Optimal Financing Structures

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Contents

1. General Introduction

The theory of corporate finance focuses on the optimal capital structure of a firm in a given environment: the firm chooses how to finance a given set of assets by selling financial claims to a given set of potential buyers. This dissertation extends the theory of corporate finance by accounting for the fact that both, the set of available assets as well as the demand for claims, can be altered by other firms and investment funds which buy and sell financial claims.

The following three chapters illustrate different implications of this extension. Chapters 2 and 3 take the assets as given, but study the emergence of intermediation chains: instead of choosing the capital structure that would be optimal if only retail investors bought financial claims, firms can benefit from selling a different composition of debt claims to funds or other firms, which finance these securities by selling their own debt to retail investors. Studying this possibility, the two chapters can explain the existence and some characteristics of intermediation chains that have emerged in financial markets in recent decades. Chapter 4 relaxes the assumption that a firm's set of assets is given and allows firms to buy financial assets created by other agents in the market. The chapter shows how the possibility to buy financial assets challenges common notions about the optimal capital structure of a firm. It thereby addresses an issue of particular importance for the regulation of banks: the supposed costs of capital requirements.

An objective of all three chapters is to provide a better understanding of changes in the financial structure of banks and other intermediaries. This includes a better understanding of both, causes for changes that have occurred in recent decades as well as consequences of changes that can be enforced by regulation. In this way, the dissertation contributes to the ongoing debates about the regulation of banks and financial markets.

Abstract of Chapter 2: This chapter compares 'direct maturity transformations', in which risky long-term assets are directly financed with short-term debt, with 'indirect maturity transformations', in which such assets are financed with long-term debt that is financed with short-term debt in a second, separate step. (An example of the latter is the financing of senior tranches of securitized assets with short-term debt.) I show that the default probability of the short-term debt is higher in case of an indirect maturity transformation than in case of a direct transformation, given the same assets and the same level of short-term debt. If the purpose of short-term debt is the provision of 'money-like' claims, indirect maturity transformations can be efficient in spite of the higher solvency risk, because long-term debt securities are more liquid than the underlying assets. But indirect maturity transformations can also emerge as form of regulatory arbitrage, if there is a public insurance of short-term debt and indirect maturity transformations are not subject to higher capital requirements than direct transformations.

Abstract of Chapter 3: This chapter provides an explanation for intermediation chains with stepwise maturity transformation, 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 that are financed by daily demandable shares). The explanation reconciles the idea of debt as disciplining device with the idea of safe debt as 'money-like' claim. The chapter shows that these two purposes of debt financing lead to conflicting predictions of the optimal level and the optimal duration of bank debt. This conflict can be resolved by a partial separation of the two purposes: the bank chooses the capital structure that optimizes the disciplining of its managers, while it sells some of its debt to a fund that provides money-like claims, which are backed by the bank debt.

Abstract of Chapter 4: Trade-off theories of capital structure describe how a firm chooses its leverage for a given set of assets. This chapter studies how the predictions of such theories change if one accounts for the possibility that firms can invest in financial markets. Studying four different trade-off theories, the chapter shows for each of them: given any set of firm assets and the corresponding optimal capital structure, the firm can reduce its leverage and its insolvency risk relative to this supposed optimum without a loss of value, if it 'integrates a fund' – i.e., if it issues additional equity in order to buy financial assets with certain properties. The chapter thus indicates a way how the leverage and the insolvency risk of banks can be reduced without any costs in the long run.

2. Indirect Maturity Transformations

2.1. Introduction

Maturity transformations are a key aspect of financial intermediation and have received a lot of attention in the banking literature. The description of maturity transformations usually refers to a financial firm that has long-term assets and finances these with short-term debt. Quite often, however, financial intermediation entails an additional layer: in a first step, long-term assets are financed with long-term debt, and this long-term debt is financed with short-term debt in a second step. A prominent example, which played a key role in the Financial Crisis 07/08, is the securitization of loans and the purchase of the resulting tranches by banks or funds that are financed with short-term debt.[1] This form of maturity transformation is 'indirect' in the sense that the short-term debt claims refer to the underlying long-term assets only indirectly, via another financial claim that has a long duration. The contribution of this chapter is to provide a comparison of such indirect maturity transformations (IMT) with the direct maturity transformations (DMT) indicated above, in which the short-term debt is directly issued by the firm that holds the long-term assets. In particular, I compare the stability of IMT and DMT, measured in terms of the default probability of short-term debt. And I discuss why the different forms of maturity transformation can emerge. Based on this analysis, I derive implications for the regulation of financial intermediation that involves IMT.

Consider an IMT in which a set of assets is financed with equity as well as long-term debt. The long-term debt is senior to the equity at its maturity date. At intermediate dates, however, the value of the long-term debt can decrease due to an increase in the conditional probability of default at maturity, while the equity maintains a strictly positive value owing to the remaining probability that the asset payoff is larger than the debt liability at its maturity. This property leads to different default probabilities of short-term debt for IMT and DMT. In case of an IMT, in which the long-term debt is financed with short-term debt whose face value is D, the short-term debt defaults in states in which the value of the long-term debt falls below D. In some of these states, however, the value of the underlying assets can be larger than the value of the long-term debt and larger than D, so that the same level of short-term debt would not default in case of DMT. The difference between the value of the long-term debt and the value of the underlying

[1] Cf. Pozsar et al. (2016), for instance.

assets is given by the equity value in the first step of the IMT. The equity in that step can maintain a strictly positive value while the short-term debt in the second step defaults. The result is: given the same underlying assets and the same level of short-term debt, the default probability of the short-term debt is higher in case of IMT than in case of DMT. Or put differently, IMT require larger amounts of equity than DMT in order to avoid a default of the short-term debt.

The difference in default probabilities between IMT and DMT follows directly from the characteristics of debt contracts and does not depend on any specific assumptions or frictions. But it also holds true and it is economically relevant, if one accounts for common frictions of financial intermediation. Consider a situation with the following two features: first, the selection and operation of assets is subject to moral hazard, which can be overcome if the agent who selects and operates the assets retains a sufficiently large equity claim to these assets (as suggested by Gorton & Pennacchi (1995) or Cerasi & Rochet (2012), for instance); second, investors pay a premium for safe debt claims, because they can use these claims similarly to money as a means of payment (as pointed out by Gorton & Pennacchi (1990)). In liquid markets, debt is safe if there is no risk that the value of the underlying portfolio is smaller than the face value of the debt at the maturity date. And since the value of a portfolio can fall less over a short duration than over a long duration, debt with a short duration allows for providing a higher level of safe, 'money-like' claims. DMT allow to finance assets with the maximally possible level of safe short-term debt, while a retention of equity by the selector of the assets ensures that good assets are chosen. In case of IMT, the selector must also retain some equity for this purpose, but sells long-term debt to a bank or fund. In order to obtain a premium for money-like claims, this bank or fund can also finance this purchase with safe short-term debt. For the reasons mentioned above, however, the level of safe short-term debt and the related premium are smaller for IMT than for DMT.

Given this disadvantage of IMT relative to DMT in providing money-like claims, one has to wonder why IMT emerge. While the disadvantage is due to a higher solvency risk, IMT can have a relative advantage owing to a decrease in liquidity risk. If the assets and capital markets are illiquid, the liquidation or refinancing of a portfolio at intermediate dates might only be possible at depressed prices. This risk of a depressed portfolio value constrains the level of safe, money-like claims that can be issued against the portfolio. As highlighted by Shleifer & Vishny (1992), one aspect of illiquidity is that selling assets to new owners can entail a loss of specialized skills in operating the assets. In this respect, a long-term debt claim to a set of assets is more liquid than the underlying assets, because a sale of the debt only transfers a passive claim without changing the operator of the assets. While the short-term debt in case of DMT refers directly to the assets, the short-term debt in case of IMT refers to the more liquid long-term debt claims. The level of safe short-term debt in case of IMT is thus less constrained by liquidity risk than in case of DMT. If the relative decrease in liquidity risk is larger than the relative increase in solvency risk, then IMT allow for providing more safe short-term debt than DMT. And given a premium for such money-like claims, there is an incentive to finance assets with IMT instead of DMT.

Besides rationalizing the emergence of IMT, the explanation just given contains a novel argument for an increase of liquidity by securitization: while assets can be illiquid, because their operation requires skills that are not perfectly transferable (like, for instance, lending relationsships with households or firms), a long-term debt security is just a financial claim whose transfer does not affect the operation of the underlying assets. Previous arguments for an increase of liquidity by securitization (as presented in DeMarzo (2005), for instance) have highlighted that an appropriate security design reduces adverse selection and maximizes the profit of an agent who sells some claims to assets, while maintaining the remainder. Arguments based on adverse selection, however, cannot explain why the payoff from liquidating the entire set of assets (which is the upper bound for safe debt in case of DMT) is smaller than the payoff from selling a long-term debt claim to these assets (which is the upper bound for safe debt in case of IMT). These arguments can thus not rationalize the emergence of IMT in a similar way as this chapter does.

The explanation for IMT given above applies to segments of financial markets that have no access to a public insurance of short-term debt (like a deposit insurance, for instance). Such an insurance negates the relative advantage of IMT that is based on a decrease of liquidity risk. To avoid moral hazard, however, insurance premiums or capital requirements are required to prevent that solvency risk can be shifted to the insurance. Since the solvency risk in higher for IMT than for DMT, the capital requirements or insurance premiums have to be larger for IMT than for DMT. If such requirements or premiums are imposed, there is no incentive for financial firms to engage in IMT instead of DMT, because it implies higher costs (i.e., higher insurance premiums or a lower level of money-like claims as consequence of higher capital requirements), while the relative advantage of IMT is lost (the relatively smaller liquidity risk). This contrast with a situation in which the same capital requirements apply to DMT and IMT, which means that the same lower bound for equity is imposed to both modes of intermediation. In that case, IMT can be privately optimal owing to an implicit subsidy by the insurance: given the higher solvency risk of IMT, the same level of equity in both modes implies that the insurance covers some solvency risk in case of IMT that is not covered in case of DMT. The policy implication of the analysis is thus: if a public authority provides an insurance of short-term debt in order to improve the provision of money-like claims, but it wants to avoid an implicit subsidization of IMT, then it should impose higher capital requirements in case of IMT than in case of DMT.

Additional related literature: There are some recent papers that analyze financial intermediation which is performed in different steps. Allen et al. (2015) and Gale &

Gottardi (2017), for instance, analyze the optimal distribution of equity between firms and banks that lend to these firms. But they do not address maturity transformations and focus on issues like diversification and bankruptcy costs instead. Flore (2018) [which is identical with Chapter 3 of this dissertation] also studies maturity transformations that involve more than one step. But that paper focuses on the division of maturity transformation into smaller steps, which means that long-term assets or securities are financed with medium-term debt which is then financed with short-term debt. The literature on financial networks, following Allen & Gale (2000) and Freixas et al. (2000), also studies financial intermediation that involves more than one step. This literature, however, has not noted the differences between IMT and DMT and its consequences. The same holds for the literature that studies regulatory differences between traditional banks and more recent forms of financial intermediation, with Hanson et al. (2015), Plantin (2015), Flore (2015), Luck & Schempp (2014,2016) as examples for theoretical papers in this area.

The **remainder of this chapter** is structured as follows: Section 2 shows that IMT lead to a higher default probability than DMT. Section 3 illustrates that this difference has relevant implications for the optimal form of financial intermediation. Section 4 provides a rationale for IMT by highlighting its positive effect on liquidity risk. Section 5 discusses the regulation of IMT in case of an insurance of the short-term debt.

2.2. The Basic Mechanism

This section derives the key result of this chapter, which is: an indirect maturity transformation, in which assets are financed with long-term debt that is financed with short-term debt in a second step, implies a higher default probability than a direct maturity transformation, in which assets are directly financed with short-term debt. This result is a direct consequence of the contractual properties of debt claims.

Consider three dates $t = 0, 1, 2$ and two types of agents: first, an 'asset operator' who needs the external funding I for her assets at $t = 0$, which she can obtain by issuing equity and debt claims; second, a continuum S_I of 'investors' whose wealth at $t = 0$ adds up to $W_I > I$ and who can either invest in a storage technology with zero return or who can buy financial claims from the asset operator or from each other. For simplicity, I start with the assumption that all agents are risk-neutral and simply want to maximize their expected wealth at $t = 2$. The investors thus buy a financial claim as long as its expected return is weakly larger than the benchmark rate $r = 0$ set by the storage technology. (Below Proposition 1, I explain why the results also holds for more general risk preferences.) The assets have the stochastic values $\tilde{x}_1$ at $t = 1$ and $\tilde{x}_2$ at $t = 2$, which are distributed according to the density functions f_1 and f_2, and which constitute a martingale process: $\mathrm{E}[\tilde{x}_2|\tilde{x}_1] = \tilde{x}_1$. For simplicity, assume that $f_1(x_1)$ and $f_2(x_2|x_1)$ are continuous functions

of x_1. (The proof of Proposition 1 shows how the results can be generalized.)
In this section, I just study the properties of the equity and debt claims that can be issued with direct or indirect reference to these assets. The optimal choice of financing, given these properties, is examined in the next section. The case that the asset operator sells debt that matures at $t = 1$ is called 'direct maturity transformation' (DMT) and the respective face value of the 'short-term' debt is denoted as D_S. Assume that the assets are perfectly liquid, so that they yield the payoff x_1 in case of a liquidation at $t = 1$. (Illiquidity will be discussed in Section 2.4.) A default of the short-term debt can then be defined as the occurrence of $x_1 < D_S$, which implies a default probability $\phi_D(D_S)$ equal to $\mathrm{E}[\tilde{x}_1 < D_S]$. The value $e_D(D_S)$ of the equity at $t = 0$ is given by the expected residual payoff $\mathrm{E}[\max\{\tilde{x}_1 - D_S, 0\}]$.
Compare this to the case that the asset operator sells 'long-term' debt which matures at $t = 2$ and which has a face value D_L. I refer to this choice of financing by calling it 'securitization vehicle'. The value $e_V(D_L)$ of the equity of the securitization vehicle at $t = 0$ is given by the expected residual payoff $\mathrm{E}[\max\{\tilde{x}_2 - D_L, 0\}]$. Consider now that one of the investors buys this long-term debt and finances the purchase by selling equity and short-term debt that is backed by the long-term debt security. The face value of this short-term debt shall be denoted as D_S^I and I refer to this financing of the long-term debt security as 'investment bank'. The value $\tilde{y}_1$ of the long-term debt at $t = 1$ is the expected payoff of the D_L-claim conditional on the value $\tilde{x}_1$ of the underlying assets: $\tilde{y}_1(D_L) = \mathrm{E}[\min\{\tilde{x}_2, D_L\}|\tilde{x}_1]$. Defining a default of the investment bank's short-term debt as the occurrence of $y_1(D_L) < D_S^I$, the default probability $\phi_I(D_S^I, D_L)$ equals $\mathrm{E}\left[\tilde{y}_1(D_L) < D_S^I\right]$. The value $e_I(D_S^I, D_L)$ of the investment bank's equity at $t = 0$ is given by the expected residual payoff $\mathrm{E}\left[\max\{\tilde{y}_1(D_L) - D_S^I, 0\}\right]$. The combination of securitization vehicle and investment bank is called 'indirect maturity transformation' (IMT), because the short-term debt refers to the underlying long-term assets indirectly, via the long-term debt claim. The two ways of maturity transformation are depicted in Fig. 2.1.

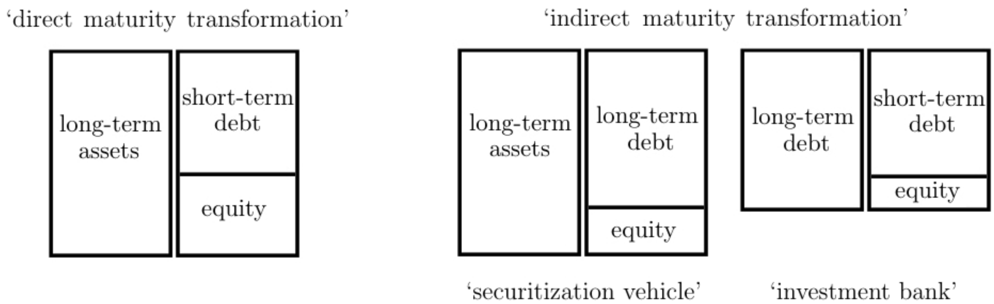

Figure 2.1.: Schematic balance sheets of two different ways of maturity transformation.

Observation 1

Despite the seniority of the long-term debt at $t=2$*, the value of the long-term debt can decline at* $t=1$*, while the equity value of the securitization vehicle remains strictly positive:* $\exists\, x_1, D_L \in \mathbb{R}^+ : \ E[\max\{\tilde{x}_2 - D_L, 0\}|x_1] > 0 \wedge y_1 = E[\min\{\tilde{x}_2, D_L\}|x_1] < E[\min\{\tilde{x}_2, D_L\}]$*. If this holds for the lowest asset value at* $t=1$*, which means for* $x_1 = x_{S,min} := \min(\text{supp}(f_1))$*, then the lowest possible value* $y_{S,min}$ *of the long-term debt at* $t = 1$ *is smaller than the lowest possible value of the underlying assets:* $y_{S,min} \leq E[\min\{\tilde{x}_2, D_L\}|x_{S,min}] < x_{S,min}$*.*

These properties have consequences for the short-term debt capacity of the two modes of maturity transformation:

Proposition 1

a) Given the same assets and the same level of short-term debt, the default probability is larger for IMT than for DMT:

$$\phi_I(D_S^I, D_L) \geq \phi_D(D_S) \quad \forall\ D_S^I = D_S \in \mathbb{R}^+ \ \textit{and}\ D_L \in \mathbb{R}^+,$$
$$\textit{with strict inequality if } D_S^I = D_S \in \text{supp}(f_1) \ \textit{and}\ D_L < \max\left(\text{supp}(f_2(x_2|x_1 = D_S^I))\right).$$

b) Given the same assets and the same initial level of equity, the default probability is larger for IMT than for DMT:

$$\phi_I(D_S^I, D_L) \geq \phi_D(D_S) \quad \forall\ D_S^I, D_S, D_L \in \mathbb{R}^+ \ \textit{s.t.}\ e_I(D_S^I, D_L) + e_V(D_L) = e_D(D_S),$$
$$\textit{with strict inequality if } D_S^I \in \text{supp}(f_1) \ \textit{and}\ D_L < \max\left(\text{supp}(f_2(x_2|x_1 = D_S^I))\right).$$

Intuition: Before I present the proof, let me give a brief intuition. Short-term in both cases, DMT and IMT, defaults at $t = 1$, if the value of the underlying portfolio is less than the debt face value. The default probability is weakly higher for IMT than for DMT, since the value of the long-term debt at $t = 1$ is weakly smaller than the value of the underlying assets. The difference is given by the value of the equity of the securitization vehicle. This equity can maintain a strictly positive value even in states at $t = 1$ in which the value of the long-term debt has declined due to an increase in the conditional probability of low payoffs. Consequently, there are debt levels for which the asset value $\mathrm{E}\,[\tilde{x}_2|x_1] = x_1$ remains larger than $D_S = D_S^I$ in some states x_1, while the value $\mathrm{E}\,[\min\{\tilde{x}_2, D_L\}|x_1]$ of the long-term debt falls below D_S^I. The remaining equity value $\mathrm{E}\,[\max\{\tilde{x}_2 - D_L, 0\}|x_1]$ of the securitization vehicle does not prevent the default of the investment bank's short-term debt. The equity of the investment bank or the asset operator is strictly junior to the short-term debt, so that the debt only incurs a loss at $t = 1$, if the equity value has fallen to zero by 'absorbing' losses of the portfolio. This does not hold for the equity of the securitization vehicle. As a result, given the same level of equity ($e_V + e_I = e_D$), the equity in case of IMT is less effective in preventing short-term debt default than the equity in case of DMT.

Proofs: Proof of statement a):

$$\phi_I(D_S^I, D_L) = \mathrm{E}\left[\tilde{y}_1(D_L) < D_S^I\right] = \mathrm{E}\left[\mathrm{E}\left[\min\{\tilde{x}_2, D_L\}|\tilde{x}_1\right] < D_S^I\right] \geq \mathrm{E}\left[\tilde{x}_1 < D_S^I\right] = \phi_D(D_S^I).$$

The inequality is strict for $D_S^I = D_S \in \mathrm{supp}(f_1)$ and $D_L < \max\left(\mathrm{supp}(f_2(x_2|x_1 = D_S^I))\right)$, since there are states at $t = 1$ in which the asset value x_1 is weakly larger than $D_S^I = D_S \in \mathrm{supp}(f_1)$ (which thus do not contribute to $\mathrm{E}\left[\tilde{x}_1 < D_S^I\right]$), while the value $\mathrm{E}\left[\min\{\tilde{x}_2, D_L\}|x_1\right] = x_1 - \mathrm{E}\left[\max\{\tilde{x}_2 - D_L, 0\}|x_1\right]$ of the long-term debt is smaller than x_1 and smaller than D_S^I (so that the states contribute to $\mathrm{E}\left[\mathrm{E}\left[\min\{\tilde{x}_2, D_L\}|\tilde{x}_1\right] < D_S^I\right]$). The set of states with this property has non-vanishing mass due to the continuity of $f_1(x_1)$ and $f_2(x_2|x_1)$ as functions of x_1.

Without imposing these assumptions on f_1 and f_2, one can generalize the result as follows: the inequality is strict for all $D_S^I = D_S \in \mathbb{R}^+ \backslash \infty$ and $D_L \in \mathbb{R}^+ \backslash \infty$, for which there is a subset $\Omega \subset \mathrm{supp}(f_1)$ with non-vanishing mass such that $D_S^I \in \cap_{x_1 \in \Omega}\left(\mathrm{E}\left[\min\{\tilde{x}_2, D_L\}|x_1\right], x_1\right]$.

Proof of statement b): the same level of equity in IMT and DMT means that

$$\begin{aligned}
e_D(D_S) &= e_V(D_L) + e_I(D_S^I, D_L)\\
\mathrm{E}\left[\max\{\tilde{x}_1 - D_S, 0\}\right] &= \mathrm{E}\left[\max\{\tilde{x}_2 - D_L, 0\}\right] + \mathrm{E}\left[\max\{\tilde{y}_1(D_L) - D_S^I, 0\}\right]\\
&= \mathrm{E}\left[\max\{\tilde{x}_2 - D_L, 0\}\right] + \mathrm{E}\left[\max\{\mathrm{E}\left[\min\{\tilde{x}_2, D_L\}|\tilde{x}_1\right] - D_S^I, 0\}\right]\\
&= \mathrm{E}\left[\max\{\tilde{x}_2 - D_L, 0\}\right] + \mathrm{E}\left[\max\{\tilde{x}_1 - \mathrm{E}\left[\max\{\tilde{x}_2 - D_L, 0\}|\tilde{x}_1\right] - D_S^I, 0\}\right]\\
&\geq \mathrm{E}\left[\max\{\tilde{x}_2 - D_L, 0\}\right] + \mathrm{E}\left[\max\{\tilde{x}_1 - D_S^I, 0\}\right] - \mathrm{E}\left[\mathrm{E}\left[\max\{\tilde{x}_2 - D_L, 0\}|\tilde{x}_1\right]\right]\\
&= \mathrm{E}\left[\max\{\tilde{x}_1 - D_S^I, 0\}\right]
\end{aligned}$$

The inequality is strict for $D_S^I \in \mathrm{supp}(f_1)$ and $D_L < \max\left(\mathrm{supp}(f_2(x_2|x_1 = D_S^I))\right)$, because there are states at $t = 1$ in which the asset value x_1 is weakly smaller than $D_S^I \in \mathrm{supp}(f_1)$ (so that $\max\left\{x_1 - D_S^I, 0\right\}$ and $\max\left\{x_1 - \mathrm{E}\left[\max\{\tilde{x}_2 - D_L, 0\}|x_1\right] - D_S^I, 0\right\}$ are both equal to zero), while the value $\mathrm{E}\left[\max\{\tilde{x}_2 - D_L, 0\}|x_1\right]$ is strictly positive. The set of states with this property has non-vanishing mass owing to the continuity of $f_1(x_1)$ and $f_2(x_2|x_1)$ as functions of x_1. The inequality $\mathrm{E}\left[\max\{\tilde{x}_1 - D_S, 0\}\right] \geq \mathrm{E}\left[\max\{\tilde{x}_1 - D_S^I, 0\}\right]$ implies $\mathrm{E}\left[\tilde{x}_1 < D_S\right] \leq \mathrm{E}\left[\tilde{x}_1 < D_S^I\right]$ and thus:

$$\phi_D(D_S) = \mathrm{E}\left[\tilde{x}_1 < D_S\right] \leq \mathrm{E}\left[\tilde{x}_1 < D_S^I\right] \leq \mathrm{E}\left[\mathrm{E}\left[\min\{\tilde{x}_2, D_L\}|\tilde{x}_1\right] < D_S^I\right] = \phi_I(D_S^I, D_L). \quad (2.1)$$

A strict inequality $\mathrm{E}\left[\max\{\tilde{x}_1 - D_S, 0\}\right] > \mathrm{E}\left[\max\{\tilde{x}_1 - D_S^I, 0\}\right]$ implies a strict inequality $\phi_D(D_S) < \phi_I(D_S^I, D_L)$. Without assumptions about f_1 and f_2, one can generalize the result in the same way as in a): the inequality $\phi_I(D_S^I, D_L) \geq \phi_D(D_S)$ is strict for all cases with $e_I(D_S^I, D_L) + e_V(D_L) = e_D(D_S)$, for which there is a subset $\Omega \subset \mathrm{supp}(f_1)$ with non-vanishing mass such that $D_S^I \in \cap_{x_1 \in \Omega}\left(\mathrm{E}\left[\min\{\tilde{x}_2, D_L\}|x_1\right], x_1\right]$. If this holds, the second inequality in Eq. (2.1) is strict, even if the first inequality is not.[2] ■

Generalized Pricing: Let me briefly indicate why the results are robust to any pricing of the claims which is monotonously increasing in payoffs at $t = 2$. The basic intuition remains the same: the assets are a more valuable backing of short-term debt than a long-term debt claim to the assets, since some payoff of the assets accrue to the equity of the securitization vehicle. The pricing of claims enter the analysis by the valuation of the initial equity as well as the liquidation values of the assets and the long-term debt security at $t = 1$. Let us denote the latter two as v_A^L and v_D^L and consider that these values are not simply given by $y_1(D_L)$ and x_1, which means by the expected payoff at $t = 2$, but by more general weighted sums of the payoffs at $t = 2$: $v_D^L = \int \nu(\min\{x_2(\omega), D_L\}, \omega)\ \rho(\omega, x_1)\, d\omega$ and $v_A^L = \int \nu(x_2(\omega), \omega)\ \rho(\omega, x_1)\, d\omega$, where ω is an index of states at $t = 2$ with respective asset payoff $x_2(\omega)$, while $\rho(\omega, x_1)$ is the probability of a state ω conditional on x_1 and $\nu(p, \omega)$ is the valuation of a payoff p in state ω. In liquid markets, the default probabilities generalize to $\phi_D(D_S) = \mathrm{E}\left[v_A^L < D_S\right]$ and $\phi_I(D_S^I, D_L) = \mathrm{E}\left[v_D^L < D_S^I\right]$. Statement a) in Proposition 1 is robust to such generalization, since $v_D^L = \int \nu(\min\{x_2(\omega), D_L\}, \omega)\ \rho(\omega, x_1)\, d\omega \le \int \nu(x_2(\omega), \omega)\ \rho(\omega, x_1)\, d\omega = v_A^L$ holds for any valuation ν that is monotonously increasing in the payoff at $t = 2$. And the inequality is strict for some D_L. Following the same logic, the valuation of equity at $t = 0$ can be generalized and it can be shown that the statement b) in Proposition 1 is robust to such generalization, given monotonous pricing.

Corollary 1

For a given amount of initial equity in IMT (i.e., $e_V(D_L) + e_I(D_S^I, D_L) = const.$), the default probability of the short-term debt increases with the amount $e_V(D_L) = E[\max\{\tilde{x}_2 - D_L, 0\}]$ of this equity that is issued by the securitization vehicle, which means that it decreases with the level D_L of the long-term debt:

$$\left.\frac{d}{dD_L}\right|_{e_I(D_S^I, D_L) + e_V(D_L) = const.} \phi_I(D_S^I, D_L) \le 0.$$

If the securitization vehicle has no equity, but only long-term debt, the default probability does not differ from DMT:

$$e_V(D_L) = 0 \Leftrightarrow D_L = \max(\mathrm{supp}(f_2)) \Rightarrow \phi_I(D_S^I, D_L) = \phi_D(D_S)\ \forall\ D_S = D_S^I \in \mathbb{R}^+.$$

These statements follow from $\phi_I(D_S^I, D_L) = \mathrm{E}\left[\tilde{y}_1(D_L) < D_S^I\right] = \mathrm{E}\left[\mathrm{E}\left[\min\{\tilde{x}_2, D_L\} | \tilde{x}_1\right] < D_S^I\right]$, which decreases in D_L and which is equal to $\mathrm{E}\left[\tilde{x}_1 < D_S^I\right]$ for $D_L = \max(\mathrm{supp}(f_2))$. The overall equity level $e_V(D_L) + e_I(D_S^I, D_L)$ remains fixed in spite of an increase in D_L and

[2] Alternatively, the result can also be generalized as follows: the inequality $\phi_I(D_S^I, D_L) \ge \phi_D(D_S)$ is strict for all cases with $e_I(D_S^I, D_L) + e_V(D_L) = e_D(D_S)$, for which there is a subset $\Omega' \subset \mathrm{supp}(f_1)$ with non-vanishing mass such that $D_S^I < x_1$ and $\mathrm{E}[\max\{\tilde{x}_2 - D_L, 0\} | x_1] > 0$ for all $x_1 \in \Omega'$.

a corresponding decrease in $e_V(D_L)$, if $e_I(D_S^I, D_L) = \mathrm{E}\left[\max\{\tilde{y}_1(D_L) - D_S^I, 0\}\right]$ increases owing to an decrease in D_S^I. This contributes to the decrease in $\phi_I(D_S^I, D_L)$, too. The case $D_L = \max(\mathrm{supp}(f_2))$, however, is degenerate in the sense that the distinction between equity and debt vanishes. The securitization vehicle only sells a single claim that receives the entire payoff of the assets and that is held by the investment bank. The investment bank thus completely 'owns' the securitization vehicle and its assets.

To sum up, this section has shown that indirect maturity transformations (IMT), in which short-term debt refers to some asset payoff via long-term debt claims to the assets, imply higher default probabilities than direct maturity transformations (DMT), in which the short-term debt directly refers to the assets. IMT imply higher default probabilities than DMT for the same underlying assets and the same level of short-term debt or the same level of initial equity. This result does not depend on any frictions, but only on the basic contractual features of debt contracts.

2.3. Relevance for Financial Intermediation

This section shows that the difference identified in the previous section is strict and relevant in a setting in which agents choose the optimal financing of assets given two frictions that are well-established in the literature: first, a premium for safe claims which can be used as means of payment – as pointed out by Gorton & Pennacchi (1990); second, moral hazard concerning the operation or selection of assets, if claims to their payoff are sold – see Gorton & Pennacchi (1995), for instance. The first friction leads to a deviation from the Modigliani-Miller Theorem and can explain the use of short-term debt financing. The second friction explains why the institution which selects or operates assets retains some claims to these assets. The two frictions are introduced in the next two subsections, before the third subsection discusses optimal financing given these frictions.

2.3.1. Risk Retention as Commitment Device

If the quality of the assets is not fixed, but depends on costly actions of the asset operator, the sale of claims to the asset payoff can lead to moral hazard. Consider the case that the asset operator can select 'bad assets' instead of the 'good assets' characterized by $\tilde{x}_t$. The stochastic value $\tilde{x}_t^b$ of these bad assets is also an martingale, but it is first-order stochastically dominated by the value $\tilde{x}_t$ of the good assets at both dates $t = 1, 2$. Let us assume that the asset operator has a private benefit μ from choosing bad assets (for instance, because a poorer screening of loans entails less costly effort), but the choice is inefficient due to $\mu < \mathrm{E}\left[\tilde{x}_2\right] - \mathrm{E}\left[\tilde{x}_2^b\right]$. As stressed by Gorton & Pennacchi (1995), among others, the asset operator can commit to choose the good assets, if she retains claims to the assets whose expected loss from choosing bad assets is weakly larger than μ.

Let us focus on the retention of equity as a commitment device, before I comment on the possibility to retain debt claims at the end of this section. The expected loss $L_A(D_d; d)$ of the equity from choosing bad assets depends on the face value D_d and the duration $d \in \{S, L\}$ of the debt as follows

$$L_A^E(D_d; d) = \mathrm{E}\left[\max\left\{\tilde{x}_{T(d)} - D_d, 0\right\}\right] - \mathrm{E}\left[\max\left\{\tilde{x}^b_{T(d)} - D_d, 0\right\}\right],$$

with the maturity dates $T(S) = 1$ and $T(L) = 2$. The boundary values $L_A^E(0; d) = \mathrm{E}\left[\tilde{x}_{T(d)}\right] - \mathrm{E}\left[\tilde{x}^b_{T(d)}\right]$ and $L_A^E(\infty; d) = 0$ imply:

Observation 2

There are maximal debt levels for which the loss of equity from choosing bad assets is still larger than the private benefit: $D_d^c := \max\{D_d | L_A^E(D_d; d) \geq \mu\}$ *for* $d = S, L$.

The asset operator has an incentive to retain a fraction γ of the equity with $\gamma\, L_A^E(D_d; d) \geq \mu$. If the asset operator retains a smaller fraction of the equity, it will be optimal for her to choose bad assets, independent of the price that investors pay for their claims. Taking this choice into account, however, the investors will only buy claims at prices that reflect their expected loss from bad assets. By means of this rational pricing the asset operator will thus incur the cost of choosing bad assets. If the asset operator retains a fraction $\gamma \geq \frac{\mu}{L_A^E(D_d; d)}$ of the equity, in contrast, choosing the good set is optimal for her and the investors account for this fact when they buy claims.

2.3.2. Safety Premium

Based on Gorton & Pennacchi (1990), I assume that the investors benefit from claims whose value is safe, because they can trade these claims without problems of asymmetric information, so that they constitute an efficient means of payment. Given this benefit of safe claims, investors accept to pay a premium for them. A microfoundation of this premium based on transaction needs of investors between $t = 0$ and $t = 1$ in presence of asymmetric information is given in Appendix A.1. For the questions addressed in this Chapter, however, it is sufficient to represent the benefits of claims with safe value in a simple way: by assuming that the investors pay a fee λ per unit of claim whose value is safe between $t = 0$ and $t = 1$.[3] I will refer to these claims as 'money-like claims' and they are measured in terms of expected payoff. For simplicity, I assume that premium is paid at the very end, after the debt has been paid off at $t = 2$.[4] Consequently, the safety

[3] One can think of fees like the ones paid for deposit accounts. Transaction needs and fees for safe claims in the second period have been considered in an earlier version of this Chapter (which can be provided on demand), but do not change the results qualitatively.

[4] This allows to ignore tedious, uninteresting effects of paid fees on the safety of the debt and the size of the premium. The assumption implies: even if investors withdraw their debt or transfer it in a payment process, they do not pay the fee for holding the safe claim (up to the withdrawal date) before the very end.

premium $\Lambda(D_d;d)$ that the asset operator earns by selling debt claims with face value D_d and duration d is:

$$\Lambda(D_d;d) = \lambda \cdot v_D(D_d;d) \;\text{ for } D_d \leq x_{d,min} \;\text{ and } \Lambda(D_d;d) = 0 \text{ else}\,,$$

where $v_D(D_d;d) = \mathrm{E}\left[\min\{D_d, \tilde{x}_{T(d)}\}\right]$ is the value (i.e., the expected payoff) of the debt claim (which equals D_d for safe debt), while $x_{d,min}$ is defined as: $x_{S,min} := \min\{\text{supp}\, f_1\}$ (which is the lower bound of $\tilde{x}_1$); and $x_{L,min} := \max\left\{D_L \,|\, \mathrm{E}\left[\min\{D_L, \tilde{x}_2\}|\tilde{x}_1\right] = const.\right\}$ (which is highest possible face value of long-term debt whose expected payoff is independent of the state at $t=1$, which means that it is safe between $t=0$ and $t=1$). I assume perfect liquidity of the assets in this section (i.e, a liquidation of the assets at $t=1$ would yield a payoff $\tilde{x}_1$), before I account for asset illiquidity in Section 2.4. For simplicity, I assume that $x_{S,min}$ and $x_{L,min}$ remain the same, if one replaces $\tilde{x}_t$ with $\tilde{x}_t^b$, which means that these bounds are the same for good and bad assets.[5]

If an investor sets up an investment bank, which means that she buys long-term debt of the asset operator and sells equity and debt claims to this long-term debt security, she can also earn a safety premium. For debt with face value D_d^I and duration d, the safety premium is:

$$\Lambda^I(D_d^I;d,D_L) = \lambda \cdot v_D^I(D_d^I;d,D_L) \;\text{ for } D_d^I \leq y_{d,min}(D_L) \;\text{ and } \Lambda(D_d^I;d,D_L) = 0 \text{ else}\,, \tag{2.2}$$

where $y_{d,min}(D_L)$ is defined in the same way as $x_{d,min}$ with $\tilde{y}_t(D_L) = \mathrm{E}\left[\min\{D_L, \tilde{x}_2\}|\tilde{x}_t\right]$ instead of $\tilde{x}_t$.

Lemma 1

a) The safety premium is maximized by selling short-term debt:

$$\underset{D_d \in \mathbb{R}^+, d \in \{S,L\}}{\text{argmax}} \Lambda(D_d;d) = (x_{S,min}, S)\,, \qquad \underset{D_d^I \in \mathbb{R}^+, d \in \{S,L\}}{\text{argmax}} \Lambda^I(D_d^I;d,D_L) = (y_{S,min}(D_L), S)\,.$$

b) DMT allows for a larger premium than IMT: $\Lambda(x_{S,min};S) \geq \Lambda^I(y_{S,min}(D_L);S,D_L)$, *with strict inequality if* $D_L < \max(\text{supp}(f_2|x_1 = x_{S,min}))$.

Proof: a) The martingale property of $\tilde{x}_t$ implies $v_D(x_{S,min},S) \geq v_D(x_{L,min},L)$ because: $v_D(x_{S,min},S) = x_{S,min} \geq \mathrm{E}\left[\min\{x_{L,min},\tilde{x}_2\}|x_{S,min}\right] = \mathrm{E}\left[\mathrm{E}\left[\min\{x_{L,min},\tilde{x}_2\}|\tilde{x}_1\right]\right] = v_D(x_{L,min},L)$ (the second last equation follows from the definition of $x_{L,min}$). This means that $(x_{S,min},S)$ is the maximum of $\Lambda(D_d;d)$. And the martingale property of $\tilde{x}_t$ implies that the value $\tilde{y}_t(D_L)$ of the long-term debt is a martingale, too:

[5] If one considered a downward shift of these bounds due to the selection of bad assets, the following results would be further strengthened, but their representation became more tedious. Owing to the stochastic dominance of $\tilde{x}_1$ over $\tilde{x}_1^b$, an upward shift is not possible for $x_{S,min}$ (which will turn out to be the relevant bound).

$\mathrm{E}[\tilde{y}_2(D_L)|\tilde{y}_1(D_L)] = \mathrm{E}[\mathrm{E}[\min\{D_L,\tilde{x}_2\}|\tilde{x}_2]\,|\mathrm{E}[\min\{D_L,\tilde{x}_2\}|\tilde{x}_1]] = \mathrm{E}[\min\{D_L,\tilde{x}_2\}|\tilde{x}_1] = \tilde{y}_1(D_L)$. Consequently, $v_D^I(y_{S,min}, S) \geq v_D^I(y_{L,min}, L)$, so that $(y_{S,min}, S)$ is the maximum of $\Lambda^I(D_d^I; d)$.
b) $\Lambda(x_{S,min}; S) = \lambda \cdot x_{S,min} \geq \lambda \cdot y_{S,min}(D_L) = \Lambda^I(y_{S,min}(D_L); S, D_L)$ follows from $\tilde{x}_1 \geq \mathrm{E}[\min\{D_L,\tilde{x}_2\}|\tilde{x}_1] = \tilde{y}_1(D_L)$. And $D_L < \max(\mathrm{supp}(f_2|\tilde{x}_1 = x_{S,min}))$ implies that $x_{S,min} > \mathrm{E}[\min\{D_L,\tilde{x}_2\}|x_{S,min}]$ and thus $x_{S,min} > y_{S,min}(D_L)$. ■

Intuition: a) If the value $v_D(D_L; L)$ of a long-term debt claim is safe at $t = 1$, the expected payoff of the debt claim at $t = 2$ must be equal to $v_D(D_L; L)$ conditional on each possible state at $t = 1$, including the worst possible one. This implies that the value of the underlying portfolio at $t = 1$ is weakly larger than $v_D(D_L; L)$ in each possible state. Since the level of safe short-term debt can be as high as the minimal possible value of the portfolio at $t = 1$, this implies that weakly more money-like claims can be provided by means of safe short-term debt than by long-term debt with safe value.
b) As shown in Section 2.2, the level of safe short-term debt is weakly larger in case of DMT than in case of IMT. As consequence of part a), the premium that can be earned for money-like claims is thus weakly larger for DMT than for IMT. The inequalities are strict, if short-term debt with face value $D_S^I = x_{S,min}$ is not safe in case of IMT, because the value $y_1(D_L)$ of the long-term debt in the worst possible state at $t = 1$ is strictly smaller than the asset value $x_{S,min}$.

2.3.3. Optimal Financing in Presence of these Frictions

This subsection compares the optimal financing of assets given two possible modes of maturity transformations. Let us start with the optimal capital structure in case of DMT and consider the decision problem of the asset operator who wants to maximize her expected wealth. Selling claims to investors, she has no incentive to deviate from the investors' reservation price for claims, which equals the expected payoff of the claim in case of risk-neutrality and a storage technology with zero return. This implies that the expected payoff P of the claims sold to investors has to be weakly larger than I in order to obtain the funding of the assets at $t = 0$. Assume that, if the asset operator sells claims worth more than I, she can also store her wealth with zero return. Her expected wealth at $t = 2$ would thus be $\mathrm{E}[\tilde{x}_2] - I$, if there were no frictions. But the asset operator can earn the premium $\Lambda(D_d; d)$ for money-like claims. And there is the potential loss from selecting bad assets: $\left(\mathrm{E}[\tilde{x}_2] - \mathrm{E}\left[\tilde{x}_2^b\right] - \mu\right) \cdot \mathbf{1}_{\left\{\mu > \gamma\, L_A^E(D_d; d)\right\}}$. While the fraction γ of equity that is retained by the asset operator has no effect on $\Lambda(D_d; d)$, it has a weakly positive effect on the moral hazard problem. It is thus always optimal for the asset operator to retain all of the equity, so that one can focus on $\gamma = 1$. The decision problem of the asset operator is then:

$$\max_{D_d\in[0,1],d\in\{S,L\}} X(D_d;d)+\Lambda(D_d;d) \text{ s.t. } P(D_d)\geq I$$
$$\text{with } X(D_d;d):=\mathrm{E}\left[\tilde{x}_2\right]-I-\left(\mathrm{E}\left[\tilde{x}_2\right]-\mathrm{E}\left[\tilde{x}_2^b\right]-\mu\right)\cdot\mathbf{1}_{\left\{\mu>L_A^E(D_d;d)\right\}}. \tag{2.3}$$

Assumption 1 $x_{S,min}\geq I$.

The purpose of this assumption is only to focus in a simple way on cases in which the funding I for the assets can be acquired, if the optimal capital structure is chosen. It applies to the remainder of this Chapter.

Lemma 2
The optimal capital structure consists of short-term debt with face value $D_S^*=x_{S,min}$.

Proof: $P(D_S^*)\geq I$, since the expected payoff of the safe claim D_S^* is $x_{S,min}$. The objective function is maximized by short-term debt with $D_S=x_{S,min}$, because it maximizes Λ, while $L_A^E(D_S^*;S)=\mathrm{E}\left[\max\left\{\tilde{x}_1-x_{S,min},0\right\}\right]-\mathrm{E}\left[\max\left\{\tilde{x}_1^b-x_{S,min},0\right\}\right]=\mathrm{E}\left[\tilde{x}_1\right]-x_{S,min}-\mathrm{E}\left[\tilde{x}_1^b\right]+x_{S,min}\geq\mu$ owing to $\mathrm{E}\left[\tilde{x}_1\right]=\mathrm{E}\left[\tilde{x}_2\right]$, $\mathrm{E}\left[\tilde{x}_1^b\right]=\mathrm{E}\left[\tilde{x}_2^b\right]$. The second equality holds because $x_{S,min}$ is the lower bound of both, $\tilde{x}_1$ and $\tilde{x}_1^b$.[6] ■

Intuition: Short-term debt financing is optimal, as it maximizes the amount of safe claims that can be provided to investors and on which a premium can be earned. And the retention of the equity claim by the asset operator ensures the efficient choice of good assets.

Having determined the optimal choice of financing which is possible with DMT, let us now study the possibility of IMT. The most profitable form of IMT can be characterized by the face values D_L and D_S^I which maximize the sum of the investment bank's premium $\Lambda^I(D_S^I;S,D_L)$ and the expected payoff $X(D_L;L)$ of the securitization vehicle. As shown in Lemma 1, $\Lambda^I(D_S^I;S,D_L)$ is maximized by $D_S^I=y_{S,min}(D_L)$ for given D_L, and one can focus the discussion on that case. The potential safety premium $\Lambda(D_L;L)$ of the securitization vehicle is neglected in the following comparison of IMT and DMT, because $\Lambda(D_L;L)$ would be paid by the investment bank, so that it would net out in the overall profit of securitization vehicle and investment bank.

Lemma 3
In the most profitable form of IMT, the equity level of the securitization vehicle is either just enough to ensure the selection of good assets (i.e., $D_L=D_L^c$) or zero (i.e., $D_L=\infty$),

[6] If this assumption is relaxed, one has to discuss whether the equity (given short-term debt with face value D_S^*) is still sensitive enough to the loss from bad assets in order to align the incentives of the asset operator. If this is not case, there is trade-off between reducing the debt below D_S^* with the aim to align incentives and accepting the expected loss from the choice of bad assets.

depending on relative size of the safety premium and the loss due to selecting bad assets:

$$\begin{aligned}
&\text{if } E[\tilde{x}_2] - E\left[\tilde{x}_2^b\right] - \mu \geq \lambda \cdot (y_{S,min}(\infty) - y_{S,min}(D_L^c)),\\
&\text{then } \underset{D_L \in \mathbb{R}^+}{\operatorname{argmax}} \left\{\Lambda^I\big(y_{S,min}(D_L); S, D_L\big) + X(D_L; L)\right\} = D_L^c,\\
&\text{else } \underset{D_L \in \mathbb{R}^+}{\operatorname{argmax}} \left\{\Lambda^I\big(y_{S,min}(D_L); S, D_L\big) + X(D_L; L)\right\} = \infty.
\end{aligned}$$

Proof: The surplus $\Lambda^I(y_{S,min}(D_L); S, D_L) + X(D_L; L)$ has two relative maxima: at $D_L = \infty$, and at $D_L = D_L^c$, which is the maximal face value of long-term debt for which the loss $\mathrm{E}[\tilde{x}_2] - \mathrm{E}\left[\tilde{x}_2^b\right] - \mu$ due to bad assets is prevented. For all $D_L < D_L^c$, this loss is also prevented and $X(D_L; L) = X(D_L^c; L)$, but $\Lambda^I\big(y_{S,min}(D_L); S, D_L\big) \leq \Lambda^I\big(y_{S,min}(D_L^c); S, D_L^c\big)$, since $y_{S,min}(D_L)$ monotonously increases in D_L. For all $D_L > D_L^c$, the loss $\mathrm{E}[\tilde{x}_2] - \mathrm{E}\left[\tilde{x}_2^b\right] - \mu$ occurs independent of D_L, while $\Lambda^I\big(y_{S,min}(D_L); S, D_L\big)$ is still monotonously increasing in D_L. The relative maximum of $\Lambda^I(y_{S,min}(D_L); S, D_L) + X(D_L; L)$ at D_L^c is larger than the relative maximum at $D_L = \infty$, if $\mathrm{E}[\tilde{x}_2] - \mathrm{E}\left[\tilde{x}_2^b\right] - \mu > \lambda \cdot \big(\Lambda^I(y_{S,min}(\infty); S, \infty) - \Lambda^I(y_{S,min}(D_L^c); S, D_L^c)\big) = \lambda \cdot (y_{S,min}(\infty) - y_{S,min}(D_L^c))$. ■

Intuition: If the long-term debt sold to the investment bank is larger than D_L^c, the investment bank can provide more safe short-term debt and the maximum level is reached for $D_L = \infty$. The risk retention by the asset operator in that case, however, is too small to incentivize the selection of good assets. If the loss from selecting bad assets is relatively large compared to the additional premium that can be earned by long-term debt with $D_L = \infty$ instead of D_L^c, then a finite leverage of the securitization vehicle with D_L^c and a sufficient amount of retained equity is the optimal form of IMT.

Proposition 2

IMT are less profitable than DMT, given a premium for money-like claims and moral hazard in the selection of assets:

$$\Lambda^I(y_{S,min}(D_L); S, D_L) + X(D_L; L) \leq \Lambda(D_S^*, S) + X(D_S^*; S) \text{ for all } D_L \in \mathbb{R}^+$$

with strict inequality for $D_L^c < \max\{\mathrm{supp}\,(f_2|x_1 = x_{S,min})\}$.

Proof: As shown in Lemma 3, there are two possible maxima of $\Lambda^I(y_{S,min}(D_L); S, D_L) + X(D_L; L)$. At $D_L = D_L^c$, $\Lambda^I(y_{S,min}(D_L^c); S, D_L^c) + X(D_L^c; L) = \lambda\, y_{S,min}(D_L^c) + \mathrm{E}[\tilde{x}_2] - I \leq \lambda\, x_{S,min} + \mathrm{E}[\tilde{x}_2] - I = \Lambda(D_S^*, S) + X(D_S^*; S)$ with strict inequality for $D_L^c < \max\{\mathrm{supp}\,(f_2|x_1 = x_{S,min})\}$, as shown in Lemma 1. At $D_L = \infty$, $\Lambda^I(y_{S,min}(\infty); S, \infty) + X(\infty; L) = \lambda\, y_{S,min}(\infty) + \mathrm{E}[\tilde{x}_2] - I - \big(\mathrm{E}[\tilde{x}_2] - \mathrm{E}\left[\tilde{x}_2^b\right] - \mu\big) < \lambda\, y_{S,min}(\infty) + \mathrm{E}[\tilde{x}_2] - I = \lambda\, x_{S,min} + \mathrm{E}[\tilde{x}_2] - I$. ■

Intuition: In order to commit to the efficient choice of the good assets, the asset operator has to retain a sufficiently large equity position. This means that the portfolio value of the investment bank that buys long-term debt of the asset operator is smaller than the value of the underlying assets. This even holds in case of negative shocks to the assets at intermediate dates, when the retained equity maintains a positive value, while the value of the long-term debt declines. Consequently, the investment bank can issue less safe short-term debt than the asset operator in case of DMT. This implies that the premium for money-like claims that can be earned is higher in case of DMT than in case of IMT.

The result qualitatively remains the same, if one considers the retention of other claims than equity by the asset operator. Independent of the type of claims retained, their payoff must be sensitive to the asset payoff in such a way that the asset operator has an incentive to choose the good assets. If the retained claims maintain a positive value in case of a negative shock at an intermediate date, then the claims sold to the investment bank are less valuable than the underlying assets in case of such a shock. The investment bank can thus not issue the same level of safe short-term debt as the asset operator.

To conclude, this section has shown that the difference between DMT and IMT derived in the previous section is relevant in situations where assets are financed with money-like claims in presence of moral hazard. In order to resolve the moral hazard, the agent who selects and operates the assets has to retain (equity) claims to these assets. The premium for providing money-like claims is maximized by selling safe short-term debt. Since DMT allow for more safe short-term debt than IMT, more money-like claims can be provided in the former case. Due to the equity that the securitization vehicle has to retain in order to align incentives, the short-term debt capacity of the investment bank is smaller than the capacity of the asset operator in case of DMT.

2.4. Rationale for Indirect Maturity Transformations

Given the result of the previous section, one has to wonder why IMT have become a common form of intermediation, as illustrated in GSBMR (2016), for instance. This section provides a rationale for IMT that is based on an advantage of an indirect reference of short-term debt to the underlying assets, which has not been analyzed so far: the indirect reference decreases liquidity risk and thus improves the provision of money-like claims.

As highlighted by Shleifer & Vishny (1992), the transfer of unmatured assets as consequence of a withdrawal of their funding can entail efficiency losses that lead to 'fire sale' prices. This loss can be interpreted as the loss of specialized skills or knowledge in operating the assets which have been obtained by the initial operator of the assets. If the assets consist of loans to firms and households, for instance, the knowledge consists of the lending relationships that have been established. Within the model used in this chapter, this asset illiquidity can be represented by a decline $\tilde{x}_1 \rightarrow (1-l_A)\tilde{x}_1$ of the expected asset payoff which occurs if the assets are sold by the asset operator at $t=1$. The transfer of the underlying assets contrasts with the transfer of a financial claim to these assets. If a long-term debt claim to assets has to be sold due to a withdrawal of its short-term funding, the operator of the underlying assets remains the same. This means, first, that the operation and the expected payoff of the assets does not change, and second, that the expected payoff $\tilde{y}_1$ of the long-term debt does not change – only the recipient of this payoff changes.

The illiquidity of the assets leads to a coordination problem at $t = 1$, if the following conditions hold: first, each investor is small and holds only an infinitesimal fraction of W_I, so that each investor can only buy an infinitesimal fraction α of the asset operator's debt; second, the investors decide simultaneously about buying/rolling over short-term debt and cannot coordinate this decision; third, maturing debt has priority to outstanding debt.[7] These features are not rationalized as optimal contractual arrangement in this chapter, but they are rather taken as given constraints of financial intermediaries with decentralized short-term debt holders.

Given these features, there is a 'run equilibrium' at $t = 1$ in case of $(1 - l_A)x_1 < D_S \leq x_1$ in which the investors do not roll over or buy the short-term debt of the asset operator, so that the asset operator has to sell the assets at the discounted price $(1 - l_A)x_1$. This price equals the expected payoff that investors who buy the assets can obtain from their operation. The collective withdrawal of the short-term debt is an equilibrium: if an investor withdraws her fraction α of the debt when all other investors do the same, she receives $\alpha\,(1 - l_A)\,x_1$ on average; if she rolled over her debt claim in that situation, she would only receive $z_\alpha := \max\{0, (1 - l_A)x_1 - (1-\alpha)D_S\}$, which is smaller than $\alpha\,(1 - l_A)\,x_1$ due to $(1 - l_A)x_1 < D_S$.[8] If another investor replaced the withdrawing investor and bought the fraction α of the asset operator's debt, she would not pay a price larger than z_α, which is the expected payoff of this debt claim given that all other investors withdraw. The revenue z_α from this 'debt roll-over' would be insufficient to pay off the withdrawing claim with face value $\alpha\,D_d$, so that the asset operator still had to liquidate the assets.

If the possibility of such a 'run' cannot be excluded, short-term debt of the asset operator with face value $D_S > (1 - l_A)\,x_{S,min}$ is not safe between $t = 0$ and $t = 1$. This means that the asset illiquidity constrains the level of money-like claims that the asset operator can provide by means of short-term debt. The corresponding premium is:

$$\Lambda(D_S; S) = \lambda \cdot D_S \text{ for } D_S \leq (1 - l_A)x_{S,min} \text{ and } \Lambda(D_S; S) = 0 \text{ } else.$$

[7] This means: if maturing debt is withdrawn at $t = 1$, the portfolio of the entity that issues the debt is liquidated in order to pay off the withdrawing debt claim, even if the overall payoff from the liquidation is too small to also pay off the debt that matures later.

[8] After selling the assets for $(1 - l_A)x_1$ and paying off the other investors, who withdraw their fraction $1 - \alpha$ of debt with face value D_S, the amount left over is $\max\{0, (1 - l_A)x_1 - (1-\alpha)D_S\}$.

For the reasons suggested above, the portfolio of the investment bank is more liquid than the underlying assets, so that the provision of money-like claims by short-term debt is not constrained by the possibility of a self-fulfilling run. Consequently, the premium $\Lambda^I(D_S^I; S, D_L)$ that the investment bank can earn by issuing safe short-term debt remains the same as stated in Eq. (2.2).

Proposition 3

If the illiquidity of the assets is large compared to the risk retention that is necessary to prevent moral hazard, then IMT are more profitable than DMT.

$$\text{if } (1 - l_A)\, x_{S,min} < y_{S,min}(D_L^c), \text{ then}$$
$$\Lambda^I\big(y_{S,min}(D_L^c); S, D_L^c\big) + X(D_L^c; L) > \Lambda(D_S; S) + X(D_S; S)\ \forall\ D_S \in \mathbb{R}^+.$$

Proof: For $d = S$, the maximal possible $\Lambda(D_S; S)$ equals $\lambda \cdot (1 - l_A)\, x_{S,min}$, which is smaller than $\lambda \cdot y_{S,min}(D_L^c)$, if the stated condition holds. And $X(D_S; S)$ cannot be larger than $X(D_L^c; L) = \mathrm{E}[\tilde{x}_2] - I$. ■

Intuition: The previous Proposition has shown that IMT have a relative disadvantage in providing money-like claims, because the value of the investment bank's portfolio, which is given by the expected payoff of the long-term debt, is smaller than the value of the underlying assets. If one considers liquidity risk, however, DMT also have a relative disadvantage in providing money-like claims. In case of DMT, the short-term debt refers directly to the illiquid assets, so that the level of safe short-term debt is constrained from above by $(1 - l_A)x_{S,min}$ due to the risk of self-fulfilling runs at $t = 1$ for higher levels of short-term debt. Given a more liquid portfolio to which the short-term debt refers, IMT are not constrained in this way. If this relative advantage of IMT is larger than its relative disadvantage, which means if $y_{S,min}(D_L^c) > (1 - l_A)\, x_{S,min}$, then IMT can provide more money-like claims. Given a sufficiently large equity retention by the asset operator (i.e., $D_L = D_L^c$), the moral hazard problem is also solved and $X(D_L; L)$ is at least as large as in case of DMT.

The comparison of IMT and DMT neglect losses from inefficient liquidations, which means losses from selling assets at the price $(1 - l_A)\, x_1$ instead of x_1 in case of a 'run'. This negligence does not change the comparison, because the optimal choice of short-term debt maximizes Λ, which means that the highest possible level of safe short-term is chosen. And safe short-term debt implies that the risk of a 'run' and liquidations is zero.

Corollary 2

If IMT are more profitable than DMT, the asset operator has an incentive to be a securitization vehicle, given that the investment bank transfers such a fraction ω of the premium

Λ^I to the asset operator that

$$\omega \cdot \Lambda^I(y_{S,min}(D_L); S, D_L) + X(D_L; L) > \Lambda(D_d; d) + X(D_d; d) \quad \forall \ D_d \in \mathbb{R}^+, \ d \in \{S, L\}.$$

An investor has an incentive to set up an investment bank, because she can earn $(1-\omega)\Lambda^I$. Apart from this premium for money-like claims, buying the long-term debt and selling equity and short-term debt claims to this debt security implies neither gains nor losses in the setting discussed here. The fraction ω of Λ^I that is transferred from the investment bank to the asset operator depends on the characteristics of the financial market. If investors can costlessly set up an investment bank, then $\omega = 1$ in the model studied here, in which there is a single asset operator and a continuum of investors.

To sum up, this section has illustrated that indirect maturity transformations can be the optimal form of financing in spite of the relatively higher default risk. Keeping the same setting as in the previous section (i.e., a premium for money-like claims and a moral hazard problem that demands for equity in the securitization vehicle), I have suggested a novel argument for a decrease in liquidity risk owing to IMT. I suppose that a financial claim to some assets is more liquid than the assets, because a sale of assets entails a disruption of their operation, while a sale of a financial claim does not affect the operation of the underlying assets. The relatively more liquid portfolio, to which the short-term debt refers in case of an IMT, allows for issuing more short-term debt without facing a self-fulfilling run. If this relative advantage of IMT is stronger than the relative disadvantage highlighted in previous sections, an IMT can provide more money-like claims than a DMT and it can be thus be the optimal form of financing.

2.5. Regulation of Indirect Maturity Transformations

The previous section has pointed out that IMT can provide more money-like claims than DMT, because they can issue more short-term debt without facing the risk of a self-fulfilling run. As highlighted in Diamond & Dybvig (1983), however, coordination problems of short-term debt can be resolved by an insurance of the debt claims. Such an insurance eliminates the relative advantage of IMT. But it also entails moral hazard, if risk can be shifted to the insurance provider by issuing too much debt and too little equity. To prevent such risk-shifting, the insurance has to be accompanied by capital requirements or a fair pricing of insurance premiums. This section highlights that equally high capital requirements or insurance premiums for DMT and IMT lead to an implicit subsidy for IMT, which can incentivize the formation of IMT. And it describes how this subsidy for IMT depends on the distribution of equity over securitization vehicle and investment bank.

Let us assume that there is a public authority that insures short-term debt in both cases, DMT and IMT. The insurance means: if there is a collective withdrawal of short-term funding of DMT or IMT at $t = 1$, the authority steps in and fully pays off all debt holders (independent of their withdrawal decision). The funds for the insurance payments are taken from the liquidation of the assets (in case of DMT) or debt securities (in case of IMT) as well as – to fill the remaining funding gap – from a lump-sum tax imposed on all investors. This insurance resolves the coordination problem of the short-term debt holder in case of DMT for $D_S \in \big((1-l_A)x_{S,min}\,,\,x_{S,min}\big]$, because the expected payoff of a short-term debt holder is independent of the withdrawal decision of the other investors. This increases the amount of money-like claims that can be provided by DMT.

Depending on the debt level, the insurance does not only cover liquidity risk, but also solvency risk. For DMT, there are two possibilities. For $D_S \leq x_{S,min}$, the asset operator can roll over the debt in each possible state at $t = 1$, because she can offer a risk-adjusted face value $D_{S,1}$ of the new debt claim, so that the expected payoff equals D_S.[9] And the asset operator has an incentive to roll over the debt with an adjusted price because of the remaining expected payoff $\mathrm{E}\left[\max\{\tilde{x}_2, D_{S,1}\}|x_1\right]$ that she can receive. This means that an insurance of debt up to $D_S \leq x_{S,min}$ does not cover solvency risk. In case of $D_S > x_{S,min}$, however, there are states $x_1 \in (x_{S,min}, D_S)$, for which such a roll-over is not possible, because the expected payoff $\mathrm{E}\left[\min\{D_{S,1}, \tilde{x}_2\}|x_1\right]$ of the rolled-over debt would be smaller than D_S for any possible $D_{S,1}$. As a consequence, the short-term debt holders will withdraw at $t = 1$ in order to receive the insured payment D_S. While the insurance covers some part of this payment by means of taxes, the asset operator can sell the short-term debt at the price D_S at $t = 0$, since the payoff D_S at $t = 1$ is safe. This means that the insurance entails an implicit subsidy for DMT with $D_S > x_{S,min}$. To avoid this subsidy, the authority can impose regulation that enforces $D_S \leq x_{S,min}$, which is equivalent to a capital requirement $e_B \geq \mathrm{E}\left[\tilde{x}_1 - x_{S,min}\right]$. (I focus on capital requirements, but explain at the end why the results are the same for insurance premiums.)

Observation 3

An insurance of short-term debt at $t = 1$ accompanied by the constraint $e_B \geq E\left[\tilde{x}_1 - x_{S,min}\right]$ increases the profitability of DMT (i.e., in increases $\Lambda + X$), because it raises the upper bound for the premium $\Lambda(D_S; S)$ from $\lambda\,(1 - l_A)\,x_{S,min}$ to $\lambda\,x_{S,min}$.

In the simple setting studied in this chapter, an insurance of short-term debt in case of IMT has neither a positive nor a negative effect on the provision of money-like claims. It would only have a positive effect, if one considered additional causes for illiquidity that also affect the portfolio of the investment bank, like cash-in-the market pricing, for instance. Let us nevertheless consider that the short-term debt of IMT is also insured and let us discuss the effect of different types of capital requirements. The implicit subsidy

[9] The expected payoff is $\mathrm{E}\left[\min\{D_{S,1}, \tilde{x}_2\}|x_1\right] \geq \mathrm{E}\left[\min\{D_{S,1}, \tilde{x}_2\}|x_{S,min}\right]$, which can always be set equal to $x_{S,min} \geq D_S$ by choosing $D_{S,1}$ equal to ∞.

S that IMT receive from the insurance in case of equity levels (e_V, e_I) in securitization vehicle and investment bank is:

$$S(e_V, e_I) = \mathrm{E}\left[\max\{0, D_S^I(e_V, e_I) - \tilde{y}_1(D_L(e_V))\}\right] \text{ for } e_V \geq e_V^{min} ,$$

where $D_L(e_V)$ and $D_S^I(e_V, e_I)$ are implicitly given by $e_V = \mathrm{E}\left[\max\{\tilde{x}_2 - D_L, 0\}\right]$ and $e_I = \mathrm{E}\left[\max\{\tilde{y}_1(D_L(e_V)) - D_S^I, 0\}\right]$. For brevity, I focus on capital levels e_V of the securitization vehicle that are sufficient to incentivize the selection of good assets, which means $e_V \geq \mathrm{E}\left[\tilde{x}_2 - D_L^c\right] =: e_V^{min}$.

Observation 4

The capital requirements that allow for the largest profit of IMT without subsidy are

$$e_V \geq e_V^{min} , \quad e_I \geq E\left[\max\{\tilde{y}_1\big(D_L(e_V)\big) - y_{S,min}\big(D_L(e_V)\big), 0\}\right]$$

These lower bounds for equity are equal to the optimal structure of an IMT in absence of an insurance.

The lower bound for e_V ensures that $D_L \leq D_L^c$, which is highest possible level of long-term debt that incentivize the efficient choice of good assets. And the lower bound for e_I, which is equal to $\mathrm{E}\left[\max\{\tilde{y}_1\big(D_L(e_V)\big) - D_S^I, 0\}\right]$, ensures that $D_S^I \leq y_{S,min}(D_L(e_V))$. This bound for D_S is the highest possible value of safe short-term debt that the investment bank can issue without subsidy by the insurance.

Corollary 3

Given an insurance of short-term debt and capital requirements that prevent implicit subsidies, DMT are more profitable than IMT – for the same reasons as given in Section 2.3 and Proposition 2 in a setting without liquidity risk. As a consequence, the asset operator has no incentive to become a securitization vehicle in such cases.

In order to set capital requirements that prevent a subsidization of IMT, the public authority has to consider the two institutions simultaneously and has to account for the higher default probability compared to DMT. Let us briefly study what happens, if the public authority fails to do so and just imposes an overall capital requirement on IMT.

Proposition 4

a) Given an insurance of short-term debt and an overall capital requirement $e_V + e_I \geq e_{reg}$, the implicit subsidy to IMT is maximized by concentrating the equity in the securitization vehicle, which means by $(e_V = e_{reg},\ e_I = 0)$:

$$(e_{reg}, 0) = \underset{e_V, e_I \in \mathbb{R}^+}{\operatorname{argmax}}\ S(e_V, e_I)\ s.t.\ e_V + e_I \geq e_{reg}\ \wedge\ e_V \geq e_V^{min} .$$

b) If IMT are subject to the same capital requirement $e_V + e_I \geq E[\tilde{x}_1 - x_{S,min}] =: e_B^{reg}$ *like DMT and if* $e_B^{reg} \geq e_V^{min}$*, then IMT are privately more profitable than DMT:*

$$\Lambda^I\big(D_S^I(e_V,e_I)\big)+X(D_L(e_V);L)+S(e_V,e_I) > \Lambda(x_{S,min};S)+X(x_{S,min};S) \;\; for \;\; (e_V,e_I)=(e_B^{reg},0).$$

Proof: given in Appendix A.2.

Intuition: a) The implicit subsidy consists of payments of the short-term debt by the insurance in states in which the debt would default otherwise. As highlighted by Corollary 1 in Section 2.2, the default probability of short-term debt in case of IMT with fixed equity level $e_V + e_I$ increases with the equity part e_V that is issued by the securitization vehicle. Consequently, the implicit subsidy increases in e_V for fixed $e_V + e_I$.
b) If the entire equity is in the securitization vehicle, which means if $e_V = e_B^{reg} \geq e_V^{min}$, the selection of good assets is ensured and $X(D_L(e_B^{reg}); L) = X(x_{S,min}; S)$. In contrast to DMT, however, IMT receive the subsidy S, which is strictly positive in case of $(e_V,e_I) = (e_B^{reg},0)$, because the extremely levered investment bank ($e_I = 0$ implies $D_S^I = D_L$) receives some insurance payments in presence of non-vanishing risk. In addition, since the subsidy increase the payoff to the debt holders at $t = 1$, it weakly increases the amount of money-like claims that can be provided, so that $\Lambda^I \geq \Lambda$.

Let me conclude the section with two brief remarks. First, if e_B^{reg} is smaller than e_V^{min}, then $e_V = e_B^{reg}$ will be insufficient to incentivize the selection of good assets. Raising e_V to e_V^{min} would ensure good assets, but it would reduce the implicit subsidy S. Which level of e_V maximizes the private profit of IMT depends on the relative sizes of the subsidy and the costs of choosing bad assets, as well as on the fraction of these costs that is covered by the insurance.
Second, the discussion of capital requirements presented here also applies to insurance premiums as an alternative means of avoiding risk-shifting at the expense of the insurance. Fair insurance premiums have to be calibrated such that they are equal to the potential subsidy $S(e_V, e_I)$ from shifting solvency risk to the insurance. If they are calibrated in this way, they offset the possibility of subsidies. The fair premiums for IMT have to be larger than for DMT, since the probability of insurance payments are larger, given the same level of debt. If this is the case, the asset operator has no incentive to become a securitization vehicle instead of selling short-term debt directly to the investors. But if the insurance premiums for IMT are the same as for a DMT, the IMT receives a subsidy and might be chosen by the asset operator for that reason.

To sum up, this section has discussed the case that the short-term debt is insured against liquidity risk, so that the relative advantage of IMT is lost. In order to prevent risk-shifting at the expense of the insurance, however, appropriate capital requirements (or insurance premiums) have to be imposed. If the same requirements apply for IMT and DMT, the former receives an implicit subsidy owing to its relatively higher default probability, and IMT might emerge for that reason. Capital requirements that avoid a subsidy have to higher for IMT than for DMT. If this is the case, there is no incentive left for engaging in the less efficient IMT rather than in DMT.

3. Stepwise Maturity Transformations

3.1. Introduction

There are several explanations for maturity transformations by financial intermediaries. There is no explanation, however, for the fact that these maturity transformations are sometimes divided into several steps which are performed by differing firms within an ‘intermediation chain’. An important example is: banks hold long-term assets and are financed with commercial paper that has a duration of several weeks; and this commercial paper is held by money market funds (MMFs), which issue shares that can be withdrawn daily.[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 special purpose vehicles). But why is the maturity transformation, which the less regulated intermediaries provide, divided into several steps along a chain? If the financial firms only wanted to engage in regulatory arbitrage, the banks could sell commercial paper with daily roll-over to MMFs or their special purpose vehicles could get short-term funding directly from final investors. The contribution of this chapter is to provide an explanation for the division of maturity transformations along an intermediation chains, which means it provides an explanation for ‘stepwise maturity transformations’. And this explanation does not rely on regulatory arbitrage.

This chapter rationalizes 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 constitutes a ‘money-like’ claims, which can be used as means of payment and for which investors are willing to pay a premium. On the other hand, Diamond & Rajan (2000) have argued (based on Jensen (1986) and Calomiris & Kahn (1991)) that short-term debt can be an efficient device for disciplining managers of a bank, because it can be quickly withdrawn if the managers engage in costly misbe-

[1] More details about this example of stepwise maturity transformation are 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. In addition, Krishnamurthy et al. (2014) document the repo market, 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. Furthermore, 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.

havior. Both theories are used as justifications for the fact that banks have high levels of short-term debt.[2]. But do these explanations of debt financing actually refer to the same type of debt? This means: do they provide mutually compatible characterizations of the optimal capital structure of a bank? This chapter is the first one to address this question and 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 money-like claims. Having highlighted this conflict between the two objectives of debt financing, the chapter then shows that this conflict can be resolved by means of an intermediation chains with two links that issue different types of debt.

Consider the provision of money-like claims by a bank whose portfolio value follows a stochastic process. A payoff of the bank debt is safe, if its face value is weakly smaller than the lowest possible liquidation value of the bank at the maturity date of the debt. Given liquid markets, the value of the bank is determined by the fundamental value of its assets. If the asset value is given by a stochastic process, it strongest possible decline over a longer period is larger than the strongest possible decline over a shorter period. Since the level of safe debt is constrained from above by the lowest possible bank value at the maturity date of the debt, a shorter debt duration is always better than a longer duration for the purpose of providing money-like claims.

Consider now that the same bank has managers who can engage in privately beneficial, but inefficient misbehavior. Debt holders can discipline the managers by the threat to withdraw their funding, which would lead to a liquidation of the bank and a replacement of the managers. A withdrawal in reaction to manager misbehavior only occurs, however, if the payoff of the debt claims is sensitive to this behavior. This implies: if the debt shall be sensitive to the manager behavior in more cases than only the worst possible evolution of the bank assets, the debt level has to be higher than the 'safe level' discussed above and the debt 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. The duration of the debt thus has to be relatively short. But if a high level of debt has to be rolled over before the assets mature, the bank faces the risk of a costly premature liquidation because of a low asset value at the roll-over date. Such a premature liquidation becomes the more likely, the shorter the debt duration is: if there is less time before the debt has to be rolled over, 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 the possibility to stop manager misbehavior before its completion. The optimal duration of disciplining debt thus depends on the bank characteristics like the costs of a premature liquidation and the time that managers need to complete their costly misbehavior. The chapter shows that, for a plausible range of parameters, the optimal debt duration for disciplining managers

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

is an interior solution, which means: it is shorter than the asset duration, but longer than the shortest duration possible.
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 bank 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 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 a separation of the different purposes of debt financing.
Besides resolving the conflict concerning the optimal capital structure, the intermediation chain can also resolve another conflict 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 money-like claims which should be 'informationally insensitive' in order to serve 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. The fund constitutes a delegated monitor on behalf of its investors who demand money-like claims. And the operator of the fund has an incentive to perform the monitoring correctly, as long as the operator holds an equity position in the fund (or something similar like guarantees) which is sufficiently sensitive to the manager misbehavior.

Additional related literature: There are papers about the optimal duration of debt financing like von Thadden (1995), Leland & Toft (1996), and Cheng & Milbradt (2012). These papers, however, do not address the combination and the reconciliation of two purposes of debt financing, as it is done in this chapter. 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.

The literature on financial networks, following Allen & Gale (2000) and Freixas et al. (2000), describes a certain type of 'intermediation chain' with maturity transformation. This literature, however, studies systems of mutual liquidity insurance, and it does not address the division of maturity transformations along chains in which different links provide different purposes of debt financing.

The **remainder of the chapter** is organized as follows. Section 3.2 describes the conflict between the two purposes of debt financing which a bank faces when it chooses its capital structure. Section 3.3 shows how an intermediation chain with stepwise maturity transformation can resolve this conflict. Section 3.4 discusses potential agency problems when the fund acts as delegated monitor as well as the robustness of the results to staggered debt structures.

3.2. Two Purposes of 'Short-term' Debt Financing

This section provides a model that illustrates how the choice of capital structure depends on the purpose of debt financing. The first subsection introduces the agents in the model. The second subsection describes the capital structure that minimizes the agency costs of a bank by disciplining its managers, whereas the third subsection describes the optimal choice of debt for providing 'money-like' claims. And the fourth subsection highlights the conflict between these two purposes of debt financing, when a bank owner chooses the capital structure of the bank.

3.2.1. Basic Structure

The model consists of four dates $t = 0, 1, 2, 3$ and three types of agents: an 'initial owner' of a bank, the 'managers' of the bank, and a set of 'investors'.

The initial owner and the bank assets: The bank has a set of assets with a stochastic payoff x_3 at $t = 3$. At $t = 0$, the initial owner sells debt and equity of the bank to the investors. Assuming that the initial owner wants to consume the revenue from this sale at $t = 0$, her aim is to choose the capital structure that maximizes this revenue. To neglect problems with the adjustment of the capital structure in presence of outstanding debt, let us assume that the bank has no outstanding debt at $t = 0$ and it cannot issue equity after $t = 0$. The initial owner chooses the face value of the debt at $t = 0$ as well as the duration of the debt, which can be short (maturing at $t = 1$), medium (maturing at $t = 2$) or long (maturing at $t = 3$). 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 $t = 3$).

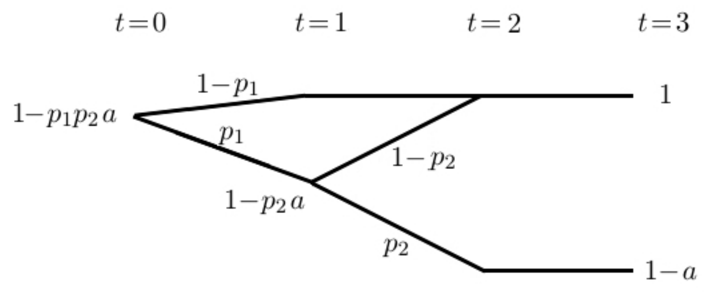

Figure 3.1.: Event tree representing evolution of the expected payoff x_t of the bank assets.

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

Managers: My analysis of the disciplining effect of debt follows Diamond & Rajan (2000), who combine ideas of Jensen (1986) and Calomiris & Kahn (1991). Assume that the bank assets are operated by managers who obtain special knowledge in this operation, so that firing them at $t=1$ or $t=2$ reduces the expected asset payoff by l. While operating the assets, the managers can start to misbehave at $t=0.5$, which yields private benefits $\mu\delta > 0$ with $\mu \in (0,1)$, but which also leads to a reduction of the expected asset payoff by δ. Although managers might be able to cause some costs in the short run, their misbehavior can cause more damage to the bank in the medium or long run. To focus on the second case, I assume that the private benefit and the loss of asset payoff only accrue, if the misbehavior lasts until $t=2.5$. Section 4.5 briefly discusses how the results change, if one accounts for costs of short-term misbehavior that lasts until $t=1.5$. Assume that the managers do not start their misbehavior, if the probability of completing their misbehavior is zero. Abstracting from other incentives, the managers can thus simply be described by: they start to misbehave as long as there is a strictly positive probability of continuing to misbehave until $t=2.5$.

Investors: The investors can either invest their initial endowment, which adds up to $W_I > 1$, in a storage technology with zero return or they can buy equity and debt of the bank. (The possibility that investors buy financial claims from each other is considered in Section 3.3.) For simplicity, I assume that the investors are risk-neutral and simply want to maximize their expected payoff at $t = 2$. The investors thus buy financial claims as long as their expected return is weakly larger than the benchmark rate $r = 0$ set by the storage technology. 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. Appendix A.1 provides a microfoundation of the premium for safe claims based on transaction needs between the dates. For the questions addressed in this chapter, however, 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 claim (measured in expected payoff), if the value of the claim is safe between $t = 0$ and $t = 1$.[3] I will refer to these claims as 'money-like claims'. For simplicity, I assume that the premium is paid at the very end, after the bank debt has been paid off at $t = 3$.[4]

3.2.2. The Optimal Choice of Debt for Disciplining Managers

I first want to study the optimal choice of debt for the purpose of disciplining the managers. Assume that $l > \delta$ and that the bank is not able to write contracts at $t = 0$ which condition on the possible misbehavior of the managers. In this case, the equity holders tolerate the misbehavior. If the equity holders notice at $t = 1$ or $t = 2$ that managers misbehave, 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 δ). Consequently, the managers always misbehave, if there is no disciplining by means of the debt financing.

The debt holders can stop the misbehavior of managers at $t = 1$ or $t = 2$ by collectively withdrawing their maturing debt, so that the bank has to be liquidated and the managers are replaced. Given that the liquidation costs l are larger than δ, this collective withdrawal is inefficient ex post. The following paragraphs explain why the debt holders can yet have an incentive for collective withdrawals and why the threat of collective withdrawals can be efficient ex ante. In this section and the subsequent ones, I assume that investors can costlessly observe manager misbehavior. In Section 3.4.2, however, I comment on potential monitoring costs and the resulting conflict between debt as disciplining device and debt as money-like claim.

Consider that the bank sells medium-term debt with face value D_M to a set of investors, so that each investor i only holds a fraction α_i of the debt with $\alpha_i D_M < 1 - a - l$.

[3] One can think of fees like the ones paid for deposit accounts. Transaction needs and fees for safe claims in the second and third period have been considered in an earlier version of this paper (which can be provided on demand), but do not change the results qualitatively.

[4] This allows to ignore uninteresting effects of paid fees on the debt safety and on the premium. The assumption implies: even if investors withdraw their debt or transfer it in a payment process, they do not pay the fee for holding safe claim (up to the withdrawal date) before the very end.

Consider further that maturing debt has priority to outstanding debt, which means: if a bank is liquidated at $t = 1$ or $t = 2$ due to a withdrawal of its debt, the withdrawn debt is paid off first, while the outstanding debt only receives the remaining liquidation value. In this case, the strictly dominant strategy of investors is to withdraw at the maturity date $t = 2$, if $x_2 - \delta\,\mathbf{1}_\delta < D_M$ with $\mathbf{1}_\delta$ as indicator function for the start of misbehavior by managers. If the other investors did not withdraw, a single investor would prefer to withdraw and to receive $\alpha_i\, D_M$ instead of rolling over and receiving the expected payoff $\alpha_i \cdot (x_2 - \delta)$ at most. (The expected payoff of the debt holders cannot be larger than the expected payoff of the bank assets, which is $x_2 - \delta$ if the bank is not liquidated, and it is $x_2 - l$ if the bank is liquidated.) If the other investors withdraw and the bank has to be liquidated with a payoff $x_2 - l$, a single investor will withdraw as well in order to receive $\alpha_i \cdot (x_2 - l)$ on average.[5] An investor that rolls over her debt claim cannot receive more than $x_r := \max\{0, x_2 - l - (1 - \alpha_i)D_M\}$, given that the withdrawn debt with face value $(1-\alpha_i)D_M$ have priority to the rolled over debt. And $x_r < \alpha_i \cdot (x_2 - l)$ due to $D_M > x_2 - l$. To sum up, withdrawing is the dominant strategy in case of $x_2 - \delta\,\mathbf{1}_\delta < D_M$.

In case of $x_2 - \delta\,\mathbf{1}_\delta \geq D_M$, in contrast, the investors are willing to roll over their debt claims as long as the new face value $D_{M,2}$ of the claim is such that the expected payoff of the claim equals D_M. This is possible by chosing $D_{M,2}$ large enough, since the expected asset payoff $x_2 - \delta\,\mathbf{1}_\delta$ is larger than D_M. Neither the managers nor the equity holders have an incentive to offer an insufficiently low face value, because it would trigger withdrawals and the liquidation of the bank. In this chapter, I neglect non-fundamental runs by assuming that the financial market is sufficiently liquid, which means: there is an investor with sufficient funds who can buy all debt of the bank, if the other investors withdraw in spite of a fair pricing (which means a sufficiently large $D_{M,2}$, as just discussed).[6]

To sum up, there is collective withdrawal of maturing debt, which stops misbehaving managers, if the expected bank payoff $x_2 - \delta$ is smaller than D_M. If the debt level D_M is larger than $1 - \delta$, so that the managers cannot expect to complete their misbehavior in any state, they will abstain from it. In this way, a high debt level can discipline managers. The implicit cost of debt as disciplining device is, however, that withdrawals and liquidations also occur in states in which $x_2 < D_M$ due to a low asset value x_2.

The same logic applies to short-term debt: investors collectively withdraw their short-term debt and stop ongoing manager misbehavior, if $x_1 - \delta < D_S$; and the cost of this disciplining device is again the loss form liquidating assets at intermediate dates, when the asset value has fallen below the debt liabilities. The relative benefits and costs of different form of debt financing can be represented by the 'agency costs' $\Delta(D_d; d)$, which are the sum of the expected loss due to liquidations and the expected loss due to manager

[5] Whether the withdrawing debt holders are served sequentially or with equal priority does not matter for the questions discussed here. It only matters that they are served with priority to those debt holders that roll over, so that their debt matures at a later date.

[6] The problem of non-fundamental runs in intermediation chains will be studied in a follow-up paper.

misbehavior. The dependence of $\Delta(D_d; d)$ on D_d and d is presented in the following. I first state the form of $\Delta(D_d; d)$, before I explain it.

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

In case of long-term debt, there are no roll-overs, which implies: there are no withdrawals and costly liquidations, while the managers can misbehave without being stopped.

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

The description of Δ focuses on the case $a > \delta$ (which will be imposed by Assumption 2 b)), for which the disciplining of managers by debt financing is not costless, but entails the liquidation of the bank in some states. In case of medium-term debt, there are no withdrawals and liquidations for $D_M \leq 1 - a - \delta$, since $1-a$ is lowest possible asset value at $t = 2$, which implies that $x_2 - \delta < D_M$ is not possible. For $D_M > 1 - \delta$, in contrast, the debt claims would be withdrawn at $t = 2$ in both possible states of the asset value (i.e, for $x_2 = 1-a$ and $x_2 = 1$), if the managers misbehaved. But having no chance to complete their misbehavior, the managers do not start it. A withdrawal and liquidation at $t = 2$ due $x_2 < D_M$ thus only occurs in case of $x_2 = 1-a$, i.e. after two bad shocks whose joint probability is $p_1\,p_2$. If the medium-term debt is in the range $D_M \in (1 - a - \delta, 1 - \delta]$, in contrast, the managers start their misbehavior, because they can complete it at $t = 2.5$ in case of an asset value $x_2 = 1$ at $t = 2$. And for this debt level the bank is also liquidated after two shocks, since $x_2 - \delta < D_M$ for $x_2 = 1 - a$.

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

with $\phi(D_S; S)$ as probability of a debt withdrawal at either $t = 1$ or $t = 2$ in case of short-term debt with face value D_S. The stated form of $\Delta(D_S; S)$ holds for the parameter range $1 - \delta \geq 1 - p_2\,a$, which will be imposed by Assumption 2 b). The discussion below Lemma 4 indicates how the result changes for the alternative parameter range. As in case of medium-term debt, the managers do not start to misbehave if and only if the level D_S of the short-term debt is larger than $1 - \delta$, so that the misbehavior would always be stopped before completion. The difference to medium-term debt is, however, that there can be a withdrawal and a liquidation already at $t = 1$. This happens if the conditional expected payoff of the bank is smaller than the face value D_S of the short-term debt. For

$D_S > 1 - \delta \geq 1 - p_2\, a$, this happens in case of a bad shock which leads to $x_1 = 1 - p_2\, a$ and which occurs with probability p_1.

Having derived the agency costs $\Delta(D_d; d)$, we can study which choice of debt minimizes these costs. Let us do this for a scenario in which bad shocks are unlikely (i.e., p_1 and p_2 are small) but large (i.e., a is large), which is represented by:

Assumption 2

a) $p_1\, p_2\, l < \delta$

b) $\delta < p_2\, a$

Lemma 4

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

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

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

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

Proof: a) Due to $l > \delta$, $\Delta(D_d, d) > \delta$ for $D_d \in (1 - a - \delta, 1 - \delta]$ and $d \in \{S, M\}$, with δ being the agency costs for $D_M < 1 - a - \delta$ and for any level of long-term debt. If $p_1\, p_2\, l < \delta$, however, $\Delta(D_M; M) < \delta = \Delta(D_L; L)$ for $D_M \in (1 - \delta, 1]$.

b) If $1 - \delta \geq 1 - p_2\, a$, the functional form of $\Delta(D_S; S)$ is the one stated above, which means that $\Delta(D_S; S)$ can only be smaller than δ for $D_S \in (1 - \delta, 1]$. But $\Delta(1; S) = p_1\, l$ is strictly larger than $\Delta(1; M) = p_1\, p_2\, l$. ■

Intuition: If the bank has a high level of debt (with face value larger than $1-\delta$), the expected payoff of the debt claim would always be reduced by misbehavior of the managers. If the debt has a medium duration, the investors would thus always withdraw their debt at $t = 2$ in reaction to manager misbehavior. Consequently, a high level of medium-term debt has a disciplining effect on managers, because they lose their incentive to misbehave. A high debt level, however, implies that the bank defaults and is liquidated, if the value of the bank assets declines due to bad shocks. Issuing a high level of medium-term debt instead of equity or long-term debt is optimal, if the expected loss from such liquidations is smaller than the expected loss due to misbehaving managers that are not disciplined. This holds, if the probability of bad shocks is small compared to the loss that managers can cause (as given by Assumption 2 a)).

A high level of short-term debt can discipline the managers, too. But it does so in a more costly way than medium-term debt, because it makes the bank prone to transitory shocks. If Assumption 2 b) applies, the level of debt necessary for disciplining managers is so high that a bad shock at $t = 1$ leads to a withdrawal of the short-term debt and a liquidation of the bank. Medium-term debt, in contrast, allows for a recovery of the asset value after a shock before the debt becomes due at $t = 2$. Disciplining managers with short-term debt thus leads to a higher probability of debt withdrawal and a higher expected loss due to liquidation than disciplining managers with medium-term debt.

Discussion of variations: If Assumption 2 b) does not apply, then $1-\delta < 1-p_2\,a$ holds true. In that case, the bank can issue a level of short-term debt which is high enough to discipline managers (owing to $D_S > 1-\delta$), but which does not lead to a liquidation after a bad shock at $t = 1$ (because $D_S < 1 - p_2\,a$). As in case of medium-term debt, a liquidation only occurs after two bad shocks. Consequently, short- and medium-term debt are equally efficient disciplining devices in that case.
As argued above, I focus on the costs of manager misbehavior in the medium run, because managers can cause more damage in the medium run than in the short run. If one took 'short-term misbehavior' into account which can be completed at $t = 1.5$, then short-term debt could stop it by a withdrawal at $t = 1$, while medium-term debt could not prevent it. Nevertheless, medium-term debt would remain the optimal disciplining device, as long as the loss due to short-term misbehavior were small compared to the increase in expected liquidation loss that a shortening of the debt duration entails.[7]

The results of this subsection do not change, if one considers **multiple debt tranches** with differing durations and different seniority levels. Assume that $D^i_{d_i}$ denotes the face value of a debt tranche with $i = I, II, ...$ increasing with decreasing seniority. In order to discipline managers, the level of short- and medium-term debt has to be so high that a potential misbehavior would always be stopped by a withdrawal of debt, even in case of $x_2 = 1$. This means that there has to be a short- or medium-term debt tranche with face value D^j_d and seniority j, so that $1 - \delta - \sum_{i=1}^{j-1} D^i_{d_i} < D^j_{d_j}$. In that case, however, the bank also faces a liquidation in case of two bad shocks to the asset value, because $1 - a - \sum_{i=1}^{j-1} D^i_{d_i} < D^j_{d_j}$. Consequently, the agency costs cannot be reduced below $p_1\,p_2\,l$, even if one accounts for multiple debt tranches.

To sum up, this subsection has built on the idea that misbehaving managers can be disciplined by the threat of a debt withdrawal at intermediate dates in reaction to such misbehavior. In contrast to previous literature, the subsection has illustrated that medium-term debt can be better than short-term debt for the purpose of disciplining managers. While medium-term debt is rolled over frequently enough to prevent costly misbehavior of managers, a bank with medium-term debt is less prone to costly liquidations in case of a bad

[7] An earlier version of this paper (which can be provided on demand) has explicitly accounted for costs of short-term manager misbehavior, arriving at the trade-off that is indicated here.

shock than a bank with short-term debt.

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

Let us now study the optimal choice of debt for the provision of money-like claims. If investors pay a fee λ per unit of debt claim whose value is safe between $t = 0$ and $t = 1$, then the total premium $\Lambda(D_d; d)$ for money-like claims depends on the face value D_d and the duration d of the debt as follows:[8]

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

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

$$\Lambda(D_S; S) = \begin{cases} \lambda \cdot D_S & \text{for } D_S \in [0, D_S^c] \\ 0 & \text{for } D_S > D_S^c \end{cases}$$

$$\text{with } D_S^c := \max\{1 - p_2\,(a + l) - (1{-}p_2)\,\delta\,,\, 1 - a - \delta\}.$$

For $D_L \leq 1 - a - \delta$, the payoff of the long-term debt is safe, so that its value is safe between $t = 0$ and $t = 1$ and the bank earns a premium $\lambda \cdot D_L$. For $D_L > 1 - a - \delta$, the long-term debt is risky and its value at $t = 1$ depends on the occurrence of a shock (the value is D_L in case of a good shock and it is $(1{-}p_2)\,D_L + p_2\,(1{-}a{-}\delta)$ in case of a bad shock). Consequently, the bank earns no premium for $D_L > 1 - a - \delta$. Given that I abstract from risk in the third period, the premium for medium-term debt is the same as for long-term debt: the debt is safe and leads to a premium $\lambda\, D_M$, if and only if $D_M \leq 1 - a - \delta$. If the bank issues short-term debt with face value $D_S \leq 1 - a - \delta$, the short-term debt is also safe and it can be rolled over at $t = 1$ and $t = 2$ without change of face value, before the debt claim yields the safe payoff $1 - a - \delta$ at $t = 3$.[9] Short-term debt, however, allows to issue a higher level of safe claims than $1 - a - \delta$, if $D_S^c = 1 - p_2\,(a + l) - (1{-}p_2)\,\delta > 1 - a - \delta$. In case of a bad shock at $t = 1$, the expected payoff of the bank equals D_S^c.[10] Consequently, the bank can roll over short-term debt with $D_S \leq D_S^c$, as long as the face value $D_{S,1}$ of the debt after the roll-over is such that the expected payoff of the debt claim equals D_S. To sum up, the level of money-like claims is constrained from above by the lowest possible bank value at the maturity date of the bank debt (with the bank value given as the conditional expected payoff of the bank).

[8] As mentioned above, fees for money-like claims in the second and third period have been considered in an earlier version of this paper, but they do not change the results qualitatively.

[9] For $r = 0$, risk-neutral investors are willing to roll over safe debt claims without change in the face value, since the expected payoff of the new claim equals the payoff of the maturing claim.

[10] The expected payoff of the bank after a bad shock at $t = 1$ is D_S^c for the following reasons. With probability $1 - p_2$, the assets recover and yield $1 - \delta$, given that the debt level is too low to prevent manager misbehavior. And with probability p_2, the expected asset payoff declines further to $1{-}a{-}\delta < D_S$. This implies that the bank is liquidated at $t = 2$, so that the bank payoff is $1 - a - l$.

Observation 5

In liquid markets, short-term debt is weakly better for providing money-like claims than medium- or long-term debt: $\Lambda(D_M; M) = \Lambda(D_M; L) \leq \Lambda(D_M; S) \ \forall \ D_S \in \mathbb{R}^+$.

In accordance with the discussion of the agency costs, let us focus on a scenario in which bad shocks are unlikely (i.e., p_1 and p_2 are relatively small), but large (i.e., a is large), and let us impose:

Assumption 3 *:* $\frac{p_2}{1-p_2}\,(l-\delta) < a\,.$

Lemma 5

If Assumption 3 holds, short-term debt is strictly better for providing money-like claims than medium- or long-term debt: $\Lambda(D_d; d)$ *has its unique maximum at* $D_S = 1 - p_2\, a$.

Proof: If Assumption 3 holds, then $D_S^c = 1 - p_2\,(a+l) - (1-p_2)\,\delta > 1 - a - \delta$ and $\Lambda(D_S^c; S) = \lambda \cdot D_S^c > \lambda \cdot (1 - a - \delta) = \Lambda(1-a-\delta; M) = \Lambda(1-a-\delta; L)$. ■

Intuition: In liquid markets the bank debt is safe, if there is no risk that the face value of the debt will be larger than the value of the bank assets at the maturity date of the debt. The value of the bank assets is given by the conditional expected payoff of these assets. Since more shocks can occur over a longer period of time than over a shorter period, the lowest possible bank value at $t = 2$ and $t = 3$ is smaller than the lowest possible bank value at $t = 1$. Consequently, short-term debt allows for providing a higher level of money-like claims than medium- or long-term debt.

The results of this subsection do not change, if one considers **multiple debt tranches** with different durations and different seniority levels. In liquid markets, safe medium- or long-term debt can be substituted by the same level of safe short-term debt, so that different durations cannot improve the provision of money-like claims relative to just issuing short-term debt. And splitting safe short-term debt into tranches with different seniority does not change the overall amount of safe debt. Consequently, short-term debt with face value D_S^c remains optimal for providing money-like claims, even if considers multiple tranches.

To sum up, this subsection has shown that the provision of money-like claims, which are given in form of safe debt claims, is optimized by issuing short-term debt. The maximal level of safe debt is constrained from above by the lowest possible value of the bank at the maturity date of the debt. And the value of the bank can decline more over a longer period of time than over a shorter one.

3.2.4. The Conflict between Disciplining Managers and Providing Money-like Claims

Let us now study the decision problem of the initial bank owner in presence of both, the agency costs Δ as well as the premium Λ for providing money-like claims. This section focuses on the conflict between the two purposes of debt financing with respect to the choice of capital structure. The conflict between the two purposes with respect to the information level of the debt holders is addressed in Section 3.4.2.

As mentioned above, I assume that the initial bank owner wants to maximize the revenue from selling equity and debt claims to investors at $t = 0$. This is equivalent to maximizing the expected payoff of the set of all equity and debt claims, given that the investors are risk-neutral and there are no information asymmetries. The total expected payoff of all claims equals the expected payoff $x_0 = 1 - p_1\, p_2\, a$ of the bank assets, minus the expected agency costs Δ, plus the expected premium Λ. In order to discuss the problem in a general form, let us directly account for the possibility of multiple debt tranches with respective face values $D^i_{d_i}$, durations d_i and seniorities that decrease with increasing $i = I, II, ...$ The initial owner then solves

$$\max_{j\in\mathbb{N}\,,\,D^i_{d^i}\in[0,1]\ \text{and}\ d^i\in\{S,M,L\}\,\text{for}\ i=I,..,j} x_0 + \Lambda\left(\{D^i_{d^i}\}^j_{i=1}\right) - \Delta\left(\{D^i_{d^i}\}^j_{i=1}\right),$$

where $\Lambda\left(\{D^i_{d^i}\}^j_{i=1}\right)$ and $\Delta\left(\{D^i_{d^i}\}^j_{i=1}\right)$ are the generalizations of premium and agency costs for multiple debt tranches, which are described in the proof of the following Proposition.

Proposition 5

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

$$\Lambda\left(\{D^i_{d^i}\}^j_{i=1}\right) - \Delta\left(\{D^i_{d^i}\}^j_{i=1}\right) < \Lambda\left(D^c_S, S\right) - \Delta\left(1, M\right)$$
$$\forall\, j \in \mathbb{N},\ D^i_{d^i} \in [0,1]\ \textit{and}\ d^i \in \{S, M, L\}\ \textit{for}\ i = I, .., j\,.$$

Proof: Subsection 4.5 has shown that the agency costs Δ are minimized by a set of debt tranches with medium or short duration for which the face values add up to $\sum_{i=I}^{j_1} D^i_{d_i} > 1 - \delta$, while the more junior debt tranches must be medium-term: $d_{i'} = M$ for all i' for which $\sum_{i=I}^{i'} D^i_{d_i} > D^c_S$. Subsection 3.2.3, in contrast, has shown that the premium Λ is maximized by a set of debt tranches with medium or short duration for which the face values add up to $\sum_{i=I}^{j_2} D^i_{d_i} = D^c_S$, while the more junior debt tranches must be short-term: $d_{i'} = S$ for all i' for which $\sum_{i=I}^{i'} D^i_{d_i} > 1 - a - \delta$. Consequently, a set of debt tranches that could simultaneously minimize Δ and maximize Λ had to be a set $\{D^i_{d_i}\}^{j_1}_{i=I}$ for which

all these conditions hold and for which $\sum_{i=I}^{j_2} D_{d_i}^i = D_S^c$ holds for the subset $\{D_{d_i}^i\}_{i=I}^{j_2} \subset \{D_{d_i}^i\}_{i=I}^{j_1}$. The relation $j_2 < j_1$ is due to $1 - \delta > D_S^c$. If the bank has such a set of debt, however, it is liquidated with probability p_1 and $\Delta\left(\{D_{d^i}^i\}_{i=1}^{j_1}\right) = p_1\, l > p_1\, p_2\, l = \Delta\,(1, M)$, because:
In case of a bad shock at $t = 1$ (which occurs with probability p_1), the short-term debt in the subset $\{D_{d_i}^i\}_{i=I}^{j_2}$ is only rolled over, if the new face values $\{D_{d_i,1}^i\}_{i=I}^{j_2}$ are such that the expected payoff of the debt equals $\sum_{i=I}^{j_2} D_{d_i}^i = D_S^c = 1 - p_2(a + l) - (1 - p_2)\delta$.[11] Given that there is a second bad shock with probability p_2 which leads to the payoff $1 - a - l$, the expected payoff the debt claims can only equal D_S^c, if the payoff of these debt claims in case of a good shock at $t = 2$ (occurring with probability $1 - p_2$) is $1 - \delta$. This means that the new face values have to add up to $\sum_{i=I}^{j_2} D_{d_i,1}^i = 1 - \delta$. In addition to this debt, however, the bank still has the set $\{D_{d_i}^i\}_{i=j_2+1}^{j_1}$ of more junior, medium-term debt tranches, whose face values add up to $\sum_{i=j_2+1}^{j_1} D_{d_i}^i > 1 - \delta - D_S^c = p_2(a + l - \delta)$. Consequently, the overall debt level of the bank after a roll-over in case of a bad shock at $t = 1$ equals $\sum_{i=I}^{j_2} D_{d_i,1}^i + \sum_{i=j_2+1}^{j_1} D_{d_i}^i > 1 - \delta + p_2(a + l - \delta)$. The overall debt level is larger than 1, given that $\delta < l$ and that $\delta < p_2\, a$ due to Assumption 2 b). The bank thus defaults and is liquidated at $t = 2$ even if the asset value recovers to $x_2 = 1$ owing to a good shock. This means that a bad shock at $t = 1$ always leads to a costly liquidation of the bank at an intermediate date. ■

Intuition: There is a conflict between the two purposes of debt financing, because they are optimized by different capital structures, which cannot be reconciled in the balance sheet of a bank. Concerning the debt level, the worst possible asset value constitutes an upper bound for money-like claims, whereas the disciplining of managers requires a higher level of debt. Concerning the debt duration, the agency costs due to managers are minimized by medium-term debt, whereas the provision of money-like claims is maximized by short-term debt. The differing optimal capital structures cannot be reconciled by a set of debt tranches with different durations. The high level of debt necessary for disciplining managers is prone to transitory shocks, even if only that amount of debt is short-term that is necessary for optimizing the provision of money-like claims.

3.3. Reconciliation by Means of an Intermediation Chain

Having highlighted the conflict between disciplining managers and providing money-like 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. In the model studied in this chapter, intermediation chains means: an investor holds debt of the bank and finances this portfolio by selling debt claims to other investors. Put differently, an investor sets

[11] Remember that the short-term debt has junior seniority within the subset $\{D_{d_i}^i\}_{i=I}^{j_2}$.

up a fund that invests in bank debt. In the following, I first describe a particular case of such an intermediation chain, before I explain why this case represents the optimal form of an intermediation chain.

Consider that the bank issues a senior tranche of short-term debt with face value $D_S^I = 1-a-l$ and a junior tranche of medium-term debt with $D_M^{II} = a+l$, so that $D_S^I + D_M^{II} = 1$. If Assumptions 2 and 3 hold, this capital structure minimizes the agency costs, which means that $\Delta\left(\{D_S^I, D_M^{II}\}\right) = p_1\, p_2\, l = \Delta\,(1; M)$, as explained in Footnote [12]. But this capital structure does not maximize Λ. Only the short-term debt with $D_S^I < D_S^c$ is safe and yields a premium, while the medium-term debt is risky. Let y_t denote the value of the D_M^{II}-claim at time t, which is given by its expected payoff at $t = 2$ conditional on the information at date t. This value depends on the value x_t of the bank assets: $y_t = \mathrm{E}\left[\min\{D_M^{II}\,,\, x_2 - l - D_S^I\}|x_t\right] = \mathrm{E}\left[\min\{a+l\,,\, x_2 - l - (1-a-l)\}|x_t\right]$. The evolution of y_t can be represented by the following event tree:

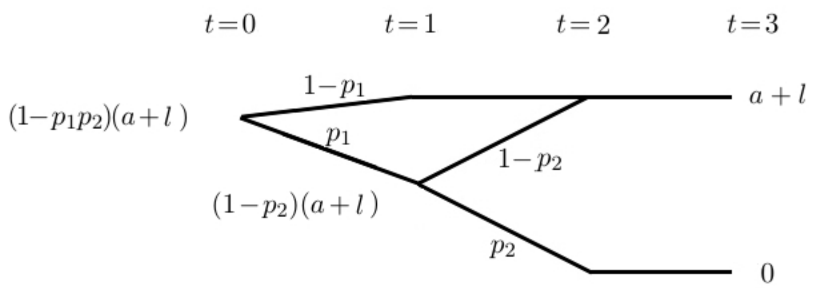

Figure 3.2.: Event tree showing the evolution of the expected payoff y_t of the D_M^{II}-claim.

Consider that an investor purchases the D_M^{II}-claim and sells debt claims to this security to other investors. Put differently, 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'. Below the next Observation, I 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 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.

Given that investors pay a fee λ per unit of claim whose value is safe between $t = 0$ and $t = 1$, the fund sponsor can earn a premium Λ_M equivalent to the bank. If the debt of

[12] Due to $D_S^I + D_M^{II} = 1 > 1 - \delta$, the managers do not misbehave. The senior short-term debt with $D_S^I = 1 - a - l$ remains safe in all possible states. It can thus be rolled over in case of a bad shock at $t = 1$ 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 in case of two bad shocks, which means it occurs with probability $p_1\, p_2$.

the fund has the face value M_d and the duration d, this premium is:[13]

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

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

Observation 6
The premium $\Lambda_M(M_d;d)$ is maximized by short-term debt with $M_S^* = (1-p_2)(a+l)$.

Given risk neutral investors and $r = 0$, 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. The fund sponsor thus has to provide the amount $y_0 - M_S$ of her own initial endowment as equity position in the fund. She is willing to do so, because this investment has the same expected return as the storage technology in which she could invest otherwise, while the fund yields the fee income Λ_M in addition.
In the intermediation chain described here, the two purposes of debt financing are partly separated. Although the bank provides some money-like claims, it focuses on the disciplining of the managers and chooses the capital structure that is optimal for this purpose. The fund, however, which holds the medium-term debt of the bank, can provide additional money-like claims.
Before I state the main result of this section, let me briefly argue why the fund is less affected by agency problems than the bank. The agency problem in the bank is due to the illiquidity of the long-term bank assets, which results from special knowledge that managers obtain while operating the assets (like lending relationships, for instance). Given the costs of replacing bank managers, the threat of firing misbehaving managers is not credible and the bank has to rely on debt financing as disciplining device. This contrast with the situation in the fund: the portfolio of the fund consists of passively held medium-term bank debt. It can simply be 'liquidated' at $t = 2$ by not rolling over the debt, so that the bank has to pay off the debt. There are thus no costs of liquidating the fund portfolio, so that the fund sponsor can simply discipline fund managers by the credible threat of firing them. For this reason, I abstract from an agency problem within the fund here. Section 3.4.2, however, discusses potential agency problems that might arise when information is costly and the monitoring of the bank managers is delegated to the fund.

Assumption 4 *:* $\delta - p_1\, p_2\, l > \lambda \cdot (p_2\, l - \delta)$.

[13] In accordance with the previous section, I assume that the fees are paid at the very end, so that the uninteresting impact of paid fees on the safety and pricing of the M_d claim can be neglected.

This assumption is imposed in order to discuss the optimality of the intermediation chain described above.

Proposition 6
If Assumptions 2 and 3 hold, then:

a) An intermediation chain can provide more money-like claims to investors than a bank, while it minimizes the agency costs in the bank:

$$\Lambda\left(\left\{D^I_S, D^{II}_M\right\}\right) + \Lambda_M\left(M^*_S; S\right) > \Lambda(D^c_S; S)\,,$$
$$\textit{while } \Delta\left(\left\{D^I_S, D^{II}_M\right\}\right) = \Delta(1; M)\,,\ \textit{with } D^I_S = 1 - a - l \textit{ and } D^{II}_M = a + l\,.$$

b) If Assumption 4 holds, there is no intermediation chain that leads to a higher surplus $\Lambda - \Delta + \Lambda_M$ *of bank and fund than the chain described here:*

$$\Lambda\left(\left\{D^I_S, D^{II}_M\right\}\right) - \Delta\left(\left\{D^I_S, D^{II}_M\right\}\right) + \Lambda_M\left(M^*_S; S\right) \geq \Lambda\left(\{D^i_{d_i}\}^{j_D}_{i=I}\right) - \Delta\left(\{D^i_{d_i}\}^{j_D}_{i=I}\right) + \Lambda_M\left(\{M^j_{d_j}\}^{j_M}_{j=I}\right)$$
$$\forall\ j_D, j_M \in \mathbb{N} \wedge D^i_{d_i}, M^j_{d_j} \in [0,1]; d_i, d_j \in \{S, M, L\} \textit{ for } i = I, ..., j_D; j = I, ..., j_M\,.$$

Proof: a) $\Lambda\left(\left\{D^I_S, D^{II}_M\right\}\right) + \Lambda_M\left(M^*_S; S\right) = \lambda\,(1-a-l) + \lambda\,(1-p_2)(a+l) = \lambda\left(1 - p_2\,(a+l)\right) > \lambda\left(1 - p_2\,(a+l) - (1-p_2)\,\delta\right) = \Lambda(D^c_S; S)$ and $\Delta\left(\{D^I_S, D^{II}_M\}\right) = p_1\,p_2\,l = \Delta\,(1; M)$ as shown in Footnote 12.
b) On the one hand, $\Delta\left(\{D^I_S, D^{II}_M\}\right) = p_1\,p_2\,l$ is the lowest possible value of the agency costs, as explained in Section 4.5. On the other hand, the amount of money-like claims is constrained from above by the lowest possible bank value at $t = 1$ (with the bank value given as the conditional expected payoff of the bank). In the chain described above, this upper bound for money-like claims is $1 - p_2(a + l)$, which is reached by $D^I_S + M^*_S$, so that $\Lambda\left(\left\{D^I_S, D^{II}_M\right\}\right) + \Lambda_M\left(M^*_S; S\right) = \lambda\left(1 - p_2\,(a+l)\right)$. The lowest possible bank value at $t = 1$ can only be larger than $1 - p_2(a + l)$, if the bank has short- and medium-term debt with an overall face value smaller than $1 - a$, so that there is no liquidation with cost l after two bad shocks. In that case, however, the managers misbehave, so that the agency costs are δ instead of $p_1\,p_2\,l$, and the lowest possible bank value at $t = 1$ is $1 - p_2\,a - \delta$. The maximal premium that can be earned in this case is thus $\lambda\,(1 - p_2\,a - \delta)$. (This premium is possible, for instance, if the bank is completely financed with long-term debt, which is held by a fund that sells short-term debt with $M_S = 1 - p_2\,a - \delta$.) This premium is larger than $\lambda\left(1 - p_2\,(a + l)\right)$, if $p_2\,l > \delta$ holds. The relative increase $\lambda\,(p_2\,l - \delta)$ of the premium is smaller than the relative increase $\delta - p_1\,p_2\,l$ in agency costs, if Assumption 4 holds. ■

Intuition: a) An intermediation chain allows to reconcile the two purposes of debt financing by partly separating them. The capital structure of the bank, which is affected by an agency problem, can be chosen such that it optimizes the disciplining of the bank

managers. (This capital structure entails short-term debt, but also some junior, medium-term debt.) At the same time, the capital structure of the fund, which caters to the demand of investors, can be chosen such that the overall provision of money-like claims is optimized. (Holding the medium-term debt of the bank, the fund sells as much safe short-term debt as possible.) The overall level of safe short-term debt is constrained from above by the lowest possible value of the bank at $t = 1$. And this upper bound is not changed, if short-term debt claims to the bank payoff are sold in two parts instead of one: the first part is the short-term debt directly issued by the bank, and the second part is the short-term debt issued by the fund which holds the junior, medium-term debt of the bank. The chain can even provide more money-like claims than a bank without fund: the lowest possible value of the bank in the chain is larger than the lowest possible value of a bank without fund which focuses on maximizing money-like claims. The latter is subject to losses from manager misbehavior that is prevented by the disciplining in the chain.
[The reduction of the level of safe debt due to an 'indirect maturity transformation', which has been identified in Chapter 2, does not apply here. In the scenario studied here, the equity level of the bank is zero: $1 - D_S^I - D_M^{II} = 0$. And in case of zero equity in the bank, indirect maturity transformations do not lead to a reduction in the level of safe debt.]
Proposition 6 shows that an intermediation chain can resolve the conflict between different purposes of debt financing, which has been pointed out by Proposition 5. In case of a bank without fund, each claim of an investor refers directly to the bank and this claim has an unambiguous duration. This duration can be chosen with the aim to maximize Λ or with the aim to minimize Δ, but it is not possible to optimize both simultaneously. In case of an intermediation chain, however, some part of the short-term debt refers to the bank via the medium-term debt. This means that a claim to the bank payoff can have two different durations: first, in 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 can be chosen such that it optimizes the disciplining of managers, and the duration of the second claim can be chosen such that is optimizes the provision of money-like claims to investors.
b) The description so far has focused on a particular case of intermediation chain, but alternative chains are possible in which bank and fund issue different sets of debt tranches. An alternative intermediation chain can only yield a higher surplus $\Lambda - \Delta + \Lambda_M$ than the chain described above, if it improves the disciplining of managers or if it increases the amount of money-like claims. An improvement of the disciplining is not possible, since the agency costs of the bank are already minimized by chain described. And the amount of money-like claims is constrained from above by the lowest possible value of the bank at $t = 1$. Since the lowest possible value of the bank assets at $t = 1$ is $1 - p_2\, a$, the overall premium $\Lambda + \Lambda_M$ can only be larger than $\lambda\,(1 - p_2(a + l))$, if the loss l of a liquidation after two bad shocks can be prevented. This is only possible, if the bank has

a relatively low level of short- and medium-term debt. An example is a bank that issues only long-term debt (i.e., $D_L = 1$), which is held by a fund that sells safe short-term debt with face value $M_S = 1 - p_2\, a - \delta$.[14] This level of money-like claims might be larger than $D_S^I + M_S^* = 1 - p_2(a+l)$, but the capital structure of the bank implies that the managers are not disciplined. If the relative increase $\lambda \cdot (p_2\, l - \delta)$ in the premium for money-like claims is smaller than the relative increase $\delta - p_1\, p_2\, l$ in agency costs, such a chain is less efficient than the chain with $\{D_S^I, D_M^{II}\}$ and M_S^*, which has been described above.

Corollary 4

If Assumptions 2 and 3 hold, an intermediation chain can achieve a strictly higher surplus $\Lambda - \Delta + \Lambda_M$ than a bank without fund:

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

Both, initial bank owner and fund sponsor, benefit from forming an intermediation chain, if the fund transfers a sufficiently large fraction $\omega \in [0,1]$ of $\Lambda_M(M_S^*; S)$ to the bank.

The relative gains from the formation of 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. If the bank receives a sufficiently large fraction of Λ_M, the initial owner is willing to join a chain by issuing $D_S^I = 1-a-l$ and $D_M^{II} = a+l$ and selling the medium-term debt to a fund. The fraction ω of Λ_M that is transferred from fund to bank depends on the bargaining situation between or the competitive structure of the market.

To sum up, this section has demonstrated 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 money-like claims that are backed by the bank debt.

3.4. Robustness Analysis and Discussion

This section discusses whether the results of the previous analysis are robust if one accounts, first, for staggered debt structures as well as a different timing of the shocks, and

[14] This case of intermediation chain is similar to the one discussed in Chapter 2, where an indirect reference of the short-term debt to the underlying assets allows for a higher level of money-like claims, since possible liquidations are prevented.

second, for cost of acquiring information (which might imply an agency problem when the monitoring of the managers is delegated to the fund). These two issues are addressed in the following two subsections. The third subsection concludes with a discussion whether the analysis in this chapter describes banks in particular or firms more generally.

3.4.1. Staggered Debt Structures

This subsection illustrates how the results of the previous sections extend to a case in which banks can have a staggered debt structure and in which there is uncertainty about the timing of the shocks. Furthermore, the subsection points out that the optimal financing structure entails a shortening of the debt duration as consequence of a shock.

Consider that the shocks to the bank assets 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:

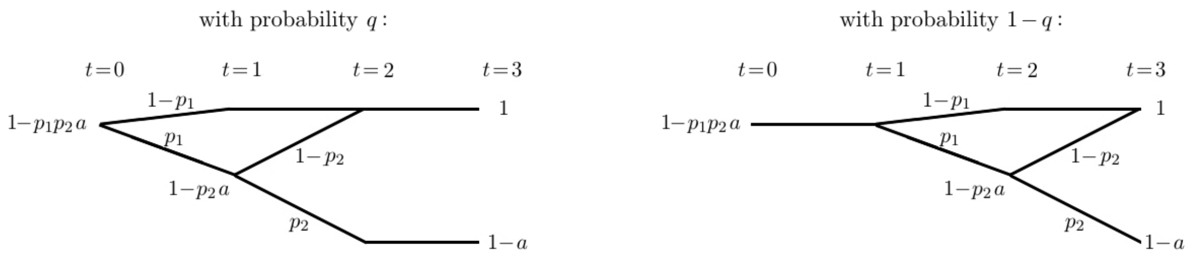

Figure 3.3.: Event trees representing two possible distributions of shocks over time.

Let me first present a specific example of a staggered debt structure and its consequences for the disciplining of managers as well as the liquidation probability, before I explain why the presented structure is the optimal one. With the possibility of staggered debt, the bank can sell 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 $t = 3$. Consider now that the bank issues three tranches of debt at $t = 0$ with the following face values and initial durations:

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

Assumption 5 *:* $\delta > \frac{p_2-p_1\,p_2^2}{2-p_1-p_2} \cdot (a+l)\,.$

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 $D_S^I + D_S^{II} + D_M^{III} > 1 - \delta$. In case of this debt level, the managers do not start to misbehave. And the expected liquidation loss is $p_1\,p_2\,l$, as I show in the following.[15]

[15]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. Consider that the D_S^{II}-claim is rolled over with a face value $D_{S,M}$ and medium duration, so that the debt becomes due at $t = 3$. Informed buyers of this $D_{S,M}$-claim 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 $\frac{1}{1-p_2} D_M^{III}$.[16] 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 $\frac{1}{1-p_1\,p_2} D_S^{II}$.[17] As a result, the overall face value after a 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 at $t = 3$, but the asset value recovers to 1 at $t = 3$.

If a bad shock already occurs at $t = 1$, the event tree on the left-hand side above applies. The D_S^I-claim can be rolled over without change in the face value, because it is the most senior claim and it thus remains safe anyway. The D_S^{II}-claim has to be rolled over as well, but the expected payoff of the bank in that state is only $1 - p_2\,(a + l) < D_S^I + D_S^{II} + D_M^{III}$. Therefore, 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 $\frac{1}{1-p_2} D_S^{II}$.[18] 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 at $t = 2$, but the asset value recovers to 1 at $t = 2$.

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

[16] 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.

[17] As indicated in the main text, the debt can be fully paid as long as there not two bad shocks. 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. Since two bad shocks only occur with probability $p_1\,p_2$, the expected payoff of the claim with face value $D_{S,M} = \frac{1}{1-p_1\,p_2} D_S^{II}$ is thus $(1 - p_1\,p_2)D_{S,M} = D_S^{II}$.

[18] The pricing is analogous to the one in Footnote 16 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 at $t = 1$, the D_S^{II} claim is rolled over as short-term debt instead of medium-term debt. This means that there is a shortening of the maturity structure in case of a bad shock.[19]

If Assumption 2 holds, this disciplining of the managers is efficient, since the expected loss $p_1\, p_2\, l$ from premature liquidations is smaller than the cost δ of manager misbehavior which is prevented. Given that $1 - \delta > 1 - a$, any level of short- and medium-term that is high enough to discipline managers necessarily entails a liquidation after two bad shocks. This implies that the staggered debt structure described above minimizes the agency costs Δ of the bank. Choosing this debt structure, 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 other two claims to a fund, which can create additional safe claims by means of tranching. For the same reasons as described in Section 3.3, such an intermediation chain maximizes the premium for money-like claims net of the agency costs.

3.4.2. Delegation of Monitoring

Let me now address the conflict between the two purposes of debt financing with respect to the information level of the respective debt holders. After indicating the conflict, I will also discuss how an intermediation chain can resolve it.

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 shocks to the bank assets, and information about the misbehavior of the bank managers. It seems plausible that information about significant shocks to the bank assets is relatively easy to obtain, even by those investors who demand money-like claims. 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.

If short- or medium-term debt is supposed to work as disciplining device, however, the debt holders must have information about ongoing manager misbehavior. This type of information is probably more difficult to obtain, because misbehavior of managers is usually not reported in the news before it is completed. To identify manager misbehavior before its completion requires a close monitoring, which can probably not be performed by investors who briefly check the state of the bank at roll-over dates.

The intermediation chain described in Section 3.3 can resolve this tension between investors with demand for safe, 'informationally insensitive' claims 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 $D_S^I = 1 - a - l$) is not affected by the manager behavior, but it remains safe in all states and can thus be used as means of payment. The

[19] 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).

payoff of the second debt tranche (the medium-term debt with face value $D_M^{II} = a + l$) is sensitive to the manager behavior and should be withdrawn at $t = 2$, if the managers misbehave. 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 $M_S = (1 - p_2)(a + l)$) which is safe and money-like.

The agency problem between the fund sponsor (who is supposed to provide the monitoring)[20] and the buyer of the M_S-claim (who wants to have a safe claim) can be resolved, since the fund sponsor holds an equity position in the fund and thus incurs a loss from poor monitoring. If this loss is larger than the costs of monitoring, the fund has an incentive to monitor the bank correctly.[21]

Besides monitoring, one might think of other dimensions of moral hazard that might 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.[22] Such contracts can fix the eligible set of securities that can be held (as 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 pointed out 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 gained from 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 is equivalent to higher promised yields); 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 3.3 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 is a prerequisite for the coordination problem which is necessary for the disciplining effect of the debt. 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

[20] The agency problem between fund sponsor and fund managers has been discussed in Section 3.3.

[21] 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, if the monitoring costs are smaller than the reduction in the agency costs owing to the monitoring.

[22] 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).

the debt: if the cost of monitoring is smaller than the relative loss that a fund would incur from withdrawing after the other funds, each fund has an incentive to monitor the bank in order to avoid being the last one withdrawing.

3.4.3. 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 loans from banks to firms usually have a relatively long duration, these loans often entail some type of reassessment of the credit condition before the firm investment matures.[23] They can thus 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 considers the range of parameters on which the analysis has focused. The emergence of an intermediation chain has been rationalized for the parameter range expressed by the Assumptions 2 and 3. This parameter range is characterized by a small probability of significant shocks to the portfolio of assets. Since the assets of banks mainly consist of loans, which are senior claims to the payoff of firms or 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 significant shocks to the portfolio, this chapter's analysis 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 high levels of short- and medium-term debt. 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 instead of manager misbehavior.

Apart from this, banks might be more dependent on the coarse disciplining device of debt financing, because a resolution of the agency problem by writing and enforcing contracts with the managers might be particularly difficult for banks. This might be the case because banks are firms which do not produce standardized or tangible objects, but which 'produce' complex, customized contracts that allow for a lot of discretion.

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

4. Optimal Capital Structure in the Presence of Financial Assets

4.1. Introduction

Capital requirements are a key instrument for the regulation of banks, and their potential costs are a key issue in debates about financial regulation. Arguments for the existence of costs of capital requirements in the long run are based on theories that predict an optimal capital structure, which can be disturbed by such requirements.[1] These theories deviate from Modigliani and Miller (1958) by describing a trade-off between the respective costs of equity and debt financing. The classic example is the trade-off between taxes and bankruptcy costs (see Modigliani & Miller (1963) or Kraus & Litzenberger (1973)). In these trade-off models, the optimal capital structure always depends on the characteristics of the firm assets.[2] And in their description of the firm problem, these models always take the set of available assets as given. If one accounts for the fact, however, that firms can invest in financial markets, the set of available assets is not given on the firm level, but it depends on the decisions of other agents in the market. In particular, the set is not fixed, if new assets can be created by writing financial contracts. The aim of this chapter is to show for several trade-off theories how their predictions about the optimal capital structure and the private costs of capital requirements change significantly, if one takes account of the possibility to invest in financial markets.

To put it differently, this chapter analyze how the optimal capital structure of a firm changes, when it 'integrates a fund'. This means that I examine the capital structure of a firm which can choose to passively hold securities that are issued in the same financial market in which the firm issues its own debt and equity. I restrict the set of possible securities to simple financial assets whose payoffs only depend on the payoffs of firms in the market - like debt and equity claims or CDS. This implies that I do not consider a set of complete contracts that can condition on the processes within the firms and that could

[1] If capital requirements deviate from the optimal capital structure, banks incur private costs. And these can lead to social costs, if they impair the provision of credit and banking services to the economy. According to DeAngelo and Stulz (2015), capital requirements can cause social costs even directly by reducing the volume of 'money-like claims'. I will come back to this argument in more detail later.

[2] In case of a trade-off between taxes and bankruptcy costs, for instance, firms with less risky assets use more debt, because it reduces taxes while the expected costs of bankruptcy are small at the margin.

directly remove the frictions described by the trade-off theories. The frictions and the capital structure of the firm thus matter. But the possibility to invest in simple financial assets has important consequences.
I do not only consider the trade-off between taxes and bankruptcy costs, but also the one between different types of agency costs highlighted by Jensen and Meckling (1976). And I also address theories that are specific to banks and that try to explain their particularly high leverage - either by the disciplining role of demandable debt, as in Diamond and Rajan (2000), or by a premium of safe, 'money-like' claims, as in DeAngelo and Stulz (2015) or Gorton and Winton (2014).
For these four theories of capital structure I show: given any set of assets and the optimal capital structure that a firm chooses given these assets, the firm can reduce its leverage and its insolvency risk relative to this supposed optimum without a loss of value by means of an 'integrated fund'. This means: by passively holding financial assets of the type described above which are issued in the same market like its own debt and equity. In fact, the integration of a fund that reduces insolvency risk can even lead to private gains for the firm. Let me briefly preview why (and under which conditions) this result holds for the different theories of capital structure, before I explain why firms might not use integrated funds in spite of their benefits.

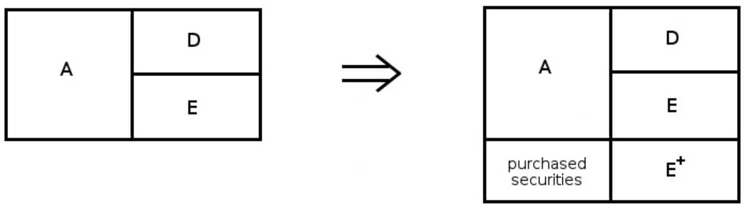

Figure 4.1.: The 'integration of a fund': a balance sheet with assets A, which are financed with debt D and equity E, is enlarged by purchasing financial assets. This purchase is financed by issuing new equity E^+.

Consider a firm that chooses its optimal capital structure for a given set of assets in the presence of a trade-off between taxes and bankruptcy costs. Assume now that this firm issues more equity in order to purchase financial assets in the same market, as illustrated in Fig. 4.1. The reduction of the firm leverage by means of such an 'integrated fund' can lead to private gains rather than losses, if the resulting reduction of the bankruptcy costs is larger than the increase in tax payments. This holds if the purchased financial assets have two properties: first, they have a sufficiently large value in states in which the firm without fund would become insolvent (so that they can avoid costly bankruptcies); second, their payoff in all other states is not too large (so that the increase in taxes is not larger than the decrease in bankruptcy costs). The possibility of a costless reduction of leverage and insolvency risk is thus due to the diversification that becomes possible with an integrated fund. Advantages of a diversification by means of financial assets have already been identified by the literature on hedging, see Smith and Stulz (1985), for instance.[3] In contrast to that literature, however, this chapter shows that passively holding financial assets in an 'integrated fund' enables firms to decrease their leverage and insolvency risk without any of the costs that such changes of the capital structure supposedly entail. Let me briefly explain why this result also holds for other trade-off theories, before I discuss the availability of financial assets with the properties mentioned above.

According to Diamond & Rajan (2000) and their model of debt as a disciplining device, the optimal capital structure is the result of a trade-off that is very similar to the trade-off between taxes and bankruptcy. If the debt can be withdraw quickly, it can stop managers that try to extract rents from the firm payoff. Consequently, an increase of the debt level reduces this rent extraction (like it reduces taxes). A higher debt level, however, entails a higher probability that a low firm payoff triggers a run on the firm and leads to costly liquidations (similar to bankruptcy costs). Given the similar form of the trade-offs, the results are also similar: a reduction of leverage and insolvency risk by means of an integrated fund allows for gains rather than losses, if the payoff of the financial assets is such that the reduction in liquidation costs is larger than the increase in extracted rents.

The effect of an integrated fund on the provision of safe, money-like claims is weakly positive, unconditionally. An integrated fund does not reduce the volume of debt issued by the firm.[4] But it weakly increases the safety of the debt owing to the additional payoff from the purchased assets. Thus, if there is a premium for issuing safe debt, the effect of integrated funds on the firm value is weakly positive.

In case of a trade-off between agency costs of debt (due to risk-shifting) and equity (due to reduced manager effort), as described by Jensen and Meckling (1976), the effect of an integrated fund depends on the payment scheme of the managers. As long as the payment does not condition on the payoff of the financial assets which are passively held in the fund, then the managers' incentives to exert effort or to engage in risk-shifting are not changed by the fund. Consequently, the integration of fund entails neither gains nor losses for the firm. But it stills reduces the leverage and the insolvency risk.

Summing up this preview, there is only one critical condition for the costless reduction of leverage and insolvency risk by means of integrated funds: the availability of financial assets with an appropriate distribution of payoffs. In order to study the availability of such assets, one could empirically investigate the properties of all outstanding financial assets. But this extensive investigation would only provide an incomplete answer, because

[3]A similar mechanism has also been identified for mergers, see e.g. Lewellen (1971).

[4]Gorton and Winton (2014) and DeAngelo and Stulz (2015) already indicate that equity-financed purchases of securities do not reduce the level of safe debt. But they are skeptical towards the ability of such purchases to reduce the bankruptcy risk. In Section 4.8, I show that comparably small funds already provide a significant increase of loss-absorbing capital, even in states with the worst aggregate risk.

it is always possible to create additional financial assets by writing new contracts. In fact, there is always a way to create financial assets with the properties that have been identified as sufficient conditions for the costless reduction of leverage and insolvency risk. I properly explain this creation in Section 4.6, but let me already indicate that it consists of a contract between the firm and an investment fund that is very similar to the 'liability holding company' (LHC) that has been proposed by Admati et al. (2012).

This chapter and Admati et al. (2012) thus arrive at similar conclusions. But they derive these conclusions in different ways. Admati et al. (2012) provide qualitative arguments why LHCs allow for socially beneficial increases in capital requirements that do not disturb the corporate governance of banks, but rather improves it. This chapter, in contrast, starts with a systematic analysis of optimal capital structures in the presence of financial assets. And studying four different trade-off theories, I show that integrated funds allow for private gains and that LHCs are a particularly beneficial type of integrated fund.

While integrated funds decrease the insolvency risk on the firm level, one might wonder how the insolvency risk of firms changes in the aggregate. The cash flow from the financial assets held in integrated funds has to be provided by other agents in the market. And the overall level of cash flows in the economy does not change by rearranging them. Nevertheless, integrated funds can decrease the insolvency risk of firms in the aggregate. If a fund is added to an existing firm without changing its debt level, the insolvency risk of the firm never increases, but can only decrease. At the same time, the solvency of the providers of cash flows to integrated funds does not deteriorate because the cash flows are sold to integrated funds instead of other agents. To put it differently: Integrated funds allow to 'channel' cash flows from different sources through the balance sheets of firms, where they have beneficial effects, before the final recipients receive these cash flows.

The results of this chapter lead to a puzzle: given that integrated funds allow for private gains, why do firms not use integrated funds? As pointed out by Admati et al. (2018), there is an asymmetric distribution of the gains and losses from changes in the capital structure, if the firm has outstanding debt. In case of a reduction of firm leverage and insolvency risk, the gains (e.g. reduced bankruptcy costs) accrue to the holders of the outstanding debt, while the firm owners incur costs (e.g. higher taxes).[5] This asymmetric distribution also applies in case of changes in the capital structure which lead to net gains. Since the owners only incur the losses, they have no incentive to implement such a change. This asymmetric distribution of gains and losses between debt and equity holders can explain the fact that firms do not use integrated funds. But it does not negate the result that a decrease of leverage and insolvency risk by means of integrated funds increases rather than decreases the value of the firm. And the asymmetric distribution

[5]As highlighted by Admati et al. (2018), this asymmetric distribution holds even in absence of frictions like e.g. taxes. A reduction of the insolvency risk always implies that the expected payoff to holders of outstanding debt increases. And they do not pay for this increase, but they gain at the expense of the equity holders.

of the net gains is only temporary, since the equity can participate in the gains once the outstanding debt has matured or has been rolled over with adjusted prices. This implies: integrated funds allow for an increase of capital requirements for banks and a decrease of their insolvency risk in a way that leads to benefits for all agents in the long run.

The **remainder of the chapter** is organized as follows: Section 4.2 illustrates the basic idea in a simple example. Section 4.3 analyzes the trade-off between bankruptcy costs and taxes, and it also accounts for a premium for safe debt. Section 4.4 addresses the argument for a disciplining role of demandable debt, and Section 4.5 studies the trade-off between agency costs of debt and equity. Section 4.6 discusses the availability of financial assets with beneficial characteristics, before Section 4.7 indicates why firms do not use integrated funds despite their benefits. Section 4.8 concludes with stressing the implications of the analysis for the regulation of banks.

4.2. An Illustrative Example

This section uses a simple example to illustrate two key results of this chapter. First, it demonstrates why an integrated fund allows for a costless increase of equity above the level that is supposedly optimal for a single firm according to a trade-off theory of capital structure. Second, it demonstrates why integrated funds can decrease the probability of insolvencies in an economy, although the net amount of available payoffs as well as the debt levels of the firms remain the same.

Assume that there are two firms, A and B, with assets that have a stochastic payoff at $t = 1$. There are three equally probable states $\{I, II, III\}$ at $t = 1$ and the state-dependent payoffs y_A and y_B of the respective firm assets are:

	state I	state II	state III
asset payoff of firm A (y_A)	90	100	110
asset payoff of firm B (y_B)	105	90	105

The correlation between the asset payoffs of both firms is zero. Assume that each firm is initially owned by an agent who sells equity and debt claims to the firm to a continuum of investors at $t = 0$ and who tries to maximize the revenue from this sale. For simplicity, let us think of the investors as a continuum of risk-neutral agents who are willing to buy a claim at $t = 0$ at a price that equals its expected payoff at $t = 1$ (which is equivalent to a risk-free interest rate $r = 0$). Both types of claims entail losses. On the one hand, the payoff of equity claims at $t = 1$ is reduced by a relative loss τ (like a tax, for instance), so that equity holders only receive the payoff $1 - \tau$ per unit of residual firm payoff. On the other hand, if the firm has to default on the debt at $t = 1$, the asset payoff is reduced by a firm-specific loss b_x with $x \in \{A, B\}$ (like bankruptcy costs, for instance). Given that the initial firm owners want to maximize the revenue from selling equity and debt claims at $t = 0$, their problem consists of choosing the face values D_x of the firm debt that maximize the expected payoff of the sold claims. Formally, the initial owner of firm $x \in \{A, B\}$ solves the problem

$$\max_{D_x \in \mathbb{R}} \frac{1}{3} \sum_{i=I}^{III} \left(y_x^i - \tau \max\{0, y_x^i - D_x\} - b_x \cdot \mathbf{1}_{\{y_x^i < D_x\}} \right).$$

In order to focus on an interesting case, let us impose

Assumption 6 *: $10\tau < b_A < 20\tau$ and $30\tau < b_B$.*

Lemma 6
If Assumption 6 holds, the optimal debt levels of the firms are $D_A = 100$ and $D_B = 90$. This choice implies that firm A becomes insolvent in state I.

Given the optimal choice, the state-contingent payoffs of assets, debt and equity are:

***Firm* A**	state I	state II	state III
asset payoff	90	100	110
debt payoff	$90-b_A$	100	100
equity payoff	0	0	$(1-\tau)10$

***Firm* B**	state I	state II	state III
asset payoff	105	90	105
debt payoff	90	90	90
equity payoff	$(1-\tau)15$	0	$(1-\tau)15$

Proof: The first term in the objective function (i.e., y_x^i) is independent of D_x. The second term (i.e., $-\tau \max\{0, y_x^i - D_x\}$) is continuously increasing in D_x and reaches it maximum when D_x equals the largest possible realization of y_x^i. And the last term (i.e., $-b_x \cdot \mathbf{1}_{\{y_x^i < D_x\}}$) decreases with increasing D_x by discrete steps at each possible y_x^i. Consequently, the relative maxima of the objective function are at $D_x = y_x^i$ for $i \in \{I, II, III\}$. For firm A, the absolute maximum is at $D_x = 100$, since switching to $D_x = 90$ changes the objective function by $\frac{1}{3} b_A - \frac{1}{3} \tau\, 20 < 0$, and switching to $D_X = 110$ changes the objective function by $-\frac{1}{3} b_A + \frac{1}{3} \tau\, 10 < 0$. For firm B, the absolute maximum is at $D_x = 90$, since switching to $D_x = 105$ changes the objective function by $-\frac{1}{3} b_B + \frac{1}{3} \tau\, 30 < 0$.

Lemma 6 states the capital structures that are optimal for the firms, if one considers each firm separately. Let us now account for the possibility of an 'integrated fund'. Consider that firm A reduces its debt-to-equity ratio (relative to the case described in Lemma 6) by issuing more equity and investing the proceeds in securities issued by firm B. More precisely, consider the following. At $t = 0$, when firm B sells debt with face value $D_B = 90$ as well as its equity, firm A buys the fraction $\frac{10}{(1-\tau)15}$ of the equity of firm B. Given prices that equal the expected payoff of the claims, firm A has to pay $\frac{10}{(1-\tau)15} \cdot \left(\frac{1}{3}(1-\tau)15 + \frac{1}{3}(1-\tau)15\right) = \frac{20}{3}$ for this fraction of equity. The purchase implies that the portfolio of firm A is enlarged. The state-contingent payoff of the enlarged portfolio is the sum of the payoff of the firm assets plus the payoff of the fraction $\frac{10}{(1-\tau)15}$

of the equity of firm B (both are stated in the tables above). Given the enlargement of the portfolio, firm A can sell a more valuable set of claims to the investors. Let us assume, however, that firm A does not change its debt level relative to the benchmark case given in Lemma 6, which means that it sells debt with face value $D_A = 100$. Given this 'integration of a fund', the state-contingent payoffs of firm portfolio, debt and equity claims are:

***Firm* A** *(incl. fund)*	state I	state II	state III
portfolio payoff	100	100	120
debt payoff	100	100	100
equity payoff	0	0	$(1-\tau)20$

Observation 7

The integration of a fund (which means that firm A enlarges its portfolio by buying equity of firm B without increasing its debt level D_x) leads to the following changes relative to the benchmark case determined in Lemma 6 given Assumption 6:

1. *The fund is efficient as well as privately beneficial for firm A: the price/expected payoff $\frac{20}{3}$ of the equity of firm B held by firm A is smaller than the increase in the expected payoff of claims that firm A sells to investors, which is $\frac{1}{3}(10+b_A)+\frac{1}{3}(1-\tau)10$.*

2. *The leverage of firm A decreases: while the debt level remains $D_A = 100$, the expected payoff of the firm portfolio increases from 100 to $\frac{320}{3}$; and in terms of expected payoffs of the claims, the debt-to-equity ratio decreases from $\frac{290-b_A}{(1-\tau)10}$ to $\frac{300}{(1-\tau)20}$.*

3. *The probability of firm insolvencies decreases: firm A does no longer become insolvent in state I, while the insolvency probability of firm B remains zero.*

The reduction of leverage and insolvency risk by means of an integrated fund differs from a reduction of these parameters by means of a decrease in the debt level. The latter only affects the liability side, while the former changes the asset side as well as the liability side. The integration of a fund has two positive effects on the solvency of the firm: it does not only reduce the firm leverage (as a debt reduction does), but it also allows for an improved diversification of the portfolio.[6] The fund can prevent an insolvency, if the payoff of purchased financial assets is sufficiently large in those states in which the payoff of the firm assets is too low to pay off the debt, as in case of firm A and state I. As a consequence, an integrated fund can be more efficient in decreasing the insolvency probability than a simple debt reduction: if the insolvency risk of firm A is reduced to zero by reducing the firm debt from the optimal level $D_A = 100$ to $D_A = 90$, then the equity value increases by $\frac{1}{3}(1-\tau)20$ and the corresponding increase $\frac{1}{3}\tau\,20$ in taxes dominates the

[6]This result does not rely on a strong negative correlation of the firms and their assets, as demonstrated by this example, in which the correlation between the asset payoffs is zero.

reduction $\frac{1}{3}b_A$ in bankruptcy costs; if the insolvency risk of firm A is reduced to zero by an integrated fund as described above, then the equity only increases by $\frac{1}{3}(1-\tau)10$ and the increase $\frac{1}{3}\tau\,10$ in taxes is smaller than the reduction $\frac{1}{3}b_A$ in bankruptcy costs.

The result has some similarity to the argument of Lewellen (1971) that mergers can be beneficial owing to the diversification which they entail. But the example here shows that the benefits from diversification can already be obtained by just holding some securities issued by another firm instead of completely merging with that firm. Furthermore, the mechanism highlighted here does not depend on the fact that the purchased assets are equity claims of another firm, but it holds for any financial assets with an appropriate distribution of payoffs. The mechanism is related to mechanisms that have been discussed in the literature about hedging (see e.g. Smith and Stulz (1985)). The distinguishing feature of the example discussed here (and of this chapter in general) is that it shows how the diversification benefits from the purchase of financial assets can be used to reduce the leverage and insolvency risk of firms without private or social costs.

The example demonstrates that the aggregate insolvency risk in the economy can decrease owing to an integrated fund, although neither the debt liabilities D_A and D_B nor the payoffs y_A and y_B of the underlying assets change. The integrated fund only redirects the cash flows from the assets before they are received by the investors. Some part of the payoff of firm B is not directly paid to the investors, but the investors receive it via the balance sheet of firm A. Since the debt level of firm B does not change, this redirection does not change its insolvency risk. But the redirection prevents the insolvency of firm A in state I, and it thus also prevents the related costs. To sum up, integrated funds allow to 'channel' cash flows from firms through the balance sheets of other firms, where they have beneficial effects, before they arrive at the final recipients.

The fact that integrated funds allow for a costless decrease of leverage and insolvency risk is not a particular feature of the example studied here. The next sections show that this result holds for more general cases of firms and for different trade-off theories. The result that integrated funds do not only reduce the insolvency risk at the firm level but also on the aggregate level is generalized in Appendix B.2.

4.3. Taxes, Bankruptcy Costs, and Safe Debt

This section shows that the possibility to costlessly reduce the insolvency risk of a firm by means of an integrated funds holds for any firm that faces a trade-off between taxes and bankruptcy costs (as described in Modigliani & Miller (1963) or Kraus & Litzenberger (1973), for instance). In addition, I account for a premium for safe debt, as suggested by DeAngelo & Stulz (2013) and Gorton & Winton (2014). This premium is very similar to the tax benefit of debt, apart from its restriction to a certain subset of the firm debt.[7] This section does not provide a complete solution of the firm problem (which depends on the financial assets offered by other firms), but it indicates that each firm can gain from an integrated fund, given that financial assets with certain features are available on the market. The availability of such assets and the potential puzzle that firms might not use integrated funds despite the gains is discussed in the Sections 4.6 and 4.7.

Consider an owner of a firm with assets that yield a stochastic payoff $R \in \mathbb{R}^+$ at $t = 1$. Besides these firm-specific assets, the firm can also 'integrate a fund', which means that it can buy a set S of financial assets in the same financial market in which it issues its own debt and equity. I will comment on the choice of S later, but let us first assume that the composition of S is given and that the firm only chooses the amount s it invests in this portfolio at $t = 0$. The portfolio yields a stochastic cash flow $R_S \in \mathbb{R}^+$ at $t = 1$ per unit of s. The joint distribution of R and R_S is continuous and denoted as $\hat{f}$. The univariate marginal distribution of R is $f(R) := \int \hat{f}(R, R_S)\, dR_S$.

At $t = 0$, the initial firm owner issues equity and two types of debt claims: senior debt with safe payoff D_s at $t = 1$, and junior debt with face value D_r and default probability ϕ. Assume that the firm has no outstanding debt at $t = 0$. The probability that the firm become insolvent at $t = 1$ is

$$\phi(D_s, D_r, s) = \int \mathbf{1}_{\{R + s\, R_S < D_s + D_r\}}\, \hat{f}(R, R_S)\, dR_S\, dR\,.$$

Let us define the leverage $l(D_s, D_r, s)$ of the firm as the ratio of the face value of its debt over the expected cash flow of its assets: $l(D_s, D_r, s) = \frac{D_s + D_r}{E_{\hat{f}}[R + s\, R_S]}$

Observation 8

If the debt level $D_s + D_r$ is fixed, an increase in the size s of the integrated fund leads to:

- *a decrease of the probability of insolvency: $\frac{d}{ds}\phi(D_s, D_r, s) \leq 0 \;\forall\; s \in \mathbb{R}^+$, with a strict inequality for some $s \in \mathbb{R}^+$ if $E_{\hat{f}}\left[\mathbf{1}_{\{R_S > 0\}} \mathbf{1}_{\{R < D_s + D_r\}}\right] > 0\,;$*

- *a decrease of the leverage: $\frac{d}{ds} l(D_s, D_r, s) < 0 \;\forall\; s \in \mathbb{R}^+$.*

Assume that the objective of the initial owner is to maximize the revenue from selling the equity and debt claims at $t = 0$. For simplicity, assume that the claims are priced in competitive markets with risk-neutral investors and a risk-free interest rate $r = 0$. (Appendix B.3 shows the robustness of the results to more general preferences of investors.) Assume that all agents can observe the firm's choice of capital structure and know $\hat{f}$ at $t = 0$. With b denoting bankruptcy costs that reduce the asset payoff in the event of insolvency,

[7] According to Gorton and Pennacchi (1990), safe debt is useful as a means of payment and investors thus accept a discount on the interest rate of such claims.

the value d_r of the junior debt sold at $t = 0$ is given as

$$d_r(D_s,D_r,s) = \big(1-\phi(D_s, D_r, s)\big) D_r + \int \mathbf{1}_{\{R+s\,R_S<D_s+D_r\}} \big(R+s\,R_S-D_s-b\big)\, \hat{f}(R, R_S) dR_S dR$$

To account for the premium of safe debt, let us assume that the claim is priced with a reduced interest rate $r_s = -\frac{\lambda}{1+\lambda}$. A microfoundation of the premium for safe debt is given in Appendix A.1. The value d_s of the safe debt at $t = 0$, which is the discounted value of the safe payoff D_s, is then

$$d_s(D_s) = \frac{1}{1+r_a} D_s = \frac{1}{1-\frac{\lambda}{1+\lambda}} D_s = (1+\lambda)\, D_s\,.$$

To account for the tax benefit of debt, let us assume that the tax payments of the firm are given by $T(y_e)$ with $T'(y_e) > 0$ and y_e as residual payoff $y_e = \max\{0, R+s\,R_S-D_r-D_s\}$. The value e of the equity at $t = 0$ is the expected residual payoff net of taxes:

$$e(D_s, D_r, s) = \int \max\{R + s\,R_S - D_r - D_s, 0\}\, \hat{f}(R, R_S)\, dR\, dR_S - T^{exp}(D_r, D_S, s)\,,$$

with $T^{exp}(D_r, D_S, s) := \int T\big(\max\{R + s\,R_S - D_r - D_s, 0\}\big)\, \hat{f}(R, R_S)\, dR\, dR_S$. The 'firm value' v_s, which means the joint value of the equity and debt claims at $t = 0$, is

$$\begin{aligned} v_s(D_r, D_s, s) &= d_r(D_r, D_s, s) + d_s(D_s) + e(D_r, D_s, s) \qquad (4.1)\\ &= \int \big(R + s\,R_S\big)\, \hat{f}(R, R_S)\, dR\, dR_S - T^{exp}(D_r, D_S, s) - b\,\phi(D_s, D_r, s) + \lambda\, D_s \end{aligned}$$

The 'net firm value' v, which means the firm value v_s net of the expected payoff $E_{\hat{f}}\,[s\,R_S]$ of the financial assets held in the integrated fund, is:

$$\begin{aligned} v(D_r, D_s, s) &= v_s(D_r, D_s, s) - E_{\hat{f}}\,[s\,R_S] \qquad (4.2)\\ &= \int R\,\hat{f}(R, R_S)\, dR\, dR_S - T^{exp}(D_r, D_s, s) - b\,\phi(D_s, D_r, s) + \lambda\, D_s \end{aligned}$$

Assumption 7 *(no-arbitrage-condition)*
a) The price of the financial assets at $t = 0$ equals their expected payoff $E_{\hat{f}}\,[s\,R_S]$ at $t = 1$.
b) The outcome $R_S = 0$ has strictly positive probability.

Assumption a) is imposed in order to study the case that the firm purchases financial assets in the same market in which it issues its own claims, where the riskfree rate is $r = 0$. Assumption b) excludes the purchase of financial assets with a safe payoff. It is only imposed to simplify further notation. If $R_S > 0$ in all states, the safe part of this payoff would be priced in terms of the reduced rate r_a, but this premium would net out with the premium of the claims that the firm issues against this portfolio.

If the initial owner wants to maximize the revenue from the sale of claims at $t = 0$ net of the costs of purchasing the financial assets, then her decision problem is:

$$\max_{s\in\mathbb{R}^+,\, D_s\in[0,\overline{D}_s],\, D_r\in\mathbb{R}^+} \Big(v^s(D_s, D_r, s) - E_{\hat{f}}\left[s\, R_S\right]\Big) = \max_{s\in\mathbb{R}^+,\, D_s\in[0,\overline{D}_s],\, D_r\in\mathbb{R}^+} v(D_s, D_r, s)\,,$$

with $\overline{D}_s := \min\big(R + sR_S \,|\, \hat{f}(R, R_S) > 0\big)$ as the lowest possible firm payoff. The problem of the firm owner thus consists of maximizing the net firm value v. In order to discuss how the integration of a fund affects the net firm value, let us define the constrained problems

$$\begin{aligned} &\textit{Problem } P(s): \max_{D_s\in[0,\overline{D}_s],\, D_r\in\mathbb{R}^+} v(D_s, D_r, s) \text{ for given } s \in \mathbb{R}^+, \\ &\textit{Problem } P(s, D): \max_{D_s\in[0,\overline{D}_s],\, D_r\in\mathbb{R}^+} v(D_s, D_r, s) \text{ s.t. } D_s + D_r = D, \text{ for given } s \in \mathbb{R}^+. \end{aligned}$$

The solution of $P(0)$ is the capital structure that the firm owner chooses, if there is no possibility of an integrated fund. It shall be denoted as $(D_{s,0}, D_{r,0})$, and $D_0 := D_{s,0} + D_{r,0}$. The solution of $P(s, D)$ is the combination of safe and risky debt that the firm optimally sells, if the joint face value $D_s + D_r$ of the debt is fixed at D and the firm has an integrated fund with size s. This solution shall be denoted as $(D_s(s, D), D_r(s, D))$.

Proposition 7

a) Relative to the optimal capital structure of a firm without integrated fund, a reduction of the leverage and insolvency risk by means of an integrated fund increases the net firm value, if the payoff of the purchased financial assets is such that Eq. (4.3) *holds:*

$\frac{d}{ds} v(D_{s,0}, D_{r,0}, s)\big|_{s=0} > 0,$ *if*

$$b\; E_{\hat{f}}\left[R_S | R = D_0\right]\; f(D_0) \;>\; \int R_S\, T'(R - D_0)\, \hat{f}(R, R_S)\, dR\, dR_S\,. \tag{4.3}$$

b) An integrated fund weakly increases the minimal possible payoff of the firm and thus weakly increases the fraction of the firm debt D_0 that can be sold as safe debt. Accounting for this, an integrated fund already increases the net firm value, if Eq. 4.4 holds:

$$\frac{d}{ds} v(D_s(s, D_0), D_r(s, D_0), s)\Big|_{s=0} > 0, \quad \textit{if} \tag{4.4}$$

$$b\, E_{\hat{f}}\left[R_S | R = D_0\right] f(D_0) + \lambda \min\big(R_S | \hat{f}(\underline{R}, R_S) > 0\big) > \int R_S\, T'(R - D_0)\, \hat{f}(R, R_S)\, dR\, dR_S\,,$$

with $\underline{R}$ representing the lower bound $\min(R | f(R) > 0)$ *for R.*

Proof: See Appendix B.4.1.

The explanation for this result is the same as in the simple example presented in the previous section. Given an optimal capital structure $(D_{s,0}, D_{r,0})$ of the firm without fund, a reduction of insolvency risk and leverage by means of a debt reduction leads to a decrease

in the firm value. A reduction of leverage and insolvency risk by means of an integrated fund, in contrast, can increase the firm value, because it can be more efficient in decreasing the insolvency probability than a simple debt reduction. The integration of a fund has two positive effects on the solvency of the firm: besides reducing the firm leverage (which a reduction of the debt level could also achieve), it allows for an improved diversification of the firm portfolio. If the payoff of purchased financial assets are sufficiently large in those states in which the firm-specific assets yield relatively low payoffs, the bankruptcy of the firm can be prevented. If the resulting reduction in expected bankruptcy costs (given by the l.h.s. of Eq. 4.3) is larger than the increase in tax payments due to an increased payoff to the firm equity (given by the r.h.s. of Eq. 4.4), then the firm value increases.
If there is a premium for safe debt, there is an additional positive effect of the integrated fund. If the payoff of the purchased assets is greater than zero in all states in which the payoff of the initial firm assets equals the minimal possible value $\underline{R}$ (which means if $\min\big(R_S|\hat{f}(\underline{R},R_S)>0\big)>0$), the minimal payoff of the firm portfolio increases. (This is possible in spite of Assumption 7 b, since the worst realizations of both sets of assets, $R_S=0$ and $R=\underline{R}$, do not necessarily occur in a same state.) If the minimal payoff increases, the firm with integrated fund can choose a higher level of safe debt, which implies a larger premium[8].
Proposition 7 holds for any set of firm assets and corresponding optimal capital structure. For each possible distribution f of the payoff R, Eq. (4.3) specifies a sufficient condition for a costless reduction of leverage and insolvency risk by means of an integrated fund. More precisely, the reduction of leverage and insolvency risk is not only costless, but it even increases the firm value. The condition refers to properties of the joint distribution $\hat{f}(R,R_S)$. In principle, one can always construct a financial asset with an appropriate distribution:

Lemma 7
For every firm with continuous distribution $f(R)$ of its asset payoff and a corresponding optimal capital structure with strictly positive bankruptcy risk (i.e. $\phi(D_{s,0},D_{r,0},0)>0$), there is a financial asset whose payoff R_S is distributed such that Eq. (4.3) holds.

Proof by example: Consider a financial asset that yields a cash flow $R_S=\frac{1}{m}$ in all states with $R\in[0,D_0]$ and zero in all other states, with m being a normalization factor such that $E_{\hat{f}}[R_S]=1$. For this asset, the l.h.s. of Eq. 4.3 is strictly positive, and the r.h.s. is 0.

The possibility to construct an appropriate financial asset is a simple, theoretical result. The more interesting and relevant question is whether one should expect that financial assets with appropriate characteristics are actually offered by other agents in the market.

[8] This effect has already been indicated in Admati et al. (2013). Gorton and Winton (2014) neglect this effect in their analysis of the premium for safe debt, because they assume perfect correlation between all issuers of financial claims. I illustrate in Section 4.8 that their strict assumption is an inappropriate simplification, even if one considers the portfolio of banks in the worst crises.

I discuss this question in Section 4.6. And Appendix B.2 shows that the results obtained in this section are robust on aggregate level. This means that all firms in an economy can simultaneously benefit from integrated funds and can reduce their insolvency risk, although the underlying real assets of the economy remain the same.

4.4. Disciplining Role of Demandable Debt

This section shows that the possibility to costlessly reduce leverage and insolvency risk of a firm by means of an integrated fund is not a particular feature of the trade-off between bankruptcy costs and debt benefits, but that it holds for other trade-off theories as well. This shall be illustrated for a theory that has been used to justify the high leverage of the banking sector. Calomiris and Kahn (1991) and Diamond and Rajan (2000) have argued that a fragile funding structure with high levels of demandable debt can be optimal, because it disciplines the managers by the threat of 'runs' and reduces their possibilities to extract rents from the cash flow to investors. As the last section, this section does not provide a complete solution of the firm problem, but it indicates that each firm can gain from an integrated fund, given that financial assets with certain features are available on the market. The availability of such assets and the potential puzzle that firms might not use integrated funds despite the gains is discussed in the Sections 4.6 and 4.7.

Let us keep the same basic structure of the firm problem as in the previous section. There is a firm with a set of firm-specific assets that yield $R \in \mathbb{R}^+$ at $t = 1$, and this firm can 'integrate a fund' in addition. This means that it can invest an amount s at $t = 0$ in a set S of financial assets which yield $R_S \in \mathbb{R}^+$ per unit of s at $t = 1$. The continuous joint distribution of R and R_S is denoted as $\hat{f}$. Let us assume that the financial assets are purchased in same market with risk-neutral pricing and $r = 0$ in which the firm issues its own debt and equity. Consequently, **Assumption 7 a)** still applies and the price of the financial assets at $t = 0$ equals $E_{\hat{f}}\left[s\, R_S\right]$. (Appendix B.3 shows the robustness of the results to more general pricing kernels and preferences of investors.) The initial owner of the firm sells equity and debt claims $t = 0$ and chooses the capital structure such that it maximizes the revenue from these sales. The face value of debt is denoted as D, there is no outstanding debt at $t = 0$, and all agents know the firm's choice of capital structure as well as $\hat{f}$. The probability of insolvency at $t = 1$ is $\phi(D, s) = \int \mathbf{1}_{\{R+s\,R_S<D\}} \hat{f}(R, R_S) dR dR_S$, and the leverage is defined as $l(D, s) = \frac{D}{E_{\hat{f}}[R+s\,R_S]}$. The analogue of **Observation 8** also holds here: an increase in the size s of the integrated fund leads to a decrease of both, the leverage $l(D, s)$ and the insolvency probability $\phi(D, s)$.

For the purpose of this chapter, it is sufficient to briefly summarize the story presented in Diamond and Rajan (2000) and to focus on the resulting trade-off in the choice of capital structure.[9] Assume that the firm is operated between $t = 0$ and $t = 1$ by managers who obtain special knowledge about the firm production. (In case of a bank, for instance, they establish lending relationships.) If the operation is not completed by the managers, but debt or equity holders take over at $t = 1$ and 'liquidate' the firm, the payoff of the firm-specific assets declines from R to $R - l\,R$ with $0 < l < 1$. It seems implausible that managers have a similar advantage in passively holding financial assets within the fund. For completeness, however, I consider the possibility that R_S declines to $(1 - l_S)R_S$ with $0 \leq l_S < 1$ in case of a liquidation.

The managers are able to extract a fraction of the firm payoff at $t = 1$, because the equity holders are better off with accepting such an extraction than with firing the managers and incurring the relative loss l. This rent extraction, however, can be constrained by debt in the form of depositors. The key characteristic of deposits is: when they are withdrawn at $t = 1$, they are paid out at face value in the order in which the withdrawal request arrive. The depositors therefore immediately run when the expected payoff of their claims is smaller than the face value D, either because $R + sR_S < D$ or because the managers attempt to extract some of their payoff. Since the action of the depositors is immediate and uncoordinated, there is no chance for the managers to accomplish the extraction or to negotiate any other rent. The costs of this 'disciplining device' is the possibility of inefficient liquidations. The optimal capital structure trades off the relative losses $lR + l_S\, sR_S$ from the 'runs' of depositors against the extraction of rents by managers. In order to study this trade-off, one has to consider three types of states:

1. If $R + sR_S < D$, the depositors run on the firm and take hold of all assets. They only receive $R_l := (1-l)R + (1-l_S)s\, R_S$ due to an inefficient liquidation. Managers and equity holders get nothing.

2. If $R_l < D \leq R + sR_S$, the depositors can be sure that they receive D.[10] The managers do not dare to extract some of the payoff to depositors, because they would lose access to the remaining cash flow $R + sR_S - D$. The equity holders do not take over the firm, because they could only obtain the cash flow R_l and would hence face a run. The distribution of $R + sR_S - D$ between managers and equity holders depends on the bargaining game between them. Let $\tau_m \in (0, 1)$ simply represent the fraction that the managers obtain.

[9] The model focuses on the disciplining of the management by means of a fragile capital structure. It does not address the alleged potential of fragile funding structures to extract higher interest rates from the borrowers of banks. If one wanted to analyze comprehensively how the capital structure affects the extraction of cash flows from borrowers, one would need to go beyond Diamond and Rajan (2000), anyway. One would need to take into account, for instance, the reaction of borrowers to an increased extraction of rents that the fragile funding allows for (e.g. less entrepreneurial activity or evasion to alternative funding).

[10] The argument for a beneficial role of demandable debt by Diamond and Rajan (2000) treats the demandable debt favorably, as it neglects the possibility of non-fundamental runs. Since I want to critically discuss their argument, I follow them and neglect this type of run.

3. If $D \le R_l$, the situation is similar to case 2. The depositors can be sure to get D and the equity holders and the managers bargain over the relative surplus that arises from keeping the managers. Since the equity holders could take over the firm without facing a run, the relative surplus is $lR{+}l_S\, sR_S$. Assume again that the managers get a fraction τ_m. To sum up, the state-contingent payoffs at $t = 1$ are:[11]

Payoffs to	depositors	equity holders	managers
1. $R + sR_S < D$	R_l	0	0
2. $R_l < D \le R + sR_S$	D	$(1-\tau_m)\big(R+sR_S-D\big)$	$\tau_m \cdot \big(R+sR_S-D\big)$
3. $D \le R_l$	D	$R+sR_S-D-\tau_m \cdot (l\,R+l_S\,sR_S)$	$\tau_m \cdot (l\,R + l_S\,sR_S)$

The value v_s of the firm at $t = 0$ is defined as the joint value of the debt and equity claims. Given that the value of the claims at $t = 0$ equals their expected payoff at $t = 1$, the firm value $v_s(D, s)$ can be written as

$$\begin{aligned} v_s(D,s) &= \int (R + s\,R_S)\,\hat{f}(R,R_S)\,dR_S\,dR - L(D,s), \quad \text{with} \\ L(D,s) &= \int \tau_m \cdot \big(l\,R + l_S\,sR_S\big)\,\mathbf{1}_{\{D\le R_l\}}\,\hat{f}(R,R_S)\;dR_S\,dR \\ &\quad + \int \tau_m \cdot \big(R + sR_S - D\big)\,\mathbf{1}_{\{R_l\le D\le R+sR_S\}}\,\hat{f}(R,R_S)\;dR_S dR \\ &\quad + \int \big(l\,R + l_S\,sR_S\big)\,\mathbf{1}_{\{R+sR_S\le D\}}\,\hat{f}(R,R_S)\;dR_S\,dR \end{aligned}$$

The 'net firm value' $v(D, s)$, which is v_s net of the price of the purchased assets, is:

$$v(D,s) = v_s(D,s) - E_{\hat{f}}\,[s\,R_S] = \int R\,\hat{f}(R,R_S)\,dR_S\,dR - L(D,s)$$

If the initial owner wants to maximize the revenue from the sale of claims at $t = 0$ net of the costs of purchasing the financial assets, then her decision problem is:

$$\max_{D\in\mathbb{R}^+,s\in\mathbb{R}^+} \big(v^s(D,s) - E_{\hat{f}}\,[s\,R_S]\,\big) = \max_{D\in\mathbb{R}^+,s\in\mathbb{R}^+} v(D,s) \;\Leftrightarrow\; \min_{D\in\mathbb{R}^+,s\in\mathbb{R}^+} L(D,s)\,.$$

The decision problem consists of the maximization of the net firm value v, which is equivalent to the minimization of the expected losses L. The optimal capital structure balances out the expected extraction of payoff by managers (given by the first and second term in $L(D, s)$) and the expected loss from runs of depositors (given by the third term in $L(D, s)$). In order to study the impact of an integrated fund, let us again define the constrained problem $P(s)$: $\max_{D\in\mathbb{R}^+} v(D, s)$ for given $s \in \mathbb{R}^+$. The solution of $P(0)$ shall be denoted as D_0 and it represents the optimal capital structure of the firm without

[11] The payoff stated for depositors is the payoff of the entire group, while the individual payoffs vary in case of $R + sR_S < D$ due to the sequential order in processing the withdrawals.

integrated fund.

Proposition 8

Relative to the optimal capital structure of a firm without integrated fund, a reduction of the leverage and insolvency risk by means of an integrated fund increases the net firm value, if the payoff of the purchased financial assets is such that Eq. 4.5 holds:

$\frac{d}{ds}v(D_0,s)\big|_{s=0} > 0$, *if*

$$l\,D_0\,f(D_0)\,E_{\hat{f}}\left[R_S|R{=}D_0\right] > \tau_m\cdot\left(\int_{D_0}^{\frac{D_0}{1-l}} E_{\hat{f}}\left[R_S|R\right]\cdot f(R)\,dR + l_S\int_{\frac{D_0}{1-l}}^{\infty} E_{\hat{f}}\left[R_S|R\right] f(R)\,dR\right) + l_S\int_0^{D_0} E_{\hat{f}}\left[R_S|R\right] f(R)\,dR. \qquad (4.5)$$

Proof: See Appendix B.4.2.

The explanation for this result is similar to the one for the results in the two previous sections. Given the optimal debt level D_0 of the firm without fund, a reduction of insolvency risk and leverage by means of a debt reduction leads to a decrease in the firm value. A reduction of leverage and insolvency risk by means of an integrated fund, in contrast, can increase the firm value, because the fund can alter the distribution of the firm payoff in a beneficial way. In particular, the fund can prevent costly liquidations due to runs in states with $R < D$ by providing a sufficiently large payoff $s\,R_S \geq D - R$ in these states. The integrated fund increases the firm value, if the reduction in expected liquidation costs is larger than the rents that managers can extract from the fund payoff plus the relative loss from liquidating the fund in the remaining states with runs. This condition is expressed by Eq. (4.5) for a marginal increase of the fund size s: the l.h.s. states the reduction in costs from runs and inefficient liquidation, the first and second term on the r.h.s. state the extraction of fund payoffs by the managers, and the last term on the r.h.s. states the expected loss from liqudating the fund in case of a run.

For any set of firm assets and corresponding optimal capital structure, Proposition 8 provides a sufficient condition for the possibility to decrease the leverage and insolvency risk of a firm without decreasing the firm value, but rather increasing it. In principle, one can always construct a financial asset with properties such that this condition is fulfilled:

Lemma 8

For every firm with continuous distribution $f(R)$ of its asset payoff and a corresponding optimal capital structure with strictly positive insolvency risk (i.e. with $\phi(D_0,0) > 0$), there is a financial asset whose payoff R_S is distributed such that Eq. (4.5) *holds.*

Proof by example: Consider a financial asset with a state-contingent payoff $R_S = \frac{1}{m}\mathbf{1}_{\{R\leq D_0\}} + \frac{l_S}{l\,D_0\,f(D_0)}\mathbf{1}_{\{R=D_0\}}$, with m being a normalization factor such that $E_{\hat{f}}\left[R_S\right] = 1$. For this asset, the l.h.s. of Eq. 4.5 is $l\,D_0\,f(D_0)\frac{1}{m} + l_S$ and it is thus larger than the r.h.s.

of Eq. 4.5, which is equal to $\tau_m \cdot 0 + l_S \cdot E_{\hat{f}}[R_S] = l_S$.

The possibility to construct an appropriate financial assets is a simple, theoretical result, and the more interesting question is whether other agents in the market can offer financial assets with such characteristics. This question is addressed in Section 4.6. This section has shown, however, that the possibility to costlessly reduce leverage and insolvency risk by means of an integrated fund is not a special feature of a single trade-off theory. It rather holds for different types of such theories, including the trade-off between rent extraction by managers and inefficient liquidations, which has been used to explain the high leverage of banks. Appendix B.2 shows that this result is robust on the aggregate level, which means that it still holds when all firms simultaneously integrate funds.

4.5. Risk-Shifting and Effort Reduction

Having already discussed three theories of capital structure (disciplining role of debt, taxes vs. bankruptcy costs, premium for money-like claims), this section addresses another prominent theory of capital structure: Jensen and Meckling (1976) have argued that the optimal capital structure is determined by a trade-off between the respective agency costs of equity and debt financing. I only briefly indicate here why a firm can integrate a fund that reduces leverage and insolvency risk without disturbing the optimal trade-off between these agency costs. A more detailed and formal analysis of this issue is given in Appendix B.1.

According to Jensen and Meckling (1976), the capital structure of a firm affects the behavior of the firm managers in two ways, which have an impact on the firm value. First, the managers are paid by the firm with equity claims in order to incentivize them to exert costly effort[12] which increases the firm payoff and hence the payoff of the equity claims. This implies that the return to the manager effort is shared among all holders of equity. As a consequence, the incentive of the managers to exert costly effort decreases with an increasing amount of equity in excess of the claims that they receive as payment. This is the agency cost of equity. Second, being equity holders, the managers have an incentive to increase the risk of the firm portfolio after firm debt has issued. They gain from the upside risk, while the downside risk is partly borne by debt holders. If the increase of risk leads to a decrease in the mean firm payoff, this risk-shifting is inefficient. The incentive of the managers to engage in such risk-shifting increases with the debt level of the firm, because the part of the downside risk that the debt holders bear increases with the debt level. This is the agency cost of debt.

Assume that a firm with a set A of assets has chosen the debt level D, because this capital structure maximizes the firm value. This means that the effort c_m and the amount α of

[12] Alternatively, 'effort' can be interpreted as the discipline to abstain from a privately beneficial misuse of firm resources.

risk-shifting that the managers chooses in case of D leads to a higher firm value than the effort and risk-shifting that they would choose for any other level of debt. Consider now that this firms integrates a fund, which means: first, the firm buys a set S of financial assets in the same market in which it issues its own debt and equity; and second, in order to finance this purchase, the firm issues more of its own claims, but it does not change the face value D of the debt. The impact of the integrated fund on the firm value depends on its impact on the manager behavior (i.e., their choice of c_m and α). This impact depends on how the payment of the managers is adjusted to the integration of a fund. While the firm has many degrees of freedom in adjusting the payment scheme, I only present a simple example here, for which the integrated fund has neither a positive nor a negative effect on the firm value.

The key idea is to relate the payment of the managers to the part of the firm that actually depends on their behavior. This is the asset set A whose payoff R_A depends on the managers' effort c_m and their risk-shifting α. The payoff R_S of financial assets issued by other agents in the market is independent of the managers of the firm that only holds these assets passively. Assume that the managers are paid with a fraction m of an equity claim to the set A of assets which yields $\max\{0, R_A - D\}$. If the fraction m equals the fraction of equity that the managers would receive from the firm without fund, then the managers' return to effort is the same in both cases. Consequently, they choose the c_m and α that have been optimal for a firm without fund, given that the debt level D and the potential gains from risk-shifting have not changed. As a result, the payoff from the asset set A is not changed by the integrated fund. And the purchase of S financed with claims that are issued in the same market has zero net present value. This means that the net firm value does not change due to the integration of a fund. At the same time, however, the leverage of the firm (i.e., the ratio of its liability to the value of its portfolio) has decreases. And the same holds for its insolvency risk, as the payoff of the financial assets can be used to payoff D in states with low R_A.

The payment scheme just described relies on the possibility to separate between the payoffs of the asset sets S and A and the possibility to condition the manager payment only on the payoff of A. It should be very easy for the firm, however, to distinguish between the payoff R_S of the financial assets held in the fund and the payoff of the actual firm operation.

The adjustment of the payment scheme is an example of a more general point: although there are important relations between the capital structure of a firm and the incentives of agents in that firm, these relations are not as strict as first highlighted in Jensen & Meckling (1976). A firm has many degrees of freedom to shape these relations by writing better contracts with the involved agents. This has already been stressed for other types of problems by, for instance, Aghion & Bolton (1989) or Dybvig & Zender (1991).

4.6. A Way to Create Financial Assets with a Beneficial Distribution of Payoffs

The previous sections have identified sufficient conditions for the existence of efficiency gains owing to the integration of funds. These conditions are stated in Eq. (4.4) and Eq. (4.5) and refer to the joint distribution of the payoffs from the firm assets and from the purchased financial assets. The joint distribution has to be such that the financial assets yield relatively high payoffs in states in which the firm without fund would become insolvent. The key question is whether other agents in the financial markets provide securities that satisfy this condition.

One could empirically test for given firms whether there are outstanding assets in the financial markets that have an appropriate payoff distribution relative to the payoff distribution of those firms. If one finds financial assets with beneficial distribution of payoffs, one faces the puzzle why the firms do not 'integrate a fund' that holds these assets. Given the huge number of outstanding financial assets, however, this empirical exercise would be a vast task. And it would still provide an incomplete answer to the question, because the agents in the market can provide much more financial assets than the outstanding ones, because they can create new ones by simply writing contracts. I therefore address the question in a different way: I show that there is always a simple way to create financial assets with beneficial payoff distributions. This result leads to a puzzle, since this way of creating beneficial assets does not seem to be common practice. The puzzle is resolved in Section 4.7.

Consider that a firm with state-contingent payoff R of its assets and optimal debt level D purchases a 'capital insurance' that yields the payoff $\max\{D - R, 0\}$. This financial asset can be created by a very simple contract that simply condition on the payoff of the firm assets and on the face value of the debt liabilities. The capital insurance reduces the insolvency risk to zero, which also implies that is reduces the costs of bankruptcy or liquidations to zero. And it does not increase the payoff to equity, which means that it does not increases the taxes or the rents that managers can extract from the equity payoff. (New agency problems that might arise from a capital insurance are discussed below and in the next section.) Consequently, the capital insurance increases the firm value according to the trade-off theories discussed in the previous sections.

From a practical point of view, it might be difficult to predict the payoff R in each possible state and it might be unfeasible to specify the payoff of the financial asset in each possible state. In that case, the insurance contract has to condition on the lack of payoff itself, which means the difference $D - R$. Such an insurance contract, however, leads to moral hazard, if the payoff R can be altered by the firm. Firm owners, for instance, have an incentive to engage in risk-shifting at the expense of the insurance provider. This means that they increase the volatility of their portfolio, so that they benefit from the increase upside risk, while the increased downside risk is covered by the insurance. In the following, I explain how the capital insurance can be provided in a way that prevents this type of moral hazard. The agency problem between the insurance provider and rent extracting managers (like in Section 4.4) is discussed in Section 4.6.1.

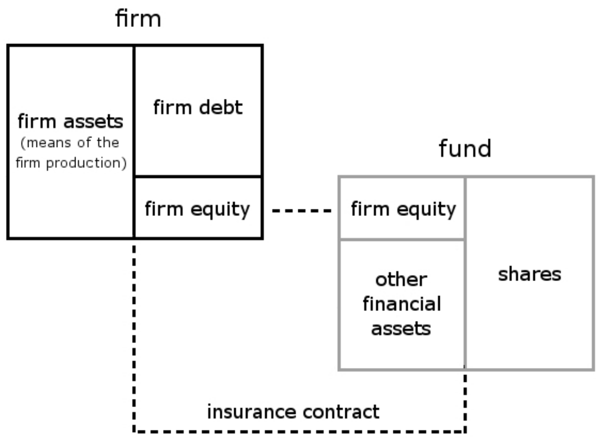

Figure 4.2.: A possibility to provide a capital insurance to a firm without allowing for risk-shifting.

The way how a capital insurance can be provided to a firm without a possibility for risk-shifting is depicted in Fig. 4.2. The entire equity of the firm is held by its owners through a fund, which also has other securities in its portfolio. And this fund sells a capital insurance to the firm whose equity it holds. If the equity holders of the firm engaged in risk-shifting, they would not shift risk to the debt holders, but to the insurance providers - which means that they would shift the risk to themselves.

The capital insurance of a firm by a fund entails efficiency gains owing to the differences between a firm and a fund. First, being financed by issuing shares, a fund cannot become insolvent and there a no costs that result from an inefficient interruption of the fund operation in case of insolvency. Second, since (passive) funds are just a set of financial contracts that transmit payoffs (in contrast to firms, which create payoffs), it is common practice that funds are not subject to corporate taxation. Consequently, the provision of the insurance entails no losses. But it allows for gains, as it reduces the losses of the firm. Owing to these gains, the fund has an incentive to provide the capital insurance to the firm that it owns completely.

It is interesting that the firm-fund structure, which I have derived as a way to obtain efficiency gains, is effectively the same as the 'liability holding companies' (LHCs) that Admati et al. (2012) have suggested in the context of bank regulation. They propose LHCs with the aim to counteract negative incentives due to implicit bailout guarantees. Opponents of capital regulation argue that the choice of capital structure by banks would not be driven by such guarantees, but mainly by the trade-offs discussed above. The result of this chapter is: if this is true, banks should actually welcome the establishment of LHCs, as they allow for private efficiency gains.

To sum up, this section has shown that there is simple way to create financial assets with a distribution of payoffs which allows for both, efficiency gains for the purchasing firm as well as a reduction of the insolvency risk. Having illustrated this for a single firm, a generalization of the result for a continuum of firms in a closed economy is given in Appendix B.2.[13] Given this strong and positive result, one might wonder why not all firms set up the firm-fund structure suggested here. Section 4.7 argues that the transition to such structures is inhibited by a problem of misaligned incentives that is similar to the 'leverage ratchet effect' highlighted by Admati et al. (2018).

4.6.1. A Capital Insurance in Presence of Rent Extracting Managers

The analysis of debt as disciplining device according to Diamond & Rajan (2000), which I have presented in Section 4.4, studied financial assets whose payoff R_S is independent of the managers of the firm that buys these assets. The last section has highlighted a capital insurance that yields $s\,R_S = \max\{0, D - R\}$ as simple way to create a financial asset with a beneficial payoff distribution. As mentioned in that section, it might be difficult to write a contract that specifies a payoff $\max\{0, D - R\}$ in each possible state, other than by condition on R itself. In that case, however, the payoff R_S becomes dependent on the behavior of the managers. And the disciplining effect of the demandable debt in states with $R \leq D$ gets lost, because the debt holder do not carry losses from the extraction by managers, but the capital insurance covers the loss. The payoff of the insurance increases with the reduction of R by a rent extraction by managers. Since the equity holders do not care for the rent extraction in states with $R \leq D$, the managers can thus increase the rent extraction in these states without any constraint.

There are (at least) two different solutions for this problem, depending on whether the depositors and the managers can collude. The solution for the case that they can collude is the more robust one. But let me also briefly point a possible solution for the case that they cannot collude.

In that case, a small modification of the capital insurance can solve the problem (if one follows the logic of Diamond & Rajan). Consider an insurance that does not only yield $D - R^n$, but $D - R^n + g(D - R^n)$ in every state with $R^n < D$, where R^n is the 'net payoff' of the firm, which means the payoff R from its assets minus the rent extraction by managers. And $\frac{d}{dx}g(x) < 0$ with $g(x) \geq 0$ for all $x \in [0, D]$. Furthermore, the additional payoff $g(D - R^n)$ in case of an insured event, which increases in R^n, shall accrue to the depositors who do not run. Running depositors simply receive their fraction of D. Given

[13] Closed economy means that there are no externally provided financial assets, but all possible financial claims have to refer directly or indirectly to the payoff from the real assets of the firms.

this kind of insurance contract, the debt holders maintain an incentive for monitoring. They can threaten the managers with a run, if their premium $g(D-R^n)$ decreases too strongly due to the rent extraction, which increases $D-R^n$. Since running depositors simply receive D, the value of keeping the managers in states with $R < D$ (when the insurance becomes effective) is $g(D-R)$. Bargaining over this continuation value, the depositors are in the same position which the theory of Diamond & Rajan assigns to equity holders. Assuming that equity holders depositors bargain in a similar way, the managers can obtain a fraction b_e of this continuation value. By choosing a function g with values slightly above zero, one can minimize the extraction $b_e\, g(D-R)$ of rents from the capital insurance. Moreover, with $b_e\, g(x)$ close to zero for all $x > 0$, the managers have no incentive to trigger an insured event by extracting so much that R^n falls below D, because the rent $b_e(R-D)$ that they can extract in states with $R > D$ is larger than $b_e\, g(x)$. As result, the capital insurance leads to an expected loss $\int_0^D b_e\, g(D-R)\, f(R)\, dR$. For sufficiently small g, however, this loss is smaller than the gains from preventing liquidations, which are $\int_0^D l\, R f(R)\, dR$.
If the depositors and the managers can collude, however, this modified insurance contract cannot suppress the moral hazard, because the overall gains for managers plus depositors from exploiting the insurance (by extracting X) are larger than the costs: $\left|\frac{d}{dX}X\right| > \left|\frac{d}{dX}g(D-R-X)\right|$ for g close to zero. In that case, the modification g of the insurance payoff is useless and the insurance provider can simply provide the payoff $\max\{D-R, 0\}$. If the insurance provider also holds the firm equity, however, it still has a disciplining device owing to the power to replace the managers. As in states with $R > D$, the insurance provider (i.e., the equity holders) can bargain with the managers over the continuation value of keeping the managers in states with $D > R$. If the equity holders took over the firm, the resulting loss $l\, R$ from inefficient liquidations would increase the insurance payments that are necessary to pay out the depositors. The value of keeping the managers is thus the avoidance of this loss $l\, R$, which is equal to the loss that would occur in case of runs. The managers, however, can only obtain a fraction b_e of this value in the bargaining process. Consequently, the loss $b_e\, l\, R$ due to an extraction of rents from the capital insurance is smaller than the loss $l\, R$ that would occur in case of a run, which is prevented by the insurance. As a result, the capital insurance leads to efficiency gains, even if the managers can exploit this insurance and can collude with the depositors.

4.7. Obstacles to Integrated Funds

This chapter shows that integrated funds allow for private gains for a firm, if its capital structure is chosen according to a trade-off between taxes and bankruptcy costs or a trade-off between rent extraction by managers and costs due to runs. If these trade-offs are empirically relevant, one should expect that all firms make use of integrated funds.

But this is not the case. The reason might simply be that the trade-offs mentioned above are in fact not important for the choice of capital structure. But I want to suggest another explanation for the lack of integrated funds, which is related to the process of changing the capital structure.

In contrast to the assumption used in the analysis of the trade-offs theories, a firm usually has outstanding debt. In that case, a problem arises that has been highlighted by Admati et al. (2018) in their description of the 'leverage ratchet effect': If the face value of this outstanding debt cannot be renegotiated, the owners of the firm will not implement a change of capital structure that has a positive net present value owing to its reduction of expected bankruptcy or liquidation costs. The reason is the asymmetric distribution of gains and losses: the benefit of reduced bankrupty costs accrues to the debt holders, while the owners/equity holders incur the cost of higher taxes, for instance.[14]

If a firm could commit to the establishment of an integrated fund at a future point in time, the pricing of debt that is rolled over or newly issued could account for the reduction of the bankruptcy risk at this future point. As a consequence, the firm owners could participate in the gains from the integrated fund and would thus have an incentive to establish it in the long run. However, once the firm owners have incurred their part of the gains in the form of adjusted debt prices, they have an incentive to reduce the integrated fund or to choose its portfolio such that risk is shifted to the debt holders. Since there are so many degrees of freedom related to an investment in financial assets at a future point in time (as the set of available assets as well as their characteristics constantly evolve), it might be impossible to credibly commit to the future characteristics of an integrated fund. The consequence of this inability is that debt holders cannot fully trust in the safety of their claims and thus do not accept debt prices that account for prospective reductions in the insolvency probability and that allow to share the gains from integrated funds with the firm owners.

4.8. Implications for the Regulation of Banks

The results of this chapter have important implications for the debate about the regulation of banks. There is the widespread notion that capital requirements for banks, which are intended to improve the stability of the financial sector, entail some costs. First, they are supposed to cause private costs for banks due to a deviation from their privately optimal choice of financing. And second, they are supposed to cause social costs - either indirectly, because the private costs for banks impair their provision of credit and other services to the economy, or directly, because the requirements allegedly reduce the volume

[14]Debt holders even gain at the expense of the equity holders in absence of such frictions, as highlighted by Admati et al. (2018). A reduction of the insolvency risk always implies that the payoff to holders of outstanding debt increases in some states. If the face value of their debt is not adjusted, but their debt contract is fixed, they gain at the expense of the equity holders.

of socially beneficial 'money-like' claims.

There are plausible arguments for private costs in the short run, when capital requirements are raised quickly. The increase in equity reduces the default probability of the outstanding debt and it thus transfers wealth from equity holders to the holders of outstanding debt, as described in Admati et al. (2016). And these private costs can lead to social costs, when the bank owners prefer to comply with increased capital requirements by liquidating assets or by forsaking new projects with positive NPV. The arguments for private and social costs of capital requirements in the long run, in contrast, are usually based on the trade-off theories discussed in this chapter. This chapter has shown, however, that these theories actually allow for a decrease of leverage and insolvency risk of banks without any costs, if one takes into account that banks can 'integrate a fund'. In fact, the integration of a fund in order to reduce bankruptcy risk can even provide gains. Such beneficial reductions of the insolvency risk depend on the availability of assets with an appropriate distribution of payoffs. In Section 4.6, I have illustrated an example how financial assets with an appropriate distribution can be created. This example is depicted in Fig. 4.6 and it is effectively the same as the liability holding companies (LHCs) suggested by Admati et al. (2012). A regulation that takes LHCs into consideration could therefore reduce the insolvency risk of banks without any private costs in the long run, but rather with gains. In absence of private costs for banks, such regulation would also not entail any social costs, as indicated above. – To be precise, one type of private costs would actually arise: the loss of the subsidies that banks get from governments in form of implicit bailout guarantees. But as long as one does not want to subsidize banks in this way, one should not be concerned about this type of these costs.

Capital regulation based on integrated funds or LHCs faces a problem similar to the one discussed in the previous subsection: the regulation has to ensure that the size of the funds and their compositions are such, that the payoffs from the securities held in the funds are large enough in states in which the banks need them to avoid insolvency. As mentioned before, the banks might exploit a discretion about the fund portfolio for the purpose of risk-shifting. By imposing appropriate rules, however, the regulation can remove this discretion. This is a standard problem of capital regulation, which tries to alleviate risk-shifting at the expense of an explicit or implicit public insurance. It might be difficult to set rules that remove the discretion and the moral hazard completely. But this problem only affects the amount of implicit subsidies that banks can extract - it does not change the result that funds allow for a reduction of the insolvency risk of banks without efficiency losses in the long run.

Let me conclude with brief **estimates for the size integrated funds/LHCs**. I consider the case that the funds invest in relatively risky assets, namely corporate bonds, and I study their ability to absorb losses in financial crises. The weighted average of default rates of all corporate bonds rated by Moody's peaked at 8.424 % in 1933 and peaked again at 5.422 % in 2009.[15] One can thus expect that a fund which issues shares in order to purchase an amount X of bonds can provide a capital insurance worth $(1-\delta_D)X$ with $\delta_D = 0.1$ even in very bad states. This is a conservative estimate, since positive recovery rates are ignored and corporate bonds are a risky type of bonds.

Let us now consider a scenario in which the loss-absorbing capital of US banks shall be increased by 5% of their assets by means of LHCs that invest in bonds. This would more than double the amount of loss-absorbing capital in banks, given that they comply with the leverage ratio that is imposed by the current regulation, which is in the range of $3-5\%$. With a discount factor δ_D and an aggregate volume A_{agg} of bank assets, the volume V^D_{abs} of bonds that the funds would need to hold is $V^D_{abs} = \frac{1}{1-\delta_D} \cdot 0.05 \cdot A_{agg}$. Take the example of the US banks in December 2012:[16] According to the FDIC the aggregate volume of assets in insured US banks was $A_{agg} = \$\,14.5\,tn$.[17] This means that the LHCs would need to absorb bonds worth $V^D_{abs} = \$\,0.8\,tn$ in order to double their capital buffer. To get an appropriate idea of this number, it should be compared to the volume of bonds available on the market. In case of the US market in December 2012, the volume of outstanding bonds was $\$\,36.6\,tn$ according to SIFMA.[18] Using information from Hanson et al. (2015) and the FDIC,[19] one can subtract the volume of bonds already held by banks. As a result, the volume of bonds that are not held by banks and that could be purchased by the related LHCs is at least $V^D_{ext} = \$\,33.8\,tn$. This means that only 2.4% of the available bonds would need to be purchased by LHCs in order to double the capital buffers of banks that are able to absorb losses even in the worst states of the economy.

[15] see `http://efinance.org.cn/cn/FEben/Corporate%20Default%20and%20Recovery%20Rates,1920-2010.pdf`

[16] a recent date for which all relevant data is easily accessible

[17] see `https://www.fdic.gov/bank/statistical/stats/2012dec/industry.pdf`

[18] see `http://www.sifma.org/uploadedFiles/Research/Statistics/StatisticsFiles/CM-US-Bond-Market-SIFMA.xls?n=13061`

[19] Hanson et al. (2015) state that 20.8 % of the assets of the banks in their sample were securities in 2012. Since bonds are only a part of this set, the given estimate for the volume of bonds already held by banks is an upper bound.

A. Appendices to Chapter 2

A.1. Microfoundation of a Premium for Safe Claims

Consider that there are three dates $t = 0, 0.5, 1$, and three types of risk-neutral agents: first, a continuum of 'informed buyers' with mass $\alpha_I \in (0, 1)$; second, a continuum of 'uninformed buyers' with mass $1 - \alpha_I$; third, two 'sellers'. At $t = 0.5$, both types of buyers have the need to consume one unit of a good that is produced and offered by the sellers. Each buyer of both types has an initial wealth w at $t = 0$, which they can store in two different technologies: a safe one that yields $1 - \lambda \in (0, 1)$ at $t = 1$ for each unit stored at $t = 0$; or a risky one whose payoff at $t = 1$ per unit stored at $t = 0$ is: $1 - b_-$ with probability p_- and $1 + b_+$ with probability $1 - p_-$. The expected payoff per unit of the risky technology equals 1 owing to $p_- b_- = (1 - p_-)b_+$. Assume that the informed buyers learn at $t = 0.5$ which of the two payoffs of the risky technology will be realized at $t = 1$. To pay for the consumption good at $t = 0.5$, the buyers transfer claims to the storage technologies to the sellers. The payoff of the remaining claims, whose expected value is denoted as P_R, is consumed by the buyers at $t = 1$. The utility u_b of the buyers is $u_b = g + \omega\, P_R$, where g equals 1 if the unit of good at $t = 0.5$ is consumed, and it equals 0 else. To stress the consumption need, assume that $\omega < 1$. The dependence of P_R on the decision whether and by which means to purchase the good is described below.

Assume that the sellers offer the good in Bertrand competition and each of them quotes two prices for it: buyers can either pay p_s units of claims to the safe technology or p_r units of claims to the risky technology (both measured in units of storage at $t = 0$). The sellers want to maximize the expected payoff of the received claims net of their production costs, whose value in terms of expected payoff at $t = 1$ is $c < 1-\lambda$. Given Bertrand competition, they thus demand $p_s = \frac{c}{1-\lambda}$ units of the safe claim as payment. The alternative price p_r in terms of risky claims is such that expected payoff of the claims equals c, given the sellers' expectation about which type of buyer uses that form of payment because of which incentive. Assume that the sellers can observe neither the composition of the buyers portfolio (i.e., their relative storage in the two technologies) nor whether they sell to an informed or uninformed buyer.

There are three decisions that have to studied here: first, the buyers' decision at $t = 0$ about the part w_s of w that they store in the safe technology (which implies $w - w_s$ is stored in the risky one); second, the sellers' quote p_r; third, the buyers' choice of the means of payment. The storage decision occurs before the price quote, while the latter is chosen without knowing the former. Consequently, the storage decision and the price quote can be represented as simultaneous moves. Taking into account the buyers' choice of the means of payment given the quoted prices, I will show:

Lemma 9
For $b_- > \lambda$, there is an equilibrium of the game in which the sellers quote $p_r \geq \frac{c}{1-b_-}$, while both types of buyers store $w_s = \frac{c}{1-\lambda}$ in the safe technology at $t = 0$.

This shows that there is a demand for safe claims by risk-neutral agents even if the expected payoff of these claims is reduced by a discount λ relative to risky claims.

Proof: Let me first derive the quote $p_r \geq \frac{c}{1-b_-}$ as optimal response to the storage $w_s = \frac{c}{1-\lambda}$. This storage implies that a payment with safe claims is feasible for the buyers. And it implies that they always purchase the good, because the purchase and consumption increases their utility u_b by at least $1 - \omega\, c > 0$, as 1 is the utility of consuming the good, while $\frac{c}{1-\lambda} \cdot (1 - \lambda) = c$ is the reduction of P_R from paying the good with safe claims. Let us consider three possibilities for the quote. First, the sellers quote $p_r \geq \frac{c}{1-b_-}$. The uninformed buyers use safe claims for the payment, because the resulting reduction c in P_R is smaller than the reduction in case of using risky claims, which would be at least $\frac{c}{1-b_-} \cdot 1 = \frac{c}{1-b_-}$, since the expected payoff of a risky claim is 1 from the uninformed buyers' point of view. Similarly, informed buyers use safe claims if they learn that the risky technology has a high payoff, because using risky claims would then imply a reduction of P_R by at least $\frac{c}{1-b_-}(1 + b_+)$. In case of a low payoff of the risky claims, the informed buyers still prefer to use safe claims for $p_r > \frac{c}{1-b_-}$ and are only indifferent between the two means of payment for $p_r = \frac{c}{1-b_-}$, when using risky claims only implies a reduction c. In any case, the sellers receive claims with an expected payoff c.
The second possibility is $p_r \in \left(c, \frac{c}{1-b_-}\right)$. Given such a price, the uninformed buyers would use the safe claims for the same reason as just mentioned. But the informed buyers would use the risky claims in case of a low payoff, as their reduction of P_R would be smaller than c in that case. Consequently, the sellers would receive claims with an expected payoff smaller than c, which means that a quote $p_r \in \left(c, \frac{c}{1-b_-}\right)$ is dominated by $p_r \geq \frac{c}{1-b_-}$. The remaining possibility is $p_r \leq c$. Given such a price, the uninformed buyers would use the risky claims as they imply a weakly smaller reduction of P_R than using safe claims, given an expected payoff 1 of risky claims. For $p_r < c$, however, the claims paid by the uninformed buyers would have an expected payoff smaller than c. The same is true for the claims paid by informed buyers for all $p_r \leq c$. For $\frac{c}{1+b_+} < p_r \leq c$, they would pay with risky claims only in case of a low payoff $1 - b_-$, which implies an expected payoff $p_r \cdot (1 - b_-) < c$ for the sellers. For $p_r \leq \frac{c}{1+b_+}$, they would pay with risky claims also in case of a good payoff, but the expected payoff $p_r \cdot 1$ for the sellers would still be smaller than c. As result, the optimal quote by the sellers is $p_r \geq \frac{c}{1-b_-}$.

Let me now explain why a storage $w_s = \frac{c}{1-\lambda}$ in the safe technology is the optimal response of both types of buyers to a quote $p_r \geq \frac{c}{1-b_-}$. First of all, not buying the good at $t = 0.5$ is worse than using the safe storage and buying the good at $t = 0.5$, because the amount $\frac{c}{1-\lambda} < 1$ of safe claims is sufficient for purchasing the good. Storing this amount in the risky technology in order to consume the payoff at $t = 1$ only yields the expected utility $\omega\frac{c}{1-\lambda}$ which is smaller than the utility 1 from consuming the good at $t = 0.5$. Storing a larger amount than $\frac{c}{1-\lambda}$ in safe claims, however, only reduces P_R by λ. If the buyers only store $w_s = (1-x)\frac{c}{1-\lambda}$ with $x > 0$, in contrast, they can store the difference $x\frac{c}{1-\lambda}$ in the risky technology. But they have to pay a fraction x of the good in terms of risky claims and given the quoted price, they have to pay at least the amount $x\frac{c}{1-b_-}$ of such claims. This is more than the relative increase $x\frac{c}{1-\lambda}$ of their storage in risky claims. Consequently, the buyers hold fewer risky claims after the purchase (which implies a smaller P_R) than for $x = 0$. As a result, the optimal storage is $w_s = \frac{c}{1-\lambda}$. ■

A.2. Proof of Proposition 4

a) For fixed e_V and unconstrained e_I, $S(e_V, e_I)$ monotonously increases in $D_S^I(e_V, e_I)$, which decreases monotonously in e_I, given that $e_I = \mathrm{E}\left[\max\{\tilde{y}_1(D_L(e_V)) - D_S^I\}, 0\right]$. This implies that the constraint $e_V + e_I = e_{reg}$ is binding at the maximum of $S(e_V, e_I)$. The derivative of $S(e_V, e_I)$ w.r.t. D_S^I for fixed $e_V + e_I$ is

$$\left.\frac{d}{dD_S^I}\right|_{e_V+e_I=const.} S(e_V, e_I) = \int \left(1 - \left.\frac{d}{dD_S^I}\right|_{e_V+e_I=const.} y_1\big(D_L(e_V)\big)\right) \cdot \mathbf{1}_{\{y_1(D_L)<D_S^I\}}\, f_1(x_1)\, dx_1\,,$$

where $y_1(D_L)$ is the function $\mathrm{E}\left[\min\{D_L, \tilde{x}_2\}|x_1\right]$ of x_1. One can determine how $y_1(D_L)$ changes with variations in D_S^I for fixed $e_V + e_I$ by differentiating $\mathrm{E}\left[\tilde{x}_2\right] - e_V - e_I = \mathrm{E}\left[\min\{\tilde{y}_1(D_L), D_S^I\}\right]$ w.r.t. D_S^I:[1]

$$0 = \int \left.\frac{d}{dD_S^I}\right|_{e_V+e_I=const.} y_1(D_L) \cdot \mathbf{1}_{\{y_1(D_L)<D_S^I\}} f_1(x_1) dx_1 + \int \mathbf{1}_{\{y_1(D_L)\geq D_S^I\}} f_1(x_1) dx_1$$

This relation has two implications: first, plugging it into the derivative of S yields $\left.\frac{d}{dD_S^I}\right|_{e_V+e_I=const.} S(e_V, e_I) = \int \left(\mathbf{1}_{\{y_1(D_L)<D_S^I\}} + \mathbf{1}_{\{y_1(D_L)\geq D_S^I\}}\right) \cdot f_1(x_1)\, dx_1 = 1$, which means that an increase of D_S^I always increases $S(e_V, e_I)$ for fixed $e_V + e_I$; second, it implies that $\int \left.\frac{d}{dD_S^I}\right|_{e_V+e_I=const.} y_1(D_L) \cdot \mathbf{1}_{\{y_1(D_L)<D_S^I\}} f_1(x_1) dx_1 < 0$ as long as $\int \mathbf{1}_{\{y_1(D_L)\geq D_S^I\}} f_1(x_1) dx_1 > 0$, which means as long as $e_I > 0$. Since $y_1(D_L) = \mathrm{E}\left[\min\{D_L, \tilde{x}_2\}|x_1\right]$ can only decrease by an decrease of D_L, which is equivalent to an increase in e_V, an increase of D_S^I for fixed $e_V + e_I$ means that e_V increases. To sum up, for $e_V + e_I = e_{reg}$, the subsidy $S(e_V, e_I)$

[1] $\mathrm{E}\left[\tilde{x}_2\right] - e_V - e_I = \mathrm{E}\left[\tilde{x}_2\right] - \mathrm{E}\left[\max\{\tilde{x}_2 - D_L, 0\}\right] - e_I = \mathrm{E}\left[\min\{D_L, \tilde{x}_2\}\right] - e_I = \mathrm{E}\left[\mathrm{E}\left[\min\{D_L, \tilde{x}_2\}|\tilde{x}_1\right]\right] - e_I = \mathrm{E}\left[\tilde{y}_1(D_L)\right] - \mathrm{E}\left[\max\{\tilde{y}_1(D_L) - D_S^I\}, 0\right] = \mathrm{E}\left[\min\{\tilde{y}_1(D_L), D_S^I\}\right]$

always increases with increasing D_S^I, which implies increasing e_V and decreasing e_I, until the boundary case $e_V = e_{reg}$ and $e_I = 0$ is reached.
b) With $e_V = e_B^{reg} \geq e_V^{min}$, the selection of good assets is ensured, so that $X(D_L(e_V); L) = \mathrm{E}[\tilde{x}_2] - I = X(x_{S,min}; S)$. Besides $S(e_V, e_I) \geq 0$, it holds also that $\Lambda^I\big(D_S^I(e_B^{reg}, 0)\big) = \lambda\, D_S^I(e_B^{reg}, 0) = \lambda\, D_L(e_B^{reg}) \geq \lambda\, x_{S,min} = \Lambda(x_{S,min}; S)$, as $D_L(e_B^{reg}) \geq x_{S,min}$ follows from $\mathrm{E}[\max\{\tilde{x}_2 - D_L, 0\}] = e_V = e_B^{reg} = \mathrm{E}[\tilde{x}_1 - x_{S,min}] = \mathrm{E}[\tilde{x}_2 - x_{S,min}] \leq \mathrm{E}[\max\{\tilde{x}_2 - x_{S,min}, 0\}]$. The inequalities are strict, because the continuity of $f_1(x_1)$ and $f_2(x_2|x_1)$ implies that $\tilde{x}_2|x_{S,min}$ in non-degenerate, but that there is a set of $\tilde{x}_2$ with non-vanishing mass for which $\tilde{x}_2 < x_{S,min}$. ■

B. Appendices to Chapter 4

B.1. Trade-off between Risk-Shifting and Effort Reduction

This appendix confirms the statements made in Section 4.5 by a formal analysis. More precisely, it shows that the possibility of costless decrease of leverage and insolvency risk by means of an integrated fund also holds in presence of agency costs that has been described in Jensen and Meckling (1976). This means that the section discusses a model with a trade-off between agency costs of debt in the form of risk-shifting and agency costs of equity in the form of a reduction in effort by the managers.[1] I present the analysis in two steps: first, the case of a firm without fund is established as a benchmark, before the impact of an integrated fund is illustrated.

B.1.1. Agency Costs of a Firm without an Integrated Fund

Consider again that a firm owner sells equity and debt claims and tries to maximize the revenue from this sale. The payoff of the firm assets at $t = 1$ depends on a basic cash flow R (with density f and upper bound $\overline{R}$) and on the behavior of the firm managers between $t = 0$ and $t = 1$:
1. The effort $c_m \in [0, \bar{c}_m]$ of the managers amplifies the payoff, so that it becomes $\rho(c_m) \cdot R$, with $\frac{d}{dc_m}\rho > 0$. Exerting the effort c_m, the managers incur a disutility that is equivalent to a negative payoff $-h(c_m)$ at $t = 1$, with $\frac{d}{dc_m}h > 0$. In order to incentivize the managers,

[1] 'Effort' can also be interpreted as the discipline to abstain from a misuse of firm resources.

the firm owner gives them a share $m \in [0,1]$ of the firm equity at $t = 0$. (Later, I explain why the results also hold for a payment of managers with other claims.)
2. The managers can choose to increase the risk of a fraction $\alpha \in [0,1]$ of the assets during the period. If upside of this change, which occurs with probability p, is that the asset payoff at $t = 1$ is raised to $\rho\, R + \alpha \cdot \beta^+$. The downside, occurring with probability $1-p$, is that the payoff is reduced to $\rho R - \alpha \cdot \beta^-$.[2] Assume that the increase in risk is inefficient: $p\,\beta^+ < (1-p)\beta^-$.
The risk-neutral managers choose c_m and α between $t=0$ and $t=1$, after the firm has issued debt with face value D. Their optimization problem is then

$$\max_{c_m \in [0,\bar{c}_m], \alpha \in [0,1]} \Big(m\,\mathrm{E}\left[\max\left\{0\,,\ \rho(c_m)R + \mathbf{1}_{\beta+}\alpha\beta^+ - (1-\mathbf{1}_{\beta+})\alpha\beta^- - D\right\}\right] - h(c_m)\Big), \quad \text{(B.1)}$$

where $\mathbf{1}_{\beta+}$ identifies states with a positive outcome of the additional risk. The optimal choices c_m^* and α^* depend on m and D. The payoff of the firm at $t=1$ is thus

$$X(R; D, m) := \rho\big(c_m^*(D,m)\big)R + \alpha^*(D,m) \cdot \left[\mathbf{1}_{\beta+}\beta^+ - (1-\mathbf{1}_{\beta+})\beta^-\right]\ . \quad \text{(B.2)}$$

Assume that all agents have complete information at $t=0$ and that the claims are again priced in markets with risk-neutral investors and riskfree rate $r = 0$. (Appendix B.3 shows that the results are robust to more general preferences of investors.) The value d of the debt at $t = 0$ is then $d(D,m) = \mathrm{E}\left[\min\left\{D, X(R; D, m)\right\}\right]$. And the value of the equity at $t = 0$ is $e(D,m) = \mathrm{E}\left[\max\left\{0, X(R; D, m) - D\right\}\right]$. The value v of the firm at $t=0$ is the sum of the values of debt and equity net of the equity given to the managers:

$$v(D,m) = \mathrm{E}\left[X(R; D, m)\right] - m\,e(D,m)$$

The decision problem of the initial firm owner who wants to maximize the revenue from selling debt and equity is thus $\max_{D \in [0,\overline{R}],\, m \in [0,1]}\ v(D,\ m)$. The firm value $v(D,m)$ depends on $X(R; D, m)$, which depends on the behavior of the managers who choose their optimal $c_m^*(D,m)$ and $\alpha^*(D,m)$ according to Eq. (B.1). Choosing D and m at $t = 0$, the initial firm owner takes this dependence into account and trades off the agency cost of debt against the agency cost of equity.

Lemma 10
There is an optimal capital structure (D^*, m^*), which maximizes v.

Proof: The manager problem and the firm problem always have finite solutions, since both are optimizations of finite expressions over a compact set: for the manager problem

[2] In order to avoid uninformative case distinctions, assume that $\rho R - \beta^- > 0$ for all possible cases. One could allow for a dependence of β^- and β^+ on $\rho\, R$, but that would not change the results of this analysis.

given in Eq. (B.1), the choice set is $[0, \bar{c}_m] \times [0, 1]$ and the objective function is bounded from below by $-h(\bar{c}_m)$ and from above by

$$\begin{aligned} \mathrm{E}\left[\rho(\bar{c}_m)R + \mathbf{1}_{\beta+}\alpha\beta^+\big(\rho(\bar{c}_m)R\big)\right] &< \mathrm{E}\left[\rho(\bar{c}_m)R + (1-\mathbf{1}_{\beta+})\alpha\beta^-\big(\rho(\bar{c}_m)R\big)\right] \\ &< 2\rho(\bar{c}_m)\mathrm{E}\left[R\right] < \infty\,; \end{aligned} \quad \text{(B.3)}$$

and for the firm problem, the choice set is $[0, \overline{R}] \times [0, 1]$ and all terms in the objective function $v(D, m)$ are bounded from above and below, since this holds for $X(R; D, m)$ as implicitly shown in Eq. (B.3).[3]

Having a benchmark that represents the managers' impact on the firm assets and the trade-off between agency costs of equity and debt, let us now study the consequences of integrating a fund.

B.1.2. The Effect of an Integrated Fund

The possibility to integrate a fund means again that the firm can choose to invest an amount s at $t = 0$ in a set S of financial assets, which are offered in the same market in which the firm issues its debt and equity. As before, I study the firm problem for a fixed composition of the portfolio S that yields R_S at $t = 1$ per unit of s, and $\hat{f}$ denotes the joint distribution with R.

The behavior of the managers might be influenced by an integrated fund, such the optimal choices c_m^* and α^* can depend on s. It seems to be reasonable, however, that the basic characteristics of the initial firm assets are not affected by financial assets held by the firm. I thus assume that the distribution f of the basic payoff R as well as the function ρ, which describes the effect of effort on the output of the initial firm assets, are independent of s. Let us also assume for a moment that β^+ and β^-, which means the potential increase of the risk of the initial firm assets, are independent of the purchased financial assets. (The issue that an integrated fund might expand the possibilities for risk-shifting has already been addressed in Sections 4.6 and 4.7.) Given these assumptions, the payoff from the productive assets is

$$X(R; D, m, s) = \rho\big(c_m^*(D, m, s)\big)R + \alpha^*(D, m, s) \cdot \left[\mathbf{1}_{\beta+}\,\beta^+ - (1-\mathbf{1}_{\beta+})\beta^-\right]\,. \quad \text{(B.4)}$$

The impact of the integrated fund on the manager behavior (which means the form of $c_m^*(D, m, s)$ and $\alpha^*(D, m, s)$ as function of s) depends on the way in which the payment scheme of the managers is adjusted to the integration of a fund. While the firm has many degrees of freedom in choosing a scheme, I only present a simple example here, for which the integrated fund has neither a positive nor a negative effect on the firm value.

[3] It is possible that several choices are equally optimal for the managers. Let us simply assume that managers choose each of these absolute maxima with equal probability in such cases.

Let us consider the case that managers receive the fraction m of equity claims to the payoff X from the initial firm assets. If the payoff from the initial firm assets has priority (over the payoff from the purchased financial assets) in repaying the firm debt, the decision problem of the managers during the period is

$$\max_{c_m\in[0,\bar{c}_m],\alpha\in[0,1]} \left(m\,E_{\hat{f}}\left[\max\left\{0,\rho(c_m)R+\mathbf{1}_{\beta^+}\alpha\beta^+-(1-\mathbf{1}_{\beta^+})\alpha\beta^--D\right\}\right]-h(c_m)\right).$$

This problem is identical to the one in the benchmark case.

Observation 9

If the managers are paid with equity claims to the initial firm assets, then their behavior is independent of the integrated fund: $\alpha^*(D,m,s)=\alpha^*(D,m)$ *and* $c^*_m(D,m,s)=c^*_m(D,m)$. *Consequently, the payoff from the initial firm assets is independent of the fund, too:* $X(R;D,m,s)=X(R;D,m)$.

The key idea behind this incentive scheme is to relate the payment of the managers to the part of the firm that depends on their behavior. This is the set of initial firm assets whose payoff X depends on the managers' effort and their risk-shifting. The payoff R_S of purchased securities is independent of the managers of the firm that only holds the securities passively. The adjustment of the payment scheme is an example for the following, quite general point: there are important relations between the capital structure of a firm and the incentives of agents in that firm, but these relations are not as strict as first highlighted in Jensen & Meckling (1976). A firm has many degrees of freedom to shape these relations by writing better contracts with the involved agents. This has already been stressed by, for instance, Aghion & Bolton (1989), or in a similar case as this one, by Dybvig & Zender (1991) in their discussion of Myers & Majluf (1984).
The possibility to separate the manager behavior from the integrated fund is independent of the initial payment scheme of the managers. I have illustrated the case in which they only receive equity claims, but the same logic applies to any set of claims with which managers are paid. The structure and payoffs of their claims can be maintained when a fund is integrated, if they continue to refer to the initial firm assets.
Although the integrated fund does not change the behavior of the managers, it has an impact on the solvency of the firm. In states in which the payoff X from the firm assets is too small to repay the firm debt D, a sufficiently large payoff $s\,R_S$ from the fund can avoid insolvency. The insolvency probability ϕ is thus given as $\phi(D,m,s)=\int \mathbf{1}_{\{X(R;D,m,s)+s\,R_S\,<\,D\}}\,\hat{f}(R,R_S)\,dR\,dR_S$. And the integrated fund also affects the firm leverage, which is again defined as $l(D,m,s)=\frac{D}{E_{\hat{f}}[X(D,m,s)+s\,R_S]}$.

Observation 10

If the debt level D is kept fixed and the managers are paid with a share m of equity claims to the initial firm assets, then an increase in the size of an integrated fund leads to a *decrease of both, the leverage and the insolvency probability:*

$$\frac{d}{ds}l(D,m,s) < 0 \;\forall\; s \in \mathbb{R}^+, \qquad \frac{d}{ds}\phi(D,m,s) \leq 0 \;\forall\; s \in \mathbb{R}^+$$

and the second inequality is strict for some $s \in \mathbb{R}^+$ *if* $E_{\hat{f}}\left[\mathbf{1}_{\{R_S>0\}}\mathbf{1}_{\{X(R;D,m)<D\}}\right] > 0$.

The additional payoff $s\,R_S$ also affects the value of the debt claims at $t=0$, which becomes $d(D,m,s) = E_{\hat{f}}\left[\min\left\{X(R;D,m,s) + s\,R_S, D\right\}\right]$. The value e' of the equity of the overall firm (initial firm assets plus integrated fund) is equal to the value of the expected payoff from the initial firm assets and the integrated fund net of the expected debt payments and the expected payoff to the managers:

$$\begin{aligned} e'(D,m,s) &= E_{\hat{f}}\left[\max\left\{0, X(R;D,m,s) + s\,R_S - D\right\}\right] - m\,e_X(D,m,s)\,, \\ \text{with }\; e_X(D,m,s) &= E_{\hat{f}}\left[\max\left\{0, X(R;D,m,s) - D\right\}\right]\,. \end{aligned} \tag{B.5}$$

The value $v_s(D,m,s)$ of the firm with integrated fund is the joint value of d and e':

$$v_s(D,m,s) = E_{\hat{f}}\left[X\right](D,m,s) + s\,E_{\hat{f}}\left[R_S\right] - m\,e_X(D,m,s)\,.$$

The 'net firm value' v, which means v_s net of the value of the financial assets, is:

$$v(D,m,s) = v_s(D,m,s) - s\,E_{\hat{f}}\left[R_S\right] = E_{\hat{f}}\left[X\right](D,m,s) - m\,e_X(D,m,s)\,. \tag{B.6}$$

If the firm buys the financial assets in the same competitive market in which it issues its debt and equity, then **Assumption 7 a** applies again: the price of the financial assets at $t = 0$ equals their expected payoff $E_{\hat{f}}\left[s\,R_S\right]$. The decision problem of the initial firm owner is then

$$\max_{D\in\mathbb{R}^+,m\in[0,1],s\in\mathbb{R}^+}\left(v_s(D,m,s) - E_{\hat{f}}\left[s\,R_S\right]\right) = \max_{D\in\mathbb{R}^+,m\in[0,1],s\in\mathbb{R}^+} v(D,m,s)\,. \tag{B.7}$$

Proposition 9

Consider a firm without integrated fund ($s \equiv 0$) *whose optimal capital structure is* (D_0, m_0). *If this firm can integrate a fund and pays its managers with claims to the initial firm assets, then its optimal capital structure* (D^*, m^*, s^*) *is given by*

$$D^* = D_0\,, \quad m^* = m_0\,, \quad \text{and } s^* \text{ being an abitrary element of } \mathbb{R}^+\,.$$

Consequently, an increase in the size of the integrated fund and a corresponding decrease of the firm leverage has no effect on the optimized net firm value:

$$v(D^*, m^*, s^*) = v(D_0, m_0, 0) \;\forall\; s^* \in \mathbb{R}^+.$$

The proposition follows directly from the fact that v is effectively independent of s, because $X(R; D, m, s)$ is effectively independent of s, when the manager payment remains aligned with the firm assets on which their behavior has an impact. The firm can thus increase its equity to any level without a reduction of its firm value.
To sum up, this section has shown that a key result of the previous sections also holds for the trade-off between agency costs of debt and equity: the integration of a fund allows for a decrease of leverage and insolvency risk without a loss of firm value. In contrast to the cases discussed before, this result does not depend on an appropriate payoff distribution of the financial assets, but on an appropriate payment scheme for the managers. Given the payment scheme discussed here, integrated funds do not increase the firm value, as in the previous sections, but they just maintain the value. Further research, however, might show that more refined payment schemes perhaps allow for an increase.

B.2. Equilibrium

This appendix shows that the results obtained in the chapter also hold on the aggregate level. This means that they hold in an economy with a finite set of firms and real assets, in which there are no externally provided financial assets, but all possible financial claims have to refer directly or indirectly to the payoff from the real assets of the firms. The section demonstrates that there is an equilibrium in which the possibility to integrate funds increases the net firm value of all firms in the economy and decreases the probability of firm insolvencies, simultaneously. This appendix thus generalizes the result obtained for the simple example in Section 4.2. In order to illustrate the effects of integrated funds, I first introduce a benchmark equilibrium with firms that can only invest in their real, productive assets, before I add the possibility of integrated funds.

B.2.1. Equilibrium of the Benchmark Case Without Funds

At $t = 0$, there is a continuum of investors who buy claims to payoffs at $t = 1$. In accordance with the previous sections, I assume that all investors are risk-neutral. The financial market can consequently be characterized by the demand and supply of claims to expected payoffs at $t = 1$. The price for one unit of expected payoff is given by $\frac{1}{1+r}$ with r representing the riskfree interest rate. The demand and supply of claims, measured by the value of the claims at $t = 0$, shall be denoted by $\mathcal{I}^d$ and $\mathcal{I}^s$. Concerning $\mathcal{I}^d$, let us simply assume that the continuum of investors has an aggregate demand for financial claims which is continuous and monotonically increasing in r: $\mathcal{I}^d = \mathcal{I}^d(r)$ with $\frac{d}{dr}\mathcal{I}^d(r) > 0$ and $\mathcal{I}^d(-1) = 0$. These characteristics can be derived from saving-consumption-decisions of households, but the additional structure would not provide any further insights.
Assume that there is a continuum $J = [0, 1]$ of firms and each firm $j \in J$ maximizes

its firm value v_j by choosing a vector of choice variables as described in the previous sections, with the temporary constraint of $s = 0$ (i.e., without integrated fund). The vector is (D_s, D_r) for the trade-off between taxes and debt benefits; it is (D) for the trade-off between liquidation losses and rent extraction; and it is (D, m) for the trade-off between agency costs of debt and equity. The optimally chosen vector of firm j shall be denoted as x_j. The expressions for the firm value at $t = 0$ can be easily generalized to any risk-free interest rates r, because the firm value is simply the sum of the $t = 0$-values of expected payoffs at $t = 1$. Accounting for the dependence of the discounting factor on r, the firm value $v(x_j; r)$ for $r \neq 0$ is given as $v(x_j; r) = \frac{1}{1+r} v(x_j)$ with $v(x_j)$ being the firm value for $r = 0$. Let us assume that the assets of the firms, which have been regarded as simply given in the previous analysis, require an initial investment of 1 at $t = 0$. The initial firm owner only invests in the assets and thus 'creates' the firm, if the investment has a strictly positive value at $t = 0$, which means if $v_j(x_j; r) - 1 > 0$; and it is inactive for $v_j(x_j; r) - 1 < 0$. For $v_j(x_j; r) = 1$, the owner is indifferent between being active or being inactive. The aggregate supply $\mathcal{I}^s(r)$ of expected payoffs by the firms at $t = 0$ is:[4]

$$\mathcal{I}^s(r) = \int_J v_j(x_j; r) \mathbf{1}_{\left\{v_j(x_j;r) \geq 1\right\}} \, dj \, . \tag{B.8}$$

Observation 11

$\mathcal{I}^s(r)$ is continuous and monotonically decreasing in r with $\lim_{r \to \infty} \mathcal{I}^s(r) = 0$.[5]

As mentioned, $v_j(x_j; r)$ depends on r only through the discount factor $\frac{1}{1+r}$, which is continuous and monotonically decreasing in r. With a continuum of firms, these properties of $v_j(x_j; r)$ also apply to $\mathcal{I}^s(r)$.

Observation 12

There is a unique interest rate r^* for which the financial market clears with $\mathcal{I}^d(r^*) = \mathcal{I}^s(r^*)$.

The existence of a unique equilibrium follows directly from the continuity and monotonicity of supply and demand. Having established this benchmark case, the next subsection studies the effect of integrated funds on an aggregate level.

B.2.2. Equilibrium with Integrated Funds

The equilibrium of the benchmark case shall serve as reference point in this section. For that purpose, all parameters of the benchmark equilibrium are denoted by a subscript 0.

[4] To be more precise, the supply function $\mathcal{I}^s(r)$ can be multi-valued, since the firm owners are indifferent about being active or inactive for $v_j(x_j; r) = r$. Consequently, $\mathcal{I}^s(r)$ maps to all values in the interval between $\int_J v_j(x_j; r) \mathbf{1}_{\left\{v_j(x_j;r) > 1\right\}} \, dj$ and $\int_J v_j(x_j; r) \mathbf{1}_{\left\{v_j(x_j;r) \geq 1\right\}} \, dj$.

[5] As mentioned in Footnote 4, $\mathcal{I}^s(r)$ might be multi-valued at some r. It is yet continuous at these points in the sense of multi-valued functions, which means it is upper-hemicontinuous as well as lower-hemicontinuous.

While Section 4.6 addresses the practical problem of creating financial assets with beneficial payoff distributions, let us impose a simplifying assumption here:

Assumption 8
There is a continuum $\mathcal{D} = [0,1]$ of profit-maximizing, risk-neutral dealers with complete information at $t=0$. They purchase debt and equity from the firms and sell derivatives (whose payoffs are conditional on the payoffs of the firms in the market) to firms and investors in perfect competition, while they have no own wealth at $t=0$.

I assume that the cost of writing a simple derivative contract are negligibly small. The structure of the interdependent decision problems is as follows. For given r, the dealers, who anticipate the decision problems of the firms, demand equity and debt from the firms and offer financial assets to them. The firms solve their decision problems as described in the previous sections, including the possibility to integrate a fund by buying assets from the dealers. Given perfect competition, the dealers earn no profits and the prices of the financial assets equal their discounted expected payoffs.
The demand for financial assets by the firms depends on the capital structure theory that describes v_j. If agency costs determine the optimal capital structure and the firm chooses the payment scheme that has been discussed in B.1.2, then a firm is indifferent about the integration of a fund. If the trade-off theories discussed in Section 4.3 or 4.4 apply, then an unconstrained firm will demand a combination of financial assets that add up to a complete hedge of the payoff of its productive assets. Let us focus on this case for the remainder of this section. In order to simplify the discussion, let us impose:

Assumption 9
The payoff R_j of the productive assets of each firm $j \in J$ has a strictly positive and finite lower bound $\underline{R}_j$ as well as a positive and finite upper bound $\overline{R}_j$.

The purpose of the assumption is mainly to ensure that there is a strictly positive minimal payoff in each possible state. If this holds, it is feasible that all firms in the economy integrate the optimal set of financial assets (which amounts to a complete hedge), as we will see in the following. In principle, there are infinitely many ways how the competitive dealers buy claims from firms and offer financial assets to them, which all add up to an optimal set of financial contracts. An optimal set of financial contracts means that it reduces the costs from frictions within the firms to zero, so that no additional financial asset can improve the net firm value any further. For simplicity, I illustrate such optimal sets of contracts by a particular example with two large dealers, denoted as $\mathcal{D}_1$ and $\mathcal{D}_2$, which represent subsets of the competitive dealers.
Consider the case that the dealer $\mathcal{D}_1$ buys the fraction $\frac{\underline{R}_j}{\overline{R}_j}$ of the debt issued by all firms $j \in J^+ := (\frac{1}{2}, 1] \subset J$. This investment yields a nonvanishing payoff in each possible state, which allows to engage in the following operations. Each firm $j \in J^- := [0, \frac{1}{2}] \subset J$

optimally chooses $D_j = \overline{R}_j$ and demands a set of financial assets that yields $\overline{R}_j - R_j$ in each state. This choice reduces the tax payments/rent extraction to zero (since there is no equity payoff), while it also reduces the costs from bankruptcies/liquidations to zero (since the firm always remains solvent owing to $R_j + (\overline{R}_j - R_j) = \overline{R}_j = D_j$). Note that this choice implies a weak increase of the debt level relative to the benchmark case in which $D_j \leq \overline{R}_j$ holds.[6] Because each single firm $j \in J^-$ is infinitesimally small relative to the aggregate payoff that $\mathcal{D}_1$ receives from its fraction of the debt of firms in J^+, it is feasible that $\mathcal{D}_1$ offers the hedge demanded by a single firm $j \in J^-$. Consider that $\mathcal{D}_1$ does not only offer the hedge to this firm, but that it also buys the fraction $1 - \frac{\underline{R}_j}{\overline{R}_j}$ of the debt of this firm (which yields $\overline{R}_j \cdot \left(1 - \frac{\underline{R}_j}{\overline{R}_j}\right) = \overline{R}_j - \underline{R}_j > \overline{R}_j - R_j$ in each state). The two-sided deal (providing $\overline{R}_j - R_j$ and buying the fraction $1 - \frac{\underline{R}_j}{\overline{R}_j}$ of its debt) does not decrease the payoff that the dealer can sell to other agents. Basically, the dealer provides a payoff that 'flows throw the firm' and reduces the frictions therein, before the dealer 'collects' it again, in addition to a fraction of the payoff from the productive assets of that firm.

Since there is no loss of payoff by this two-sided deal, the dealer can offer it to all firms in J^-. And these firms demand it, since it allows for a reduction of their frictions to zero. As a consequence of these two-sided deals with the firms in J^-, the dealer $\mathcal{D}_1$ collects a large part of the payoff from their productive real assets. It can finance the purchase of this part of the payoff by selling claims to investors. Basically, the dealer acts like a investment fund that purchase debt claims from many different firms and, in addition, sells hedges to them. As mentioned, I assume perfect competition between the dealers, so that $\mathcal{D}_1$ earns no profits and the purchased and sold state-contingent payoffs net out in the aggregate. The gains from the reduction of the frictions within the firms accrue to the firm owners and the external investors, as we will see below.

The example is completed by the second set of firms and the second dealer $\mathcal{D}_2$. It holds the share $\frac{\underline{R}_j}{\overline{R}_j}$ of the debt of firms $j \in J^-$, which provides a nonvanishing payoff in each possible state. This allows to engage in two-sided deals with firms in J^+, as they have been described above (i.e., selling a hedge plus purchasing the fraction $1 - \frac{\underline{R}_j}{\overline{R}_j}$ of debt). As a result, all firms in J are completely hedged, choose maximal debt financing, and are able to avoid all costs that are due to the frictions described in the Sections 4.3 and 4.4. In particular, this implies:

Observation 13

Integrated funds allow to reduce the insolvency risk of all firms in the economy to zero, although the real assets remain the same and the debt level rather increases than decreases.

[6]The debt level $D_j = \overline{R}_j$ is highest meaningful debt level of a firm without fund, because $\overline{R}_j$ is the highest possible payoff of the assets, and any $D_j > \overline{R}_j$ is equivalent to choosing $D_j = \overline{R}_j$.

Let us now study the aggregate supply and demand of financial assets that results from these optimal choices of firms and dealers. The aggregate demand and supply, measured in terms of the value of the claims at $t = 0$, shall be denoted as $\mathcal{I}^d$ and $\mathcal{I}^s$, again. The supply of claims by an active firm $j \in J$, which chooses to integrate a fund with size s_j, equals $(v_j + s_j)$. The aggregate supply of financial assets by the dealers shall be denoted as $\mathcal{I}^s_D(r)$. The overall supply of financial assets at $t = 0$ is thus

$$\mathcal{I}^s(r) = \mathcal{I}^s_D(r) + \int_J (v_j(x_j^S\,;\,r) + s_j)\,\mathbf{1}_{\left\{v_j(x_j^S\,;\,r)\geq 1\right\}}\,dj\,, \tag{B.9}$$

where x_j^S denotes the optimally chosen vector of variables in the firm problem that allows for an unconstrained choice of the integrated funds. The demand for financial claims by the investors is the same as in the benchmark case, and shall be denoted as $\mathcal{I}^d_{inv}(r)$ here. In addition, there is the aggregate demand of the dealers, which shall be denoted $\mathcal{I}^d_D(r)$. And each active firm $j \in J$ demands the amount s_j of financial assets. The total demand is therefore

$$\mathcal{I}^d(r) = \mathcal{I}^d_{inv}(r) + \mathcal{I}^d_D(r) + \int_J s_j\,\mathbf{1}_{\left\{v_j(x_j^S\,;\,r)\geq 1\right\}}\,dj\,. \tag{B.10}$$

It is useful to distinguish between the gross supply and demand stated in the Eqs. (B.9) and (B.10) and the net supply and demand, $\mathcal{I}^{s,n}$ and $\mathcal{I}^{d,n}$, in which the claims held between firms and dealers are netted out. The net supply represents the volume of expected payoffs by the productive firm assets, and the net demand represents the volume of financial claims held by external investors. Since the dealers are unable to earn profits in perfect competition, the value of the financial assets that they offer equals the value of the securities that they hold: $\mathcal{I}^d_D(r) = \mathcal{I}^s_D(r)$. Furthermore, the value of the financial assets demanded by the firms is equal to the funding they need to buy them $(s_j = s_j)$. Consequently, the net demand and supply of claims are given as

$$\mathcal{I}^{s,n}(r) := \mathcal{I}^s(r) - \mathcal{I}^d_D(r) - \int_J s_j\,\mathbf{1}_{\left\{v_j(x_j^S\,;\,r)\geq 1\right\}}\,dj \;=\; \int_J v_j(x_j^S\,;\,r)\mathbf{1}_{\left\{v_j(x_j^S\,;\,r)\geq 1\right\}}\,dj \tag{B.11}$$

$$\mathcal{I}^{d,n}(r) := \mathcal{I}^d(r) - \mathcal{I}^s_D(r) - \int_J s_j\,\mathbf{1}_{\left\{v_j(x_j^S\,;\,r)\geq 1\right\}}\,dj \;=\; \mathcal{I}^d_{inv}(r) \tag{B.12}$$

The net firm value is unaffected by integrated funds in case of the trade-off between agency costs, as it has been described in Appendix B.1. But if the trade-offs described in the Sections 4.3 and 4.4 apply, the integration of a fund increases the net firm value v_j of firms that have a strictly positive bankruptcy probability in the benchmark case. By buying the appropriate assets provided by the dealers, these firms can reduce the expected bankruptcy/liquidation costs and can raise their value. Consequently, there can be firms in J which are inactive in the benchmark equilibrium, but which are able to raise their net firm value v_j above 1 owing to the possibility to integrate a fund. If this is true for a non-vanishing mass of firms, the supply $\mathcal{I}^s(r)$ as well as the net supply $\mathcal{I}^{s,n}(r)$ of financial claims increase relative the benchmark case.

Observation 14

The net supply $\mathcal{I}^{s,n}(r)$ is continuous and monotonically decreasing in r, and it is weakly larger than in the benchmark case without integrated funds (described in Eq. (B.8)*):*

$$\mathcal{I}^{s,n}(r) \geq \mathcal{I}_0^s(r) \text{ for all } r > 0\,.$$

Observation 15

There is a unique market-clearing interest rate r^* with $\mathcal{I}^d(r^*) = \mathcal{I}^s(r^*) \wedge \mathcal{I}^{d,n}(r^*) = \mathcal{I}^{s,n}(r^*)$. This rate (which is the expected payoff at $t = 1$ per unit of claim sold to investors at $t = 0$) as well as the aggregate net volume $\mathcal{I}^{s,n}(r^*)$ of claims that firm owners can sell are weakly larger than in the benchmark equilibrium: $r^* \geq r_0$ and $\mathcal{I}^{s,n}(r^*) \geq \mathcal{I}_0^s(r_0)$.

While integrated funds weakly increase the net supply of expected payoffs, the net demand by investors is the same as in the benchmark case. As a consequence, the equilibrium interest rate (which is inversely related to the price) as well as the net supply in equilibrium weakly increase relative to the benchmark case. To sum up, this section has shown that there is an equilibrium in which all firms can simultaneously reduce their bankruptcy risk and increase their firm value owing to integrated funds, although the set of real, productive assets is fixed and although the debt level of the firms do not decrease.

B.3. Generalized Preferences of Investors

In order to analyze the robustness of the results to generalized preferences of investors, let us study the same models as in the Sections 4.3 & 4.4 and in Appendix B.1, but consider an alternative pricing of the debt and equity. Let Σ denote the set of all possible states at $t = 1$, in which the assets yield state-contingent payoffs $R(\sigma)$ and $R_S(\sigma)$. To simplify the discussion, let us assume that $\hat{f}(x,y) := \int_\Sigma \mathbf{1}_{\{R(\sigma)=x\}} \mathbf{1}_{\{R_S(\sigma)=y\}} d\sigma$ is continuous in x and y. Assume furthermore that the equity and debt claims issued by the firms can be held by investors through a series of funds provided in a perfectly competitive financial market without entry or contracting costs. Consequently, these funds earn zero profits and are structured such that the diverse preferences of the investors are satisfied optimally. This implies that the prices of debt and equity claims are given by their decomposition into Arrow-Debreu securities and by the prices $p(\sigma)$ of these securities at $t = 0$, with $0 \leq p(\sigma) < \infty$. See Hellwig (1981) for a more detailed discussion of such decompositions of financial claims into state-contingent securities. The assumption of perfect capital markets does not contradict the purpose of this chapter, which is the analysis of optimal capital structures on the firm level. The chapter critically discusses trade-off theories that deviate from the Modigliani-Miller Theorem because of frictions within firms, not because of frictions within the capital markets.

Let us now study the value of a firm for this generalized pricing of payoffs, and let us start with the **trade-off between taxes, bankruptcy costs and a premium for safe debt**. Since all steps in the derivation of the firm value remain the same, apart from the pricing kernel, the expressions in Eqs. (4.1) and (4.2) simply become

$$\begin{aligned}
&v_s(D_r, D_s, s) = \\
&\quad \lambda D_s + \int_\Sigma \Big(R(\sigma) + s\, R_S(\sigma) - T\big(R(\sigma){+}sR_S(\sigma) - D\big) - b\, \mathbf{1}_{\{R(\sigma)\,+\,s\,R_S(\sigma)<D\}} \Big) p(\sigma)\, d\sigma\,, \\
&v(D_r, D_s, s) = v_s(D_r, D_s, s) - \int_\Sigma s\, R_S(\sigma) p(\sigma)\, d\sigma \\
&\qquad = \lambda D_s + \int_\Sigma \Big(R(\sigma) - T\big(R(\sigma){+}sR_S(\sigma) - D\big) - b\, \mathbf{1}_{\{R(\sigma)\,+\,s\,R_S(\sigma)<D\}} \Big) p(\sigma)\, d\sigma\,.
\end{aligned}$$

with $D = D_r + D_s$. The utility that investors incur from safe debt and the corresponding premium λD_s are not state-contingent, and the premium is thus accounted as separate term. The effect of the integration of a fund is analogous to the risk-neutral case: the fund increases the equity payoffs that are taxed, but it reduces the risk of insolvency and it might increase the level of safe debt that can be issued. The result stated in Proposition 7 thus remains valid, if one accounts for the generalized pricing. This means that the condition stated in Eq. (4.3) becomes

$$\lim_{s\to 0} \int_\Sigma b\, \mathbf{1}_{\{R(\sigma)<D_0\}}\, \mathbf{1}_{\{R(\sigma)+s\,R_S(\sigma)\geq D_0\}}\, p(\sigma)\, d\sigma > \int_\Sigma R_S(\sigma)\, T'\big(R(\sigma) + s\, R_S(\sigma){-}D_0\big)\, p(\sigma)\, d\sigma.$$

And the condition in Eq. (4.4) becomes

$$\begin{aligned}
\lim_{s\to 0} \int_\Sigma b\, \mathbf{1}_{\{R(\sigma)<D_0\}} \mathbf{1}_{\{R(\sigma)+sR_S(\sigma)\geq D_0\}}\, p(\sigma) d\sigma + \lambda\, \min\big(R_S | R{=}\underline{R}\big) \\
> \int_\Sigma R_S(\sigma)\, T'\big(R(\sigma) + sR_S(\sigma){-}D_0\big) p(\sigma) d\sigma\,,
\end{aligned}$$

with $\underline{R}$ being the lower bound for R: $\underline{R} = \min\big(R(\sigma) | \sigma \in \Sigma\big)$. The implications of this result are completely analogous to the case with risk-neutral pricing. The integration of a fund can both, reduce the insolvency risk and increases the firm value. And for each set of firm assets and corresponding optimal capital structure with positive insolvency probability, there exist financial assets with a payoff distribution which fulfills the conditions stated above. This is illustrated by the example of an asset that yields $R_S(\sigma) = \frac{1}{m}$ for all $\sigma \in \Sigma$ with $R(\sigma) = [0, D_0)$ and zero in all other states, where m is a normalization parameter.

The results for the two other specifications of the model can be generalized in the same way. In case of the **trade-off between rent extraction and liquidation losses**, the problem of the firm owner in presence of state-contingent pricing is $\min_{D\in\mathbb{R}^+, s\in\mathbb{R}^+} L(D,s)$, with [7]

$$L(D,s) = \int_\Sigma b_e \left(l\,R + l_S\, sR_S\right) \mathbf{1}_{\{D\le R_l\}}\, p(\sigma)\, d\sigma + \int_\Sigma b_e \left(R + sR_S - D\right) \mathbf{1}_{\{R_l\le D\le R+sR_S\}}\, p(\sigma) d\sigma + \int_\Sigma \left(l\,R + l_S\, sR_S\right) \mathbf{1}_{\{R+sR_S\le D\}}\, p(\sigma)\, d\sigma\,,$$

and all payoffs of the assets are state-contingent: $R = R(\sigma)$, $R_S = R_S(\sigma)$, $R_l = R_l(\sigma)$. Proposition 8 remains valid for generalized preferences, if Eq. (4.5) is replaced by:

$$\lim_{s\to 0} \int_\Sigma l\,R\, \mathbf{1}_{\{R<D_0\}}\, \mathbf{1}_{\{R+s\,R_S\ge D_0\}}\, p(\sigma)\, d\sigma \ge \int b_e\, R_S\, \mathbf{1}_{\{(1-l)R\le D\le R\}}\, p(\sigma) d\sigma + l_S \left(\int R_S\, \mathbf{1}_{\{R\le D\}}\, p(\sigma)\, d\sigma + \int b_e\, R_S\, \mathbf{1}_{\{D\le(1-l)R\}}\, p(\sigma)\, d\sigma \right).$$

Again, for each set of firm assets and corresponding optimal capital structure with positive insolvency risk, there is a possibility to simultaneously decrease the insolvency risk and to increase the firm value by means of an integrated fund.

Finally, in case of a **trade-off between agency costs of debt and equity** (as described in Appendix B.1), the robustness of the results with respect to generalized preferences of the investors is straight-forward. If the firm has chosen an optimal capital structure given its firm-specific assets and has aligned the payment scheme/the incentives of the managers with the firm production, then the integration of a fund has no effect on the behavior of the managers, independent of the pricing of the state-contingent payoffs. If the fund is integrated without an increase of the debt level, the insolvency risk of the firm decreases.

[7] For simplicity, the bargaining game (i.e., the parameter b_e) is assumed to be independent of the state-contingent preferences of the agents.

B.4. Proofs

B.4.1. Proposition 7

The derivative of the net firm value $v(D_r, D_s, s)$ w.r.t. s is

$$\frac{d}{ds}v(D_r, D_s, s) = -\int R_S\, T'(R + s\, R_S - D_r - D_s)\hat{f}(R, R_S)\, dR\, dR_S - b\,\frac{d}{ds}\phi(D_r, D_s, s)$$

With $D = D_r + D_s$, the derivative of the bankruptcy probability is:

$$\begin{aligned}\frac{d}{ds}\phi(D_r, D_s, s) &= \frac{d}{ds}\int_0^D \int_0^{\frac{1}{s}(D-R)} \hat{f}(R, R_S)\, dR\, dR_S \\ &= -\int_0^D \frac{1}{s^2}(D-R)\,\hat{f}\left(R, \frac{1}{s}(D-R)\right) dR = \int_{\frac{1}{s}D}^0 R'\hat{f}(D - sR', R')dR' \\ \lim_{s\to 0}\frac{d}{ds}\phi(D_r, D_s, s) &= -\int_0^\infty R'\hat{f}(D, R')dR' = -f(D)\, E_{\hat{f}}\left[R_S | R = D\right]\end{aligned}$$

Plugging the derivative of ϕ into the derivative of v and evaluating it at $(D_s = D_{s,0}, D_r = D_{r,0}, s = 0)$, one finds that $\frac{d}{ds}v(D_{s,0}, D_{r,0}, s)\big|_{s=0} \geq 0$, if

$$b\; E_{\hat{f}}\left[R_S | R = D_0\right]\; f(D_0) - \int R_S\, T'(R - D_0)\,\hat{f}(R, R_S)\, dR\, dR_S \geq 0\,.$$

While the bankruptcy probability does not depend on the composition of D, safe debt earns a premium λ. Consequently, the firm always chooses the highest possible value for D_s, which is the lowest possible realization of $R + s\, R_S$. The derivative of this value w.r.t. s evaluated at $s = 0$ is $\min\left(R_S | R = \underline{R}\right)$. Accounting for this increase in the level of safe debt and the related premium, one has $\frac{d}{ds}v(D_s(s, D_0), D_r(s, D_0), s)\big|_{s=0} \geq 0$, if

$$b\; E_{\hat{f}}\left[R_S | R = D_0\right]\; f(D_0) + \lambda\, \min\left(R_S | R = \underline{R}\right) - \int R_S\, T'(R - D_0)\,\hat{f}(R, R_S)\, dR\, dR_S \geq 0\,.$$

B.4.2. Proposition 8

Computing the derivative $\frac{d}{ds}v(D, s) = -\frac{d}{ds}L(D, s)$ yields:

$$\begin{aligned}\frac{d}{ds}L(D, s) = &-\int_0^D \frac{D-R}{s^2}\left(l\, R + l_S\,(D-R)\right)\,\hat{f}\left(R, \frac{D-R}{s}\right)\, dR \\ &+\int_0^D\int_0^{\frac{1}{s}(D-R)} l_S\, R_S\,\hat{f}(R, R_S)dR_S dR + \int_0^{\frac{D}{1-l}}\int_{\frac{1}{s}(D-R)}^{\frac{D-(1-l)R}{s(1-l_S)}} b_e\, R_S\,\hat{f}(R, R_S)dR_S dR \\ &+\int_0^\infty\int_{\frac{D-(1-l)R}{s(1-l_S)}}^\infty b_e\, l_S\, R_S\;\hat{f}(R, R_S)\; dR_S dR\end{aligned}$$

Terms that cancel out are not displayed. Applying the same substitution of the integration variable as in the proof of Proposition 7, one can write the derivative $\frac{d}{ds}L$ for $\lim_{s\to 0}$ as

$$
\begin{aligned}
&-\int_0^\infty R'\,l\,D\,\hat{f}(D,R')\,dR' + \int_0^D \int_0^\infty l_S\,R_S\;\hat{f}(R,R_S)\;dR_S dR \\
&\quad + \int_D^{\frac{D}{1-l}} \int_0^\infty b_e\,R_S\;\hat{f}(R,R_S)\;dR_S dR + \int_{\frac{D}{1-l}}^\infty \int_0^\infty b_e\,l_S\,R_S\;\hat{f}(R,R_S)\;dR_S dR \\
&= -l\,D\,E_{\hat{f}}\,[R_S|R{=}D]\cdot f(D) \;+ \int_0^D l_S\,E_{\hat{f}}\,[R_S|R]\cdot f(R)\,dR \\
&\quad + \int_D^{\frac{D}{1-l}} b_e\,E_{\hat{f}}\,[R_S|R]\cdot f(R)\,dR + \int_{\frac{D}{1-l}}^\infty b_e\,l_S\,E_{\hat{f}}\,[R_S|R]\cdot f(R)\,dR
\end{aligned}
$$

The derivative of $v(D,s)$ w.r.t. s is positive at $s = 0$, if this expression is negative. The statement in Proposition 8 is given by comparing the negative first term with the remaining positive terms for both cases.

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