will only be rolled over if its new face value

[15] In addition to these direct liquidation losses, the liquidation also implies that no further premium would be earned even on the most senior tranche with $D^{I\,*}_S$, leading to a smaller Λ than $\Lambda\left(\{D^{I\,*}_S, D^{II*}_S\}\right)$.

$D_{S,1}^{II}$ equals $a + l - \delta_l$.[16] The sum of the debt face values is then $D_{S,1}^{I} + D_{S,1}^{II} + D_{M}^{III} > (1 - a - l) + (a + l - \delta_l) + p_2 \cdot (a + l - \delta_l) = 1 - \delta_l + p_2 \cdot (a + l - \delta_l)$. Given Assumption 2 b), this is larger than 1. Consequently, the bank becomes insolvent at $t = 2$ and has to be liquidated, even in case of a recovery owing to a good shock. This susceptibility to a transitory shock weakly increases, if the bank reduces the duration of the debt D_d^{III} to $d = S$ or if it divides the tranche into smaller ones.

To sum up, Proposition 1 highlights that the two purposes of debt financing imply different optimal debt structures, which cannot be reconciled in the balance sheet of a bank. The capital structures that optimize the respective purposes of debt financing differ in two respect. First, while the level of safe debt is constrained by the worst possible values of the assets, the disciplining of managers requires a higher level of debt: ${D_M^I}^* > {D_S^I}^* + {D_S^{II}}^*$. Second, while short durations allow for issuing a larger volume of safe claims, medium-term debt is more efficient in disciplining the managers. Medium-term debt can still prevent the more costly activities of managers, but it does not lead to a costly liquidation of bank in case of a transitory shock. The differing optimal capital structures cannot be reconciled by a set of debt tranches with different durations. The high level of debt necessary for the disciplining would still be prone to transitory shocks, even if not all of the debt were short-term, but only the amount ${D_S^I}^* + {D_S^{II}}^*$ that optimizes the provision of safe claims.

4 Reconciliation within an Intermediation Chain

Having highlighted the conflict between disciplining managers and providing safe claims which a bank faces when it chooses its capital structure, this section shows how this conflict can be resolved by means of an intermediation chain. For this purpose, I extend the model studied above by the possibility that the investors can trade simple financial claims with each other. More precisely, I analyze the case that an investor who holds bank debt can sell its own debt, which is backed by the bank debt - this means: she can set up a fund that invests in the bank debt.

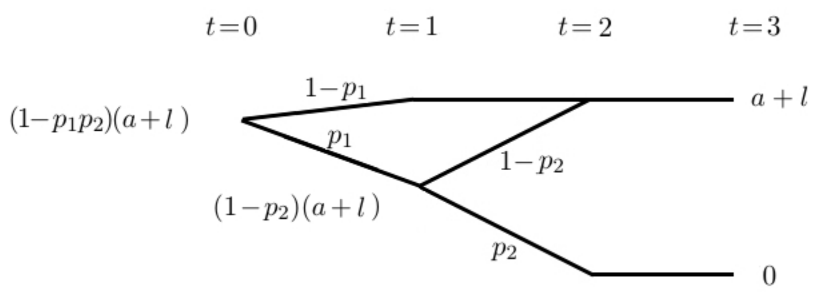
Let us start the analysis with considering that the bank issues a senior tranche of short-term debt with $D_S^I = 1 - a - l$ and a junior tranche of medium-term debt with $D_M^{II} = a + l$, so that $D_S^I + D_M^{II} = 1 = {D_M^I}^*$ (given that we set $\delta_s = 0$). If Assumptions 2 and 3 hold, this debt structure does not maximize the premium Λ for safe claims (as it deviates from the unique maximum $\{{D_S^I}^*, {D_S^{II}}^*\}$), but it minimizes the agency costs: $\Delta\left(\{D_S^I, D_M^{II}\}\right) = p_1\, p_2\, l = \Delta\left(\{{D_M^I}^*\}\right)$ (as explained in Footnote [17]). The medium-term

[16] The expected payoff the renewed claim with face value $D_{S,1}^{II}$ has to equal the face value D_S^{II} of the maturing claim. In case of a bad shock at $t = 1$, this holds for $D_{S,1}^{II} = a + l - \delta_l$, because $(1 - p_2)\min\{a + l - \delta_l, -D_S^I\} + p_2 \min\{a + l - \delta_s, 1 - a - l - D_S^I\} = (1 - p_2)(a + l - \delta_l) + p_2 \cdot 0 = D_S^{II}$.

[17] Due to $D_S^I + D_M^{II} = 1 > 1 - \delta_l$, the managers do not start the long activity. If there is a bad shock at $t = 1$, the senior short-term debt remains safe due to $D_S^I = 1 - a - l$ and it can hence be rolled over without a change of the face value: $D_{S,1}^I = D_S^I$. This implies that $D_{S,1}^I + D_M^{II} = 1$ and that the bank remains solvent in case of a good shock at $t = 2$. A liquidation thus only occurs with probability $p_1\, p_2$, in case of two bad shocks.

debt D_M^{II} is risky, since the outcome $y_2 - D_S^I = 1 - a - (1 - a - l) = l < D_M^{II}$ is possible.[18] But the value of the medium-term debt at $t = 1$ (i.e., its expected payoff at $t = 2$ given the information at $t = 1$) is bounded from below by its value in case of a bad shock, which is: $(1 - p_2) \min\{D_M^{II}, 1 - D_S^I\} + p_2 \cdot (1 - a - l - D_S^I) = (1 - p_2)(a + l)$. Consider that an investor holds this medium-term debt of the bank and sells debt claims to investors which are backed by the debt of the bank. If the debt sold to investors is short-term and its face value is weakly smaller than $(1 - p_2)(a + l)$, then this short-term debt is safe (in the first period and for the remaining periods as long as there is no bad shock). Investors are thus willing to pay a premium for it. Put differently, it is possible to set up a fund that holds the medium-term bank debt, while providing safe claims to investors.

To analyze this formally, let y_t^D denote the value of the D_M^{II}-claim at time t, which means its expected payoff at $t = 2$ given the information at date t. This value depends on the value y_t of the bank assets: $y_t^D = E_t\left[\min\{D_M^{II}, y_2 - D_S^I\}\right] = E_t\left[\min\{a + l, y_2 - (1 - a - l)\}\right]$. The evolution of y_t^D can be represented by the following event tree:



Let us consider a risk-neutral investor who holds the D_M^{II}-claim and who issues debt with face value M_d and duration d against this security. This implies that the investor provides the equity position of a fund that invests in the D_M^{II}-claim. I refer to this investor as 'fund sponsor'. After the next lemma, I will point out the incentive for an investor to become a fund sponsor. The fund described here is meant to represent a set of identical funds that jointly hold the entire D_M^{II}-claim, while a single fund only holds a fraction α of it. Consequently, the roll-over decision at $t = 2$ is still affected by the coordination problem, which is necessary for the disciplining of the managers.

The fund sponsor can earn a premium Λ_M, if there are investors who pay a fee λ per unit of safe claim per unit of time. Considering a single tranche of debt, the premium depends

[18] This implies that there is a liquidation in case of $y_2 = 1 - a$ which leads to a loss l.

on $(M_d; d)$ as follows:[19]

$$\Lambda_M(M_S; S) = \lambda \cdot \begin{cases} (3 - 2\,p_1)\, M_S & \text{for } \; M_S \leq (1-p_2)(a+l) \\ 0 & \text{for } \; (1-p_2)(a+l) < M_S \end{cases}$$
$$\text{and } \; \Lambda_M(M_M; M) = \Lambda_M(M_L; L) = 0 \;\forall\; M_M, M_L \in [0,1]\,.$$

No premium can be earned for medium- or long-term debt, since the lowest possible value of y_t^D at $t = 2$ is 0, so that any debt level larger than 0 would be risky. The optimization of Λ_M is trivial:

Observation 2
The fund maximizes the premium $\Lambda_M(M_d; d)$ by issuing short-term debt with face value $M_S = (1 - p_2)(a + l)$.

Given $r = 0$, the short-term debt with safe payoff M_S can be sold at $t = 0$ for the price M_S, while the price for the D_M^{II} claim is y_0^D. This implies that the fund sponsor has to invest the amount $y_0^D - M_S$ of its own wealth at $t = 0$. She is willing to do so, because an investment of this amount in other assets in the market would yield $r = 0$, while the equity position has the same expected return, but it enables to earn the premium Λ_M in addition.
In the scenario described in this section, the two purposes of debt financing are performed on two different levels of an intermediate chain. The bank issues debt with medium duration that efficiently disciplines the bank managers, as it prevents their engagement in costly long activities, while it allows for a recovery from a transitory shock. And the medium-term debt is held by a simple fund that provides safe claims by issuing short-term debt that is backed by the bank debt.
Before I come to the main result, let me briefly comment on the agency problem in the fund and its difference to the agency problem in the bank. The latter is due to the illiquidity of the bank assets, which results from special skills that managers obtain in their operation. Because of the costs of replacing bank managers, the bank owner cannot simply discipline them by the threat of firing them, but other disciplining devices are necessary. This contrast with the situation in the fund described above: the asset of the fund is publicly issued bank debt that can be held passively and that can be sold in a financial market, which has been described as liquid. Consequently, in case that the management of the fund is separated from the fund sponsor, the fund sponsor can simply discipline the fund managers by the threat of firing them, because selling the fund portfolio does not cause losses. For these reasons, I abstract here from an agency problem within the fund.[20] But

[19] Again, I assume that the fees are paid at the very end in order to avoid a tedious discussion of the uninteresting impact of paid fees on the safety and pricing of the M_d claim.

[20] The difference between a bank and a fund is motivated by the fact that the operation of a bank does not only consist of holding a pool of publicly traded securities, but that it entails specialized activities like loan provision, underwriting and many other specialized services.

I will return to the issue in Section 5, when I discuss the problem of delegated monitoring in case that information is costly.

Proposition 2

If Assumptions 2 and 3 apply, the following statements hold:

a) The intermediation chain minimizes the agency costs in the bank:

$$\Delta\left(\left\{{D_S^I}^\dagger, {D_M^{II}}^\dagger\right\}\right) = \Delta\left(\{{D_M^I}^*\}\right), \ \textit{with } \{{D_M^I}^*\} = \operatorname{argmin}\ \Delta\left(\{D_{d^i}^i\}_{i=I}^j\right).$$

At the same time, the chain provides more safe claims than a bank:

$$\Lambda\left(\left\{{D_S^I}^\dagger, {D_M^{II}}^\dagger\right\}\right) + \Lambda_M(M_S^\dagger) > \Lambda\left(\{{D_S^I}^*, {D_S^{II}}^*\}\right), \ \textit{with}$$
$${D_S^I}^\dagger = 1-a-l\,, {D_M^{II}}^\dagger = a+l\,, M_S^\dagger = (1-p_2)(a+l) \ \textit{and } \{{D_S^I}^*, {D_S^{II}}^*\} = \operatorname{argmax}\ \Lambda\left(\{D_{d^i}^i\}_{i=I}^j\right).$$

b) This implies that the intermediation chain is more efficient than a bank without fund:

$$\Lambda\left(\left\{{D_S^I}^\dagger, {D_M^{II}}^\dagger\right\}\right) - \Delta\left(\left\{{D_S^I}^\dagger, {D_M^{II}}^\dagger\right\}\right) + \Lambda_M(M_S^\dagger) \ > \ \Lambda\left(\{D_{d^i}^i\}_{i=I}^j\right) - \Delta\left(\{D_{d^i}^i\}_{i=I}^j\right)$$
$$\forall\ j \in \mathbb{N} \ \textit{and } D_{d^i}^i \in [0,1], d^i \in \{S, M, L\} \ \textit{for } i = I, ..., j\,.$$

This implies that both, the initial bank owner and the fund sponsor, can benefit from the formation of the intermediation, if the fund transfers a sufficiently large fraction $\omega \in [0,1]$ of $\Lambda_M(M_S^\dagger)$ to the bank.

c) The intermediation chain described above is the most efficient intermediation chain possible. This means that there are no sets of debt tranches $\{D_{d^i}^i\}_{i=I}^{j_D}$ issued by the bank and debt tranches $\{M_{d^i}^i\}_{i=I}^{j_M}$ issued by a fund (which holds the bank debt) that would lead to a larger $\Lambda - \Delta + \Lambda_M$:

$$\Lambda\left(\left\{{D_S^I}^\dagger, {D_M^{II}}^\dagger\right\}\right) - \Delta\left(\left\{{D_S^I}^\dagger, {D_M^{II}}^\dagger\right\}\right) + \Lambda_M\left(M_S^\dagger\right) \geq \Lambda\left(\{D_{d^i}^i\}_{i=I}^{j_D}\right) - \Delta\left(\{D_{d^i}^i\}_{i=I}^{j_D}\right) + \Lambda_M\left(\{M_{d^i}^i\}_{i=I}^{j_M}\right)$$
$$\forall\ j_D, j_M \in \mathbb{N} \ \wedge\ D_{d^i}^i \in [0,1], d^i \in \{S, M, L\} \ \textit{for } i = I, ..., j_D$$
$$\wedge\ M_{d^i}^i \in [0,1], d^i \in \{S, M, L\} \ \textit{for } i = I, ..., j_M.$$

The proof is given in Appendix C. Statement a) can be understood as follows. The overall debt level ${D_S^I}^\dagger + {D_M^{II}}^\dagger = 1$ of the bank in the chain is equal to the level ${D_M^I}^*$ that optimally disciplines the managers. Since a significant part of the debt is medium-term and the level ${D_S^I}^\dagger$ of short-term debt is not larger than the value of the bank that is safe in all states, transitory shocks do not lead to liquidations. Concerning the premium for safe claims, both, the bank and the intermediation chain, can issue two tranches of short-term debt that are safe initially. The most senior tranche of debt, which remains safe in all states, is the same for bank and intermediation chain: ${D_S^I}^\dagger = {D_S^I}^* = 1 - a - l$. The size of the second tranche of short-term debt, which is safe as long as there is no bad shock at $t = 1$, is constrained by the lowest possible bank value at $t = 1$ net of ${D_S^I}^\dagger = {D_S^I}^*$. This holds for a second tranche of short-term debt that is directly issued by the bank (with face value D_S^{II}) as well as for a second tranche of short-term debt that is issued by the fund (with face value M_S). In the latter case, the second tranche of debt refers to the payoff of the bank via the medium-term debt held by the fund. Since the high level of medium-term debt prevents the costly activity of the managers, the lowest possible bank value at $t = 1$ is $1 - p_2\,(a + l)$ in that case. If the second tranche of safe short-term debt is directly issued by the bank instead, this activity is not prevented and the lowest possible bank value at $t = 1$ is only $1 - p_2\,(a + l) - (1 - p_2)\delta_l$. Consequently, the second tranche of safe debt issued by the bank is smaller than the one issued by the chain.

Statement b) follows from the result just highlighted: simultaneously, an intermediation chain can achieve the optimal disciplining of the bank managers and it can provide a level of safe claims that is slightly larger than the maximal level case of a bank. This contrasts with the result of Proposition 1 that a bank without fund faces a trade-off between these two objectives and cannot simultaneously minimize Δ and maximize Λ. The disadvantage of a bank is that the two purposes of debt financing are in partial conflict with each other: the disciplining is optimized by a high level of debt, while the provision of safe claims is optimized by a level of short-term debt, which is sensitive to transitory shocks. And the combination of a high leverage with sensitivity to transitory shocks leads to a fragility that is inefficient due to the high probability of costly liquidations. The advantage of the intermediation chain is that the purposes of debt financing are partly separated. The bank chooses a high debt level in order to discipline its managers, but it avoids an excessive fragility with respect to transitory shocks by issuing some debt with medium duration. This means that the bank issues less short-term debt than it would, if it wanted to directly maximize the amount of safe claims that earn a premium. This relative reduction in the level of short-term debt is compensated by the fund. It holds the medium-term bank debt and sells safe short-term debt that is backed by the bank debt.

As mentioned, the level of safe debt that can be issued is constrained from above by the expected payoff of the bank in the worst possible states. This upper bound is not changed, if the issuance of the safe short-term debt is split into two steps (the most senior tranche is directly issued by the bank, the second tranche is issued by the fund). But this split implies that the second tranche of short-term debt refers to the bank payoff via the medium-term debt. This allows for resolving the conflict indicated above as follows. The bank issues a high level of medium-term debt that can discipline managers without being sensitive to transitory shock. The provision of safe claims is maximized by a level of short-term debt, which is also sensitive to a transitory shock, but which is issued by the fund instead of the bank. This implies: when the short-term debt of the fund becomes risky due to a shock (i.e., in case of a bad shock at $t = 1$), the increase in its face value (which is necessary in order to compensate for the risk and to avoid withdrawals) does not increase the liabilities of the bank and does not lead to costly liquidations. Instead, the increase of the face value only reduces the equity position provided by the fund sponsor. (As argued above, a fund should be subject to a smaller agency problem than a bank, so that fund equity entails smaller agency costs than bank equity.)

The efficiency gains that are available due to an intermediation chain can be shared between the fund and the bank, if the fund transfers a fraction ω of its premium Λ_M to the bank, so that the bank is better off within the chain than on its own. This means: if the bank receives a sufficiently large fraction of Λ_M, it prefers to issue ${D_S^I}^\dagger$ and ${D_M^{II}}^\dagger$ and to sell the medium-term debt to the fund instead of choosing another debt structure and selling all of its debt directly to the final investors. The fraction ω of Λ_M that is transferred from fund to bank depends on the bargaining situation between bank and fund (or on the competition in the market), which will not be further discussed here.

The intermediation chain presented in this section has not been an arbitrary example, but it represents the most efficient chain, as stressed by statement c). As mentioned, the two debt tranches $\left\{{D_S^I}^\dagger, {D_M^{II}}^\dagger\right\}$ of the bank ensures an optimal disciplining of the bank managers. Consequently, no other set of debt tranches of the bank lead to smaller agency cost Δ. At the same time, no other combination of debt tranches of bank and fund allow for issuing more safe claims and earning a larger premium Λ. The fund does not create any new cash flow, but the safe claims that the fund issues has to be backed by the payoff of the bank. The maximal amount of safe claims is thus constrained by the lowest possible bank value at $t = 1$ and $t = 2$, which is $1 - p_2 (a + l)$ and $1 - a - l$ respectively. And these upper bounds are already reached by the combination of ${D_S^I}^\dagger$ and $M_S^\dagger$.

To sum up, this section has illustrated that it can be optimal for a bank to become part of an intermediation chain with stepwise maturity transformation, because it resolves a conflict between two purposes of debt financing. The bank chooses a high level of debt which includes some safe, money-like debt as well as some risky debt with medium duration. This debt structure disciplines the bank managers without being too fragile with respect to transitory shocks. The medium-term debt is held by a fund which provides an additional amount of safe, money-like claims that are backed by the bank debt.

5 Discussion

Before I address the role of the fund as delegated monitor of the bank, let me first discuss whether the model analyzed above is a description of the optimal financing of banks in particular or of firms more generally.

5.1 Particular Features of Financial Firms

The bank has simply been characterized as a set of assets that are operated by managers. The results about the optimal form of financing might thus apply to any type of firm with these generic features. In fact, this broad interpretation seem to fit to some empirical pattern of maturity transformations in the financing of firms: while the loans that firms receive from banks usually have a relatively long duration, these loans often entail some type of reassessment of the credit condition before the firm investment matures[21], so that they can be interpreted as medium-term debt; the funding of the bank, in contrast, has a relatively short duration, so that the intermediation chain between firms and final investors entails a stepwise maturity transformation.

But the model seems to fit even better to financial firms and their funding structure, if one bears the range of parameters in mind on which the analysis has focused. The emergence of an intermediation chain has been rationalized for the parameter range expressed by the Assumptions 2 & 3. Using these assumptions, the focus has been on assets that are affected by large negative shocks with small probabilities p_1 and p_2. Since the assets of banks mainly consist of loans, which means senior claims to other firms or to private households, and since their balance sheets are usually very large and diversified, the portfolios of banks usually have relatively small variances. This notion is supported by empirical evidence that the portfolios of financial firms have much smaller standard deviations than the portfolios of other types of firms, as shown e.g. by Berg & Gider (2017). To the extent that a small standard deviation corresponds to a small probability of strong declines in the value of the portfolio, the model described in this paper fits particularly well to the banking sector.

Given the relatively small variance of their assets, banks are in a good position to provide safe claims as means of payment. At the same time, a small variance of the portfolio is advantageous, if a firm wants to discipline its managers with the coarse tool of choosing a high level of debt that can be withdrawn before the maturity of assets. The smaller the variance of the assets, the smaller is the probability that a costly withdrawal of the debt is triggered by a shock to the assets. Apart from that, banks might depend more than other firms on such a coarse disciplining device, because a resolution of the agency problem by writing and enforcing contracts with the managers might be particularly difficult in banks. This can be the case because banks are relatively large firms that do not produce standardized or tangible or easily quantifiable objects, but that 'produce' complex, customized contracts and transactions that allow for a lot of discretion.

5.2 Delegation of Monitoring

Let me now address the conceptual tension between debt as disciplining device and safe debt as a convenient means of payment, which can be used without risk of asymmetric information about its value. In a second step, I will then discuss how an intermediation chain can resolve this tension.

In case of the optimal debt structures identified above, there are two types of information that affect the payoff of debt claims: information about the occurrence of strong shocks

[21] Cf. for instance Roberts & Sufi (2009) and Roberts (2015).

to the bank assets, represented by the shocks at $t = 1$ and $t = 2$; and information about the activities of the bank managers. In particular, the debt holders are supposed to have information about ongoing activities of managers, so that they can react to it. It seems plausible that the first type of information is easily obtainable at roll-over dates even by those investors who value safe, 'money-like' claims between these dates. One might think of depositors who read the newspaper once a day and who would easily notice if there were particularly bad news about the bank in which they have deposits.

The second type of information is probably more difficult to obtain for the following reasons. First, misbehavior of managers is usually not reported in the news before it is completed. Second, noticing ongoing moral hazard by employees requires a close monitoring of a firm. It seems implausible that this close monitoring of manager activities can be performed by investors who briefly 'look' at the bank at roll-over dates.

An intermediation chain can resolve this tension between investors with demand for safe, 'informationally insensitive' debt and debt holders who are supposed to monitor the bank managers. The most senior tranche issued by the bank (the short-term debt with face value ${D_S^I}^\dagger$) is not affected by the manager behavior, but remains safe in all states and can thus be used as means of payment. The payoff of the second debt tranche (the medium-term debt with face value ${D_M^{II}}^\dagger$) is sensitive to the manager behavior and should be withdrawn at $t = 2$, if the managers engage in the long activity. This tranche, however, is held by a fund which does not use the medium-term debt as means of payment, but which can gather information and can monitor the bank and its managers. While performing the monitoring, the fund can issue a senior tranche (with face value ${M_S}^\dagger$) whose value is safe as long as there is no bad shock. The claim can thus be regarded as money-like, as long as this shock (which represents a strong decline of the bank assets) does not occur. And as discussed above, such a decline should be recognizable even by those who 'briefly check the news'.

The agency problem between the fund sponsor (who is supposed to provide the monitoring)[22] and the buyer of the $M_S^\dagger$ claim (who wants to have a safe claim) can be resolved, since the fund sponsor holds the equity position in the fund and thus incurs a loss from poor monitoring. If this loss is larger than the costs of monitoring, which shall be denoted as c_M, the fund has an incentive to monitor the bank.[23] Given an optimal capital structure with ${D_S^I}^\dagger + {D_M^{II}}^\dagger = 1$ and $M_S^\dagger = (1 - p_2)(a + l - \delta_s) < a + l - \delta_l$ (having set $\delta_s = 0$ for simplicity), the fund sponsor would incur the loss δ_l from poor monitoring in case of a good shock at $t = 1$. Consequently, if $(1 - p_1)\delta_l > c_M$, the fund sponsor has a sufficient incentive for monitoring.

Besides the monitoring, one might think of other dimensions of moral hazard that might

[22]The agency problem between fund sponsor and potential fund managers is addressed below.

[23]The expected costs of monitoring have to be priced in when the debt claims are sold, so that the fund is willing to buy the claims and to accept the role of a monitor. The monitoring costs thus effectively accrue to the bank owner, who yet benefits from the arrangement, because the monitoring costs are smaller than the reduction in the agency costs owing to the monitoring.

affect the fund. The sponsor, for instance, could change the portfolio structure and could shift risk to the investors. This kind of moral hazard, however, can be suppressed relatively easily in a fund. Since a fund is not a complex firm like a bank, the tolerated actions can simply be constrained by contracts.[24] Such contracts can fix the eligible set of securities that are held (as it is done in MMFs, for instance). Critics of this interpretation might point to the risk-taking by some MMFs after the start of the subprime crisis, which has been identified by Kacperczyk & Schnabl (2013). As shown in that article, however, the risk-taking of the funds was not at the expense of investors in the MMFs: first, they participated in the higher yields owing to the increased risk-taking; and second, when the runs on the MMFs started, the fund sponsors provided support to pay off the withdrawing investors. The situation between the start of the crisis and the run on the MMFs is actually in line with the model in case of a bad shock at $t = 1$: the debt of the fund is no longer safe from that point onward, but the investors are compensated for the risk by an increase of the face value (which implies higher yields in states in which the bank remains solvent); and this increase of the fund liabilities is at the expense of the equity position in the fund.

Remember that the fund discussed in Section 4 was meant to be representative for a set of funds, and each of these funds only holds a fraction α of the D_M^{II} claim. A distributed ownership of the debt maintains the coordination problem which is necessary for the disciplining effect of the debt. Since a fraction of the debt claim only incurs a fraction of the potential loss from poor monitoring, the condition stated above should rather be $\alpha(1 - p_1)\delta_l > c_M$. But the distributed holding of the debt also implies a free-riding problem with respect to costly monitoring. Calomiris & Kahn (1991) have pointed out that such a free-riding problem can be solved by the sequential servicing of the debt. I provide a sketch of a solution of the problem in Appendix D.

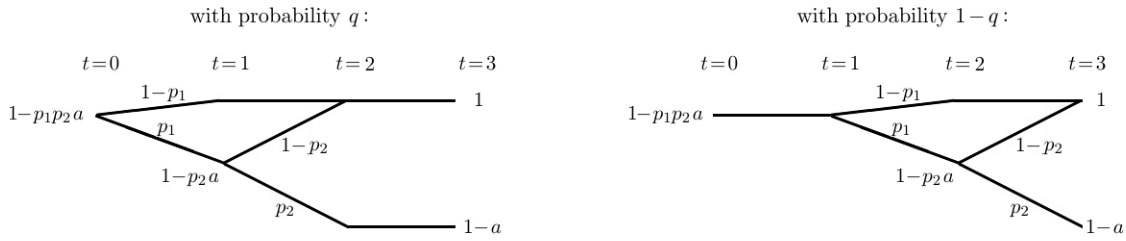
Let me conclude with a remark about a potential agency problem in case of a separation between management and ownership of the fund. The agency problem should be different from the one of a bank, in which firing managers is relatively costly, because managers might obtain special skills in the operation of the particular bank. The operation of a fund is much simpler than the operation of a bank, as it does not comprise an actual operation of a firm that produces something or starts new projects. It only consists of holding a predefined set of securities and monitoring the security issuer. Consequently, the replacement of fund managers should cause much smaller losses than the replacement of bank managers. If this is true, the fund sponsor can use simpler means of disciplining than the choice of capital structure, like the threat of firing fund managers that try to engage in costly activities at the expense of the fund sponsor.

[24] Note that the problem of monitoring the monitor is much simpler here than in Diamond (1984). Since the assets of the funds are publicly traded financial securities, the fund cannot misreport their payoffs as in Diamond (1984).

6 Staggered Debt Structures

This section illustrates how the results of the previous extend to a case with uncertainty about the timing of the shocks and it indicates why a staggered debt structure is the optimal capital structure of the bank in presence of this uncertainty. Furthermore, it points out that the optimal financing structure entails a shortening of the debt duration as consequence of a shock.

Assume that the two shocks about the bank assets, which have been described at the beginning of 2, occur at $t = 1$ and $t = 2$ only with probability q; and with probability $1 - q$, they occur at $t = 2$ and $t = 3$ instead. The evolution of the asset value can thus be illustrated as the weighted sum of the following two event trees:



Let me first present a certain debt structure and its consequences for the disciplining of managers and the liquidation probability, before I explain why the presented structure is the optimal one. Assume that the bank can issue two types of medium-term debt: one that lasts from $t = 0$ to $t = 2$ and is rolled over then, and one that is rolled over at $t = 1$ in order to last from $t = 1$ to $t = 3$. Let us consider the case that the bank issues three tranches of debt at $t = 0$ with the following face values and initial durations:

$$D_S^I = 1-a-l, \quad D_S^{II} = \frac{(1-p_1\,p_2)(1-p_2)}{2-p_1-p_2}(a+l), \quad D_M^{III} = \frac{(1-p_1)(1-p_2)}{2-p_1-p_2}(a+l).$$

As before, I set $\delta_s = 0$. Furthermore, let us impose[25]

Assumption 4 $: \delta_l > \frac{p_2-p_1\,p_2^2}{2-p_1-p_2} \cdot (a+l)\,.$

If this assumption holds, then $D_S^{II} + D_M^{III} = \frac{2-p_1-2p_2+p_1\,p_2^2}{2-p_1-p_2}(a+l) > a + l - \delta_l$, which implies that $D_S^I + D_S^{II} + D_M^{III} > 1 - \delta_l$. The managers will thus not engage in the costly, long activity, as the debt would be withdrawn and the bank would be liquidated in that case. Given that managers do not start the costly activity, there is no liquidation in case of just one bad shock, neither at $t = 1$ nor at $t = 2$. A costly liquidation of the assets only occurs after two bad shocks,[26] which means with probability $p_1\,p_2$. To show this, let me explain the state-contingent debt repricing.

[25]Note that this condition does not contradict the first inequality in Assumption 2 b), since $\frac{p_2-p_1\,p_2^2}{2-p_1-p_2} < p_2$ for $p_1 + p_2 < 1$.

[26]For the sake of a simple comparison with the previous analysis, I assume that a liquidation at $t = 3$ still causes a loss l.

If there is no shock at $t = 1$, then the event tree on the right-hand side above applies. The most senior claim with face value D_S^I remains safe and can be rolled over without change in the face value. Let us consider the roll-over of the D_S^{II} claim at $t = 1$ with a face value $D_{S,M}$ which becomes due at $t = 3$, which means that the claim has medium duration. The pricing of this claim has to take into account that the D_M^{III} claim matures at $t = 2$ and will only be rolled over, if the expected payoff of the rolled over claim equals D_M^{III}. In case of a bad shock at $t = 2$, however, the expected payoff of the bank is only $1 - p_2\,(a + l)$, which is smaller than $D_S^I + D_S^{II} + D_M^{III}$. Consequently, the D_M^{III}-claim can only be rolled over in that state, if the renewed claim has a short duration and becomes senior to the outstanding, medium-term $D_{S,M}$-claim. And the new face value $D^-_{M,S}$ of the D_M^{III} claim in that state has to be $\frac{1}{1-p_2} D_M^{III}$.[27] If the agents take this potential repricing at $t = 2$ into account, when the D_S^{II}-claim is rolled over at $t = 1$, the new face value $D_{S,M}$ has to be $\frac{1}{1-p_1\,p_2} D_S^{II}$.[28] As a result, the overall face value after a first bad shock at $t = 2$ is

$$D_S^I + D_{S,M} + D^-_{M,S} = 1 - a - l + \frac{1 - p_2}{2 - p_1 - p_2}(a + l) + \frac{1 - p_1}{2 - p_1 - p_2}(a + l) = 1 - a - l + (a + l) = 1.$$

The debt can thus be paid off as long as there is not a second bad shocks, but the asset value recovers to 1.

If a bad shock already occurs at $t = 1$, the event tree on the left-hand side above applies. The medium-term debt D_M^{III} is not rolled over at $t = 1$, and the D_S^I-claim can be rolled over without change in the face value, as it remains safe. The initially safe D_S^{II}-claim, however, becomes risky and has to be rolled over. Because the expected payoff of the bank in that state is only $1 - p_2\,(a + l) < D_S^I + D_S^{II} + D_M^{III}$, the roll-over is only possible, if the renewed claim is short-term and senior to the D_M^{III} claim. And the new face value $D^-_{S,S}$ has to be $\frac{1}{1-p_2} D_S^{II}$.[29] As a result, the overall face value after a bad shock at $t = 1$ is

$$D_S^I + D^-_{S,S} + D_M^{III} = 1 - a - l + \frac{1 - p_1\,p_2}{2 - p_1 - p_2}(a + l) + \frac{(1 - p_1)(1 - p_2)}{2 - p_1 - p_2}(a + l) = 1 - a - l + (a + l) = 1.$$

The debt can thus be paid off as long as there is not a second bad shocks, but the asset value recovers to 1.

To sum up, by issuing three claims with face values $\{D_S^I, D_S^{II}, D_M^{III}\}$ and a staggered maturity structure, the bank can have a debt level that is high enough to discipline the managers, while it can withstand transitory shocks at either date, $t = 1$ or $t = 2$. A

[27] Given this face value, the expected payoff of the claim equals D_M^{III}: $(1-p_2)D^-_{M,S} + p_2 \cdot (1-a-l-D_S^I) = (1 - p_2) \cdot \frac{1}{1-p_2} D_M^{III} = D_M^{III}$. The fact that $D^-_{M,S}$ can be fully paid off in case of a good shock at $t = 3$ follows from the analysis of the overall face value in the main text.

[28] As indicated in the main text, the debt can be fully paid as long as there not two bad shocks, which occur with probability $p_1\,p_2$. In case of two bad shocks, however, the assets are liquidated and yield $1-a-l$, so that only the most senior debt tranche can be paid off. The expected payoff of the claim with face value $D_{S,M} = \frac{1}{1-p_1\,p_2} D_S^{II}$ is thus $(1 - p_1\,p_2)D_{S,M} = D_S^{II}$.

[29] The pricing is analogous to the one in Footnote 27 with $D_M^{III} \to D_S^{II}$ and $D^-_{M,S} \to D^-_{S,S}$.

staggered debt structure means that the D_M^{III} claim lasts from $t = 0$ until $t = 2$, while D_S^{II} is rolled over at $t = 1$ in order to last until $t = 3$. Only in case of a bad shock, there is a shortening of the maturity structure. This means that the D_S^{II} claim is rolled over as short-term debt instead of medium-term debt, if there is a bad shock at $t = 1$.[30]

If Assumption 2 still holds, the staggered debt structure minimizes the agency costs Δ of the bank, because the expected liquidation loss $p_1\,p_2\,l$ (which the higher leverage necessarily entails) is smaller than the reduction δ_l in losses due to manager activities. The bank can sell the most senior tranche with face value D_S^I directly to investors who pay a fee λ for safe claims, and it can sell the two claims with staggered maturity structure to a fund, which can create an additional safe claim by means of tranching. As discussed in the main part of this paper, the maximum amount of safe debt that can be issued is constrained by the lowest possible bank values at the different dates. Given the debt structure described above, the lowest possible bank values coincide with the sum of D_S^I plus the values of the two junior debt tranches in these states, because the equity value of the bank is zero in the worst possible states. Consequently, if the bank sells D_S^I and the funds sells an appropriate tranching of the two junior debt tranches, the intermediation chain can provide the largest amount of safe claims that is possible. And that leads to the highest possible premium $\Lambda + \Lambda_M$.

[30]This feature of the debt structure is consistent with the shortening of the maturities of CPs during times of crisis, see e.g. Covitz et al. (2013).

A Proof of Lemma 2

Statement a) holds since $\Lambda(D_S^I, D_S^{II})$ comprises $\Lambda(D_S; S)$ for $D_S^{II} = 0$ and $D_S^I = D_S$. And b) follows from $(3 - 2\,p_1) < (3 - p_1\,p_2)$, which implies: first, that $D_S^I = 1 - a$ and $D_S^{II} = (1-p_2)a$ is the relative optimum of $\Lambda(D_S^I, D_S^{II})$ on the second interval; and second, that the value of $\Lambda(D_S^I, D_S^{II})$ at this optimum is strictly larger than $(3 - 2\,p_1)(1 - p_2\,a)$. This is the value of $\Lambda(D_S^I, D_S^{II})$ at the relative optima in the third and fourth interval, and it is the value of $\Lambda(D_S; S)$ at the optimum $D_S = 1 - p_2\,a$ in case of a single debt tranche. Statement c) follows from the observation that the lowest possible realizations of y_t at the different t constitute upper bounds for the level of safe debt in the different periods. These lowest possible realizations are $1 - p_2\,a$ at $t = 1$ and $1 - a$ at $t = 2$ and $t = 3$. The former (i.e., the upper bound for safe debt level in the first period) is reached by $D_S^I + D_S^{II}$ with $D_S^I = 1 - a$ and $D_S^{II} = (1 - p_2)a$, and the latter is reached by $D_S^I = 1 - a$. Consequently, no additional tranche of debt can increase the level of safe debt.

B Proof of Lemma 5

Due to $3 - p_1\,p_2 > 3 - 2\,p_1$ the maximum of $\Lambda(D_S^I, D_S^{II})$ is either $\big(D^I = 1 - a - l, D^{II} = (1 - p_2)(a + l - \delta_l)\big)$ or any combination of D_S^I and D_S^{II} with $D_S^I + D_S^{II} = 1 - a - \delta_l$. If Assumption 3 holds, the value of Λ is larger in the first case than in the second case. Further tranches cannot increase Λ, because the level of safe debt is bounded from above by the lowest possible bank values at $t = 1$ and $t = 2$, which implies that the maximal amount can be reached by a combination of two tranches.

And the lowest possible bank values at $t = 1$ and $t = 2$ cannot be increased above the values y_- and $1 - a - l$ for the following reason: The only possibility could be an increase of the lowest possible bank value at $t = 1$ above y_- by preventing a start of the long manager activity that causes the loss δ_l. As discussed in Section 2.2, this activity can only be prevented by a set of tranches with $D_S^I + D_S^{II} + \sum_{i=3} D_{d^i}^i > 1 - \delta_l$. But the D_S^{II} claim, which is safe and earns a fee as long as there is no bad shock, becomes risky in case of a bad shock at $t = 1$, so that its face value has to increase in order to be rolled over. As shown in the second paragraph below Proposition 1, however, this repricing in presence of an initial debt level $D_S^I + D_S^{II} + \sum_{i=3} D_{d^i}^i > 1 - \delta_l$ leads to such a high level of liabilities, that the bank will become insolvent at $t = 2$ even in case of a good shock. Consequently, there would be a liquidation loss l with certainty in case of a bad shock at $t = 1$, which implies that the maximal level of safe debt would be reduced to $1 - p_2\,a - l < y_-$.

C Proof of Proposition 2

The second statement in a) holds because of $\Delta\left(\{D_S^{I\dagger}, D_M^{II\dagger}\}\right) = p_1\, p_2\, l = \Delta\left(\{D_M^{I\,*}\}\right)$, as explained in Footnote 17. The first statement in a) follows from the fact that

$$\begin{aligned}\Lambda\left(\left\{D_S^{I\dagger}, D_M^{II\dagger}\right\}\right) + \Lambda_M(M_S^\dagger) =& \lambda\cdot(3-p_1\,p_2)D_S^{I\dagger} + \lambda\cdot(3-2p_1)M_S^\dagger \\ >& \lambda\cdot(3-p_1\,p_2)D_S^{I*} + \lambda\cdot(3-2p_1)D_S^{II*} = \Lambda\left(\{D_S^{I*}, D_S^{II*}\}\right),\end{aligned}$$

because $D_S^{I\dagger} = D_S^{I*} = 1-a-l$ while $M_S^\dagger = (1-p_2)(a+l) > (1-p_2)(a+l-\delta_l) = D_S^{II*}$.

Statement b) follows directly from statement a) and Proposition 1, which has shown that $\Lambda\left(\{D_S^{I*}, D_S^{II*}\}\right) - \Delta\left(\{D_M^{I\,*}\}\right) > \Lambda\left(\{D_{d^i}^i\}_{i=I}^j\right) - \Delta\left(\{D_{d^i}^i\}_{i=I}^j\right)\ \forall\ j\in\mathbb{N}$ and $D_{d^i}^i \in [0,1], d^i\in\{S,M,L\}$ for $i = I, ..., j$.

Statement c) follows from two observations. First, the debt choice $\{D_S^{I\dagger}, D_M^{II\dagger}\}$ minimizes Δ, which means that no other set $\{D_{d^i}^i\}_{i=I}^{j_D}$ of debt tranches issued by the bank can achieve a better disciplining of the managers. Second, the maximal level of safe debt that can be issued is constrained from above by the lowest possible bank values at $t=1$ and at $t=2$ (the latter is also the lowest possible value at $t=3$), which are $1-p_2(a+l)$ and $1-a-l$, respectively. The loss l could only be avoided if the overall debt level were weakly smaller than $1-a$. But this would lead to a suboptimal Λ, as shown in Lemma 5. The value $1-a-l$ is reached by the senior tranche of the bank with face value $D_S^{I\dagger} = 1-a-l$. And the value $1-p_2(a+l)$ is reached by $D_S^{I\dagger} + M_S^\dagger = 1-a-l+(1-p_2)(a+l) = 1-p_2(a+l)$. Consequently, no additional tranche of debt can increase the level of safe claims.

D Sketch of a Solution for the Free-riding Problem

Consider the case of two monitoring funds F_1 and F_2, each holding a fraction $\alpha = \frac{1}{2}$ of the D_M^{II}-claim issued by the bank. Let us assume: first, a fund that does not monitor cannot see the face value which the bank managers offer to other funds at a roll over date; and second, a fund that wants to monitor the managers has to start with this right after $t=0$, and the managers can anticipate by which funds they are monitored before they start their activities at $t=0.5$. If this holds, the funds have an incentive to monitor, as long as $c_M < (1-p_1)\lambda M_S^\dagger$ and $c_M < \alpha(1-p_1)\delta_l$, for the following reasons:

Case 1 – F_1 assumes that F_2 will not monitor: But F_1 wants to roll over the bank debt at $t=2$ following a good shock at $t=1$ in order to earn the fee $\lambda M_S^\dagger$ in the third period. And F_1 wants to avoid the loss $\alpha\,(1-p_1)\delta_l$ from manager activities. Given that the costs c_M are smaller than this loss and smaller than the benefit $(1-p_1)\lambda M_S^\dagger$ from rolling the debt over at $t=2$ in case of a good shock, F_1 will roll over in that state and will monitor the bank before.

Case 2 – F_1 assumes that F_2 will monitor: F_1 cannot rely on the monitoring by F_2, but will also monitor for the following reasons. Managers could collude with the fund F_2 at the roll-over at $t = 2$ by offering them an increased face value which compensates F_2 for losses from manager activities at the expense of the not-monitoring fund F_1. To avoid this shift of losses, fund F_1 could simply withdraw at $t = 2$ - but it would then lose the possibility to earn the fee $\lambda M_S^\dagger$ in the third period (given a good shock at $t = 1$). Consequently, it prefers to monitor the bank as well.

References

[1] Acharya, Viral V., Philipp Schnabl, and Gustavo Suarez (2013), "Securitization without risk transfer", Journal of Financial Economics 107(3), 515-36

[2] Admati, Anat R., and Martin F. Hellwig (2013), "Does debt discipline bankers? An academic myth about bank indebtedness", Working Paper

[3] Allen, Franklin, and Douglas Gale (2000), "Financial Contagion", Journal of Political Economy 108(1), 1-33

[4] Bluhm, Marcel, Co-Pierre Georg, and Jan Pieter Krahnen (2016), "Interbank Intermediation", Discussion Paper Deutsche Bundesbank - Eurosystem, No 16-2016

[5] Brunnermeier, Markus K., Martin Oehmke (2013), "The Maturity Rat Race", *The Journal of Finance* 68 (2), 483-521

[6] Brunnermeier, Markus K. (2009), "Deciphering the liquidity and credit crunch 2007-08", Journal of Economic Perspectives 23(1), 77-100

[7] Calomiris, Charles W., Charles M. Kahn (1991), "The Role of Demandable Debt in Structuring Optimal Banking Arrangements", *The American Economic Review* 81(3), 497-513

[8] Chen, Qi, Itay Goldstein, and Wei Jiang (2010), "Payoff Complementarities and Financial Fragility: Evidence from Mutual Fund Outflows", Journal of Financial Economics 97(2), 239-262

[9] Cheng, Ing-Haw, and Konstantin Milbradt (2012), "The Hazards of Debt: Rollover Freezes, Incentives, and Bailouts", Review of Financial Studies 25(4),1070-1110

[10] Chernenko, Sergey, and Adi Sunderam (2014), "Frictions in Shadow Banking: Evidence from the Lending Behavior of Money Market Mutual Funds", Review of Financial Studies 27(6), 1717-50

[11] Covitz, Daniel, Nellie Liang, and Gustavo A. Suarez (2013), "The Evolution of a Financial Crisis: Collapse of the ABCP Market", The Journal of Finance 68(3), 815-48

[12] DeAngelo, Harry, and Rene M. Stulz (2015), "Liquid-Claim Production, Risk Management, and Bank Capital Structure: Why High Leverage Is Optimal for Banks", *Journal of Financial Economics* 116(2), 219-236

[13] Diamond, Douglas W., and Philip H. Dybvig (1983), "Bank runs, deposit insurance, and liquidity", The Journal of Political Economy 91(3), 401-419

[14] Diamond, Douglas W. (1984), "Financial Intermediation and Delegated Monitoring", The Review of Economic Studies 51(3), 393

[15] Diamond, Douglas W., and Raghuram G. Rajan (2000), "A theory of bank capital", *The Journal of Finance* 55 (6), 2431-2465

[16] Freixas, Xavier, Bruno M. Parigi, and Jean-Charles Rochet, "Systemic Risk, Interbank Relations, and Liquidity Provision by the Central Bank", Journal of Money, Credit and Banking 32(3), 611-638

[17] French, Kenneth R., et al. (2010), "The Squam Lake Report: Fixing the Financial System", Princeton University Press, Princeton, NJ

[18] Glode, Vincent, and Christian Opp (2016), "Asymmetric Information and Intermediation Chains", American Economic Review 106(9), 2699-2721

[19] Gorton, Gary, and George Pennacchi (1990), "Financial Intermediaries and Liquidity Creation", *The Journal of Finance* 45(1), 49-71

[20] Jensen, Michael C. (1986), "Agency costs of free cash flow, corporate finance, and takeovers", *The American Economic Review* 76(2), 323-329

[21] Kacperczyk, Marcin, and Philipp Schnabl (2010), "When Safe Proved Risky: Commercial Paper during the Financial Crisis of 2007-2009", Journal of Economic Perspectives 24(1), 29-50

[22] Kacperczyk, M., and Philipp Schnabl (2013), "How Safe Are Money Market Funds?" The Quarterly Journal of Economics 128 (3), 1073-1122

[23] Kashyap, Anil K., Raghuram G. Rajan, and Jeremy C. Stein (2008), "Rethinking Capital Regulation", Federal Reserve Bank of Kansas City Symposium September 2008

[24] Krishnamurthy, A., Nagel, S. and Orlov, D. (2014), "Sizing Up Repo", The Journal of Finance, 69(6), 2381-2417

[25] Leland, Hayne E., and Klaus Bjerre Toft (1996), "Optimal Capital Structure, Endogenous Bankruptcy, and the Term Structure of Credit Spreads", The Journal of Finance 51(3), 987-1019

[26] McCabe, Patrick E., Marco Cipriani, Michael Holscher, and Antoine Martin (2013), "The Minimum Balance at Risk: A Proposal to Mitigate the Systemic Risks Posed by Money Market Funds", Brookings Papers on Economic Activity 2013, No. 1, 211-78

[27] Roberts, Michael R., and Amir Sufi (2009), "Renegotiation of Financial Contracts: Evidence from Private Credit Agreements", Journal of Financial Economics 93(2), 159-84

[28] Roberts, Michael R. (2015), "The role of dynamic renegotiation and asymmetric information in financial contracting", Journal of Financial Economics 116(1), 61-81

[29] Shleifer, Andrei, and Robert W. Vishny (1992), "Liquidation Values and Debt Capacity: A Market Equilibrium Approach", The Journal of Finance 47(4), 1343-1366

[30] Shleifer, Andrei, and Robert W. Vishny (1997), "The limits of arbitrage", The Journal of Finance 52(1), 35-55

[31] Stein, J. C. (2012), "Monetary Policy as Financial Stability Regulation", The Quarterly Journal of Economics 127(1), 57-95