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THE IMPACT OF CENTRALLY CLEARED CREDIT RISK TRANSFER ON BANKS' LENDING DISCIPLINE

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Abstract

This article analyzes the impact of the introduction of centrally cleared credit risk transfer on a loan originating bank's lending discipline in the primary loan market. Under Basel III, a bank can transfer credit risk via central clearing at favorable regulatory conditions. Central clearing, however, reduces the lending discipline because the fact that only standardized contracts can be centrally cleared allows the originating bank to profitably grant and hedge a low quality loan. The impact on the lending discipline crucially depends on the regulatory design of central clearing such as capital requirements, disclosure standards, risk retention, and access to uncleared credit risk transfer. I also show that the lending discipline is an important determinant of the impact of central clearing on system risk.

JEL Classification Codes: G18, G28

Keywords: Credit Risk Transfer, Central Clearing, Lending Discipline, Systemic Risk

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1 Introduction

Credit derivatives are contracts that allow investors to transfer third party credit risk from one counterparty to the other. Over the last decade, they have been intensively used by financial institutions (Norden et al. 2011). In principle, credit derivatives enable banks to manage their credit risk more efficiently. Academics, practitioners, and regulators, however, are concerned that credit risk transfer undermines the resilience of the banking industry for two reasons. First, credit risk transfer may reduce banks' lending discipline, which leads to an excessive exposure to low quality loans (see, e.g., Acharya et al. 2009; Berndt and Gupta 2009; Purnanandam 2011). Second, the Over-the-Counter (OTC) credit risk trading activities of banks can create a channel for counterparty risk contagion (see, e.g., Acharya and Bisin 2014).

In the aftermath of the 2007-2009 financial crisis, there is an intensive debate about how to regulate credit risk transfer to address such systemic risk concerns. Among the most prominent suggestions is the implementation of a centrally cleared market for credit risk. To stimulate central clearing, exposures cleared with central counterparties are planned to receive a preferential capital treatment compared to uncleared OTC positions under Basel III (BIS 2012). Additional questions regarding the regulatory design of the central clearing mechanism are widely discussed. Several important policy questions arise from these regulatory initiatives: What is the impact of the introduction of centrally cleared credit risk transfer on the lending discipline? How should central clearing be regulatively designed with respect to capital requirements, disclosure standards, and market access to mitigate the excessive lending and loan quality problems associated with standardized credit risk transfer? How does central clearing affect systemic risk if the impact on both banks' lending discipline and their hedging behavior is incorporated?

This paper answers these questions by analyzing the impact of the introduction of central clearing of credit risk on a bank's lending discipline in the primary loan market. I model a bank that can screen a loan to learn its type that is either high or low. If the screening cost is not too large, the bank sustains lending discipline by screening a loan applicant, and rejecting a detected low type. Hence, lending discipline decreases the probability that a loan is granted, and increases the expected quality of a granted loan.

Next, I introduce centrally cleared credit risk transfer. The bank has a regulatory incentive to hedge an originated loan via central clearing because centrally hedged credit exposures receive privileged capital treatment. It is, however, not possible to signal loan quality through the standardized contracts that can be centrally cleared. As a consequence, the counterparty of the bank on the credit risk transfer market can not observe the underlying loan's type, which results in the same credit spread for each contract. As this average credit spread is too small for a low loan type, the bank is stimulated to grant and hedge a detected low loan instead of rejecting it. This missing lending discipline leads to excessive lending, and reduces the expected quality of a granted loan compared to the case without credit risk transfer.

I also discuss the historical market infrastructure, in which a bank only has access to an uncleared OTC market. On an uncleared OTC market, the bank can signal loan quality by trading a tailored credit derivative contract. A bank with a detected low type rejects the loan because of the high tailoring cost that needs to be incurred to pretend hedging a high type loan. Hence, if OTC markets are not too opaque, there is lending discipline. The introduction of central clearing in this setting, however, also reduces the lending discipline. The reason is that a loan originating bank with a detected low type anticipates that it can hedge the loan untailored via central clearing at favorable regulatory conditions instead of using the uncleared OTC market. The consequential equilibrium is that the bank grants and hedges any loan, and the credit spread on the centrally cleared market corresponds to the spread for an average loan type.

My results have important policy implications. First, the new Basel III framework comprises preferential capital treatment for credit derivatives cleared with central counterparties. While pursued to increase financial stability, I show that this regulatory framework reduces the lending discipline.

Second, I demonstrate how the centrally cleared market must be regulated to mitigate the lending discipline problem. Stricter regulatory capital requirements, as currently intended under Basel III, can influence the incentive to screen a loan or to use the centrally cleared credit risk transfer market. Because they, however, don't affect the fact that a bank with access to central clearing can profitably grant both loan types, tighter capital requirements do not ameliorate the lending discipline problem. The regulator can only stimulate more prudent bank behavior on the primary loan market by imposing adequate risk retention rules on the centrally cleared market, enforcing disclosure requirements, and restricting the access to the uncleared OTC market.

Finally, I analyze the extent to which the introduction of central clearing into the historical market setting affects the marginal contribution of a loan, that is considered by a bank, to systemic risk. I follow the approach of Huang et al. (2011) to incorporate the size of an exposure, the probability of default, and the correlation of losses with systemic downturns to measure the systemic risk contribution of a loan. The current literature suggests that banks' use of a central counterparty for hedging risk could mitigate contagion (see, e.g., Zawadowski 2013), which likely reduces the component of systemic risk that captures the correlation of losses with systemic downturns. My results, however, imply a crucial trade-off with respect to the impact of central clearing on systemic risk. While the introduction of central clearing may mitigate the systemic risk contribution from banks' hedging activity, it increases the systemic risk contribution from their lending behavior. In particular, the introduction of central clearing reduces the lending discipline, which increases the components of systemic risk that capture the exposure size, and the default probability of a granted loan. I show that this deterioration in the lending discipline is important for systemic risk. With a standard parameter calibration, for example, the marginal contribution of a considered loan to systemic risk increases by more than 50% if the introduction of centrally cleared hedging does not mitigate the correlation of losses with systemic downturns.

My paper is closely related to the recent literature that analyzes the impact of the introduction of central clearing on the banking system. Acharya and Bisin (2014) argue that OTC market participants create a counterparty risk externality by taking excessive risk. Position transparency from central clearing can enable market participants to internalize this counterparty risk externality by conditioning the terms of the contract they trade on the total financial position of the counterparty and not just on bilateral positions. Zawadowski (2013) shows why banks fail to hedge counterparty risk in the OTC market thereby creating a channel for contagion. He argues that with a central counterparty, banks can be forced to contribute ex ante to bailing out counterparties of the failing bank, which eliminates the inefficiency. Duffie and Zhu (2011) and Duffie et al. (forthcoming) argue that introducing a central clearing counterparty decreases or increase the average exposures to counterparty default risk and collateral demand, depending on the fragmentation of the clearing services. It is surprising that even though the idea that credit risk transfer adversely affects banks' lending discipline is empirically well documented (see, e.g., Keys et al. 2010; Purnanandam 2011), current research only discusses the impact of central clearing on banks' hedging activities. To fill this gap, my research complements the literature by analyzing the effect of central clearing on the banks' primary business, namely their lending activity, and by showing that this channel is a crucial component of systemic risk.

I also contribute to the vein of research on information asymmetry problems in the credit risk transfer market. Gorton and Pennacchi (1995) argue that if a bank can implicitly commit to holding a certain fraction of a loan, the moral hazard associated with the loan sales market is mitigated. Similar ideas are applied to credit derivatives. Duffee and Zhou (2001) show how banks hedging high-quality loans can use credit derivatives with a maturity mismatch[1] to shift the risk of early default to outsiders. By retaining the risk of late default, they avoid the lemons problem. Morrison (2005) argues that credit derivatives could adversely affect banks by reducing their incentives to screen and monitor borrowers. Bank loans may then become less valuable because they entail a lower certification effect. Nicolò and Pelizzon (2008) show how OTC credit derivatives are flexibly tailored to signal loan quality. In particular, a credit default basket contract in which the hedging bank pays a penalty when defaults are above a certain level can provide a quality signal. If the bank cannot commit to risk exposure because of market opacity, it may still signal quality with the initial price of the credit default basket contract. What I add to this literature is to show how centrally cleared credit risk hedges need to be structured and regulated to mitigate the information asymmetry problem that

[1]In a maturity mismatch, the maturity of the credit derivative contract does not match the underlying loan contract.

reduces banks' lending discipline.

My analysis is also related to the theoretical literature on the impact of capital regulation on banks' lending behavior. Thakor (1996) explains how capital requirements linked to credit risk result in more loan rationing on the part of banks, which reduces aggregate bank lending. The impact of capital requirements on monitoring is analyzed in Besanko and Kanatas (1996). Banks need to raise more equity from outside shareholders to comply with capital requirements. Faced with dilution, inside shareholders have less incentive to monitor loans, which increases loan losses. Kopecky and VanHoose (2006) agree on the notion that stricter capital requirements do not necessarily increase monitoring. When capital requirements suddenly constrain the banking system, lending declines. At the same time, the equilibrium share of banks that optimally chooses to monitor loans decreases. Hence, the impact of capital requirements on aggregate loan quality is ambiguous. Several recent papers additionally incorporate credit risk transfer. Chiesa (2008) finds that credit risk transfer instruments based on loan portfolios with credit-enhancement guarantees provide monitoring incentives, as long as risk-based capital requirements are properly designed. According to Cerasi and Rochet (2008), optimal capital requirements should be state-dependent to incorporate banks' incentives in the different states of the economy. Finally, Wagner and Marsh (2006) show that improving banks' opportunities for credit risk transfer strengthens financial sector stability because risk is shifted out of the financial sector. Regulatory capital requirements in the banking sector should, therefore, be designed to enhance the allocation of risk across sectors. I contribute to this literature by showing that the impact of regulatory capital requirements on the lending discipline depends on the regulatory design of the centrally cleared credit risk transfer market.

The remainder of the paper is organized as follows: The next section provides a concise overview over the relevant institutional background. Section 3 introduces the structure of the model. Section 4 derives the main results before I discuss their implications for the lending discipline and systemic risk in Section 5. Finally, Section 6 concludes.

2 Institutional background

Reduced lending discipline, excessive risk-taking by financial institutions, and counterparty risk are argued to be among the main reasons for the large systemic risk that caused the recent financial crisis.[2] Academics, practitioners, and regulators currently discuss two main approaches to address these causes of systemic risk: The regulation of OTC derivative markets and stricter capital requirements.

OTC derivative markets are prone to the abuse by participants. Their opaqueness, complexity, and limited transparency ease the extent to which financial institutions are able to take irresponsibly large amounts of risk (Duffie et al. 2010). Moreover, dealers in these markets have been inconsistent in their approach to managing the counterparty credit risks of OTC positions. This complacency can be particularly dicey for those OTC products that are characterized by a lack of liquidity. Market observers, therefore, worry about systemic risk from the OTC market, i.e., that the default of a large financial institution can propagate to its OTC counterparties. One suggested remedy is the central clearing of traded derivative positions. With central clearing, a central counterparty steps into bilateral trades by means of novation, becoming the counterparty to each seller and buyer. Central clearing creates transparency because the data housed in the clearing counterparties can be made available to regulators. The availability of concentrated data may reduce the extent to which financial institutions can build up large undetected risk positions. At the same time, central clearing could mitigate the systemic risk from contagious counterparty risk under certain conditions by insulating counterparties from each other's default (Duffie and Zhu 2011). Central counterparties can be designed and regulated to maintain a robust collateral margining regime[3], clear default management procedures, and significant financial resources that back their performance. Finally, liquidity is established by central clearing of simple, standardized contracts such as credit default swaps.

[2]Counterparty risk elevates the level of systemic risk when the default of a market participant could seriously impair the financial condition of one or more of its counterparties. Systemic risk also arises when the pure fear of such an event leads counterparties to reduce their exposure to a weak market participant, possibly contributing to a run that indeed accelerates the failure of this participant.

[3]When an investor trades a contract, the central counterparty requests a deposit in a margin account of cash or cash-equivalent instruments to ensure that the investor satisfies contract obligations. The maintenance margin is the minimum requirement for the time during which that position remains open.

Due to the potential to reduce systemic risk, regulators prioritize the increased use of central clearing for standardized OTC derivatives. During 2009, a collection of major derivative dealers committed collectively to centrally clear 70 percent of new eligible trades. In July 2010, the United States Congress passed the Dodd-Frank Act. The Dodd-Frank Act focuses on controlling systemic risk to the financial system posed by large depository institutions and financial companies. One of its main pillars is to stipulate that by the end of 2012 all sufficiently standardized OTC derivatives traded by large market players must be cleared with regulated central counterparties. The Dodd-Frank Act also considers a risk retention provision - as suggested in this paper - for Asset Backed Securities. The European Commission (European Market Infrastructure Regulation), and the recent G20 reform of the OTC derivatives market have taken similar steps.

The purpose of the new capital requirements under Basel III, that were first unveiled in 2010, is to strengthen the financial sector. A key pillar is that individual banks should hold more high-quality capital to protect themselves against unexpected losses. The new framework also addresses central clearing of OTC derivatives. Under Basel II, the minimum capital that a financial institution must hold against the risk posed by an OTC derivative position is based on the credit quality rating of its counterparty. With Basel III, exposures to OTC positions cleared with central counterparties receive a preferential capital treatment (BIS 2012).[4] Due to the costs of setting up, analyzing, and pricing each type of derivative daily for the purpose of calculating variation margins, or due to the contingency of a sudden need to unwind positions held with a defaulted clearing member, however, central counterparties will only clear frequently traded, standardized credit derivatives such as credit default swaps (Duffie et al. 2010). Bliss and Steigerwald (2006) conclude that while OTC market products tend to be customized, derivatives cleared through central counterparties need to be highly standardized and liquid. Therefore, the drawback of the new regulation is that it provides a capital incentive for banks to hedge their loan exposure with centrally clearable, standardized contracts that can not be flexibly designed to mitigate information asymmetry.

[4]The Basel Accord requires that a bank's eligible capital exceeds 8 percent of the risk-weighted asset holdings, i.e., of the sum of each asset holding multiplied by its risk weight. For loans hedged OTC, the risk weight of the borrower can be replaced by the risk weight of the counterparty in the hedge. Central counterparties obtain a lower risk weight (minimum of 2%) than an uncleared OTC counterparty.

3 Structure of the model

I conduct my analysis by extending the model setup of Nicolò and Pelizzon (2008) to incorporate a screening cost and central clearing. Consider a risk-neutral bank operating in the loan market. It can grant a loan with nominal one to a borrower that belongs to a certain broad quality range. The loan is either of high specific type with a high probability of loan repayment p_H, or of low specific type with a low repayment probability p_L, with $1 \geq p_H > p_L \geq 0$. The ex-ante probability that a loan is of high type is $\mu \in (0, 1)$.

The bank has access to a screening technology as part of its core operation. At cost C, it can obtain the private information about a loan's specific type. The screening activity itself is not publicly observable. The screening cost $C \in (0, 1)$ per loan in the economy is, ex-ante, standard uniformly distributed. The setting I describe corresponds to the realistic situation in which the broad quality range of a loan such as the rating category is publicly known, but the bank can collect more specific information about loan quality due to its lending relationship to the borrower.

The model considers two dates. At date zero, a loan applicant approaches the bank. The bank observes the screening cost, and eventually screens the applicant before deciding whether to grant the loan. At date one, the loan matures. The nominal of the loan is repaid by the borrower if he does not default. Otherwise, the repayment is assumed to be zero.

The relationship between the specific loan quality and the loan interest rate is opaque because of the information asymmetry between borrowers and banks Stiglitz and Weiss (1981), the competition among banks for borrowers Von Thadden (2004), the bargaining power of the parties, and the market structure Petersen and Rayan (1995). Rather than explicitly modeling this relationship, I simplify the analysis by assuming that any loan type granted in the considered broad quality range pays the same publicly known interest rate i. Hence, it is not possible to infer the loan's specific type from the interest rate. The risk-free interest rate is normalized to zero.

As it finances a loan with deposits, the regulator requires the bank to hold a certain amount of regulatory capital as a buffer to cover losses. Under Basel III, the minimum capital requirements for counterparty credit risk are based on estimates of the probability of default, the loss given default, the exposure at default, and the maturity. The regulatory practice is to require banks to calibrate these parameters from broad quality ranges such as rating categories, and to assign the identical parameter values to each loan type in the same rating category (BIS 2011). To reflect this practice, I determine identical regulatory capital requirements of λ for each granted loan type in the considered quality range. This capital is invested in a short term asset that can not be used to finance the loan. Following Nicolò and Pelizzon (2008), the unitary costs of capital, δ, are assumed to be greater than the costs of deposits that are normalized to zero.[5] I interpret δ as the required expected return on equity, i.e., as the return that needs to be paid to the bank owners inducing them to provide the equity capital. The regulatory capital costs per granted loan then correspond to $\lambda\delta$.

At time zero, the bank can also transfer the default risk of a granted loan to an investor on a centrally cleared credit risk transfer market, or on the uncleared OTC market. I assume that credit risk is liquidly traded by numerous market participants on both markets as soon as the corresponding loan is granted. The markets are assumed to be competitive, which implies that the credit spread corresponds to the default loss of the underlying loan expected by the investor. The investor does neither know the motive for a trade, nor the total risk position of the counterparty.[6] The investor, however, knows how the ex-ante cost of the bank to screen a loan is distributed, that a loan is in the considered broad quality range, and that it is either of high or of low type.

The regulatory capital requirements for one unit of a centrally hedged loan are given by m, and by γ for an OTC hedged loan. The regulator reduces the capital charge for hedged loans, but aspires a capital incentive for central clearing (see, e.g., BIS 2012). Hence, I assume that $\lambda > \gamma > m$. I also need to define the regulatory capital requirements, ϵ, for one unit of unhedged credit risk incurred by the bank on the credit risk transfer market. "Unhedged" means that the credit derivative position is not covered by the underlying loan.

[5]Froot and Stein (1998), and Gorton and Winton (2000) discuss why δ might be greater than the costs of deposits.

[6]The investor can not infer the underlying loan's type from the fact that the bank only hedges a fraction because the bank could anonymously hedge different fractions with various counterparties.

The impact of the lending discipline in the primary loan market on the economy is captured with two measures: The probability p_G that a loan is granted, and the expected quality p_Q of a granted loan expressed as the expected probability of loan repayment. Throughout the analysis, I assume that $1 - p_\mu + \delta\lambda < i < 1 - p_L + \delta m < 1 - \delta(\lambda - m)$, in which $p_\mu = \mu p_H + (1-\mu)p_L$ is the ex-ante expected repayment probability of a loan. This assumption implies that a high type loan is worthwhile to grant, but a low type is not. In the First Best, i.e., if loan quality is publicly known, $p_G^{FB} = \mu$ and $p_Q^{FB} = p_H$ because only a high loan type is granted.

4 Results

I start by investigating the lending discipline in a market infrastructure without credit risk transfer. To illustrate the basic mechanism step by step, I first introduce centrally cleared credit risk transfer before I analyze the lending discipline in a market infrastructure with bank access to both centrally cleared and uncleared OTC credit risk transfer.

4.1 Lending discipline without credit risk transfer

This section analyzes a bank's lending discipline on the primary loan market if it has no access to the credit risk transfer market.

The bank selects a lending strategy by maximizing expected profits. The non-screening strategy consists of just granting a loan without screening, which yields an expected profit of

$$\Pi_{NS} = i - (1 - p_\mu) - \delta\lambda > 0. \tag{1}$$

The bank earns interest i, and bears regulatory costs of $\delta\lambda$. The expected default costs on the granted loan correspond to $1 - p_\mu$. Note that the low type loan is cross-subsidized by the high type as the interest rate does not compensate the total costs of a low loan, i.e., $i < 1 - p_L + \delta\lambda$ as $i < 1 - p_L + \delta m$, and $\lambda > m$. As any loan is granted, $p_G = 1 > \mu = p_G^{FB}$, and $p_Q = p_\mu < p_H = p_Q^{FB}$. Hence, the non-screening strategy entails excessive lending, and a low expected quality of a granted loan compared to the First Best.

Instead of following the non-screening strategy, the bank can screen the loan at cost C, which fully reveals its specific quality. Once the loan type is known, it grants a high loan because $i > 1 - p_H + \delta\lambda$, and rejects a low loan as $i < 1 - p_L + \delta\lambda$. By rejecting the low loan, the bank avoids cross-subsidization. The expected profit of this screening strategy for a given loan applicant is given by

$$\Pi_S = \mu(i - (1 - p_H) - \delta\lambda) + (1 - \mu)0 - C. \tag{2}$$

A bank screens if the expected profit in Equation (2) is greater or equal to the expected profit of the non-screening strategy in Equation (1). Replacing p_μ by $\mu p_H + (1 - \mu)p_L$, and rearranging yields the following screening condition:

$$(1 - p_L - i + \delta\lambda)(1 - \mu) \geq C. \tag{3}$$

The bank screens a new loan applicant and rejects a low type if C is smaller or equal to the left hand side of Inequality (3). In this case, the expected profit from avoiding cross-subsidization by screening is larger than the screening cost. As the screening cost is standard uniformly distributed, the probability that a bank screens and only grants a high type is given by $p_S = \frac{(1-p_L-i+\delta\lambda)(1-\mu)}{1}$. With probability $1 - p_S$, it does not screen and grants both loan types. Figure 1 depicts the lending decisions of the bank. The corresponding p_G and p_Q are derived in Proposition 1.

INSERT FIGURE 1 NEAR HERE

Proposition 1. *The probability that a loan is granted is given by*

$$1 > p_G = p_S\mu + (1 - p_S) > \mu. \tag{4}$$

The expected quality of a granted loan corresponds to

$$p_H > p_Q = Qp_H + (1 - Q)p_L > p_\mu, \tag{5}$$

where

$$Q = \frac{\mu}{p_G}. \tag{6}$$

Proof. See the Appendix. □

As $p_G > \mu = p_G^{FB}$ and $p_Q < p_H = p_Q^{FB}$, there still is excessive lending and a loan quality problem compared to the First Best. However, lending discipline, i.e., the fact that with probability p_S the bank screens and rejects a detected low loan type, induces $p_G < 1$ and $p_Q > p_\mu$. Hence, the excessive lending and loan quality problems are ameliorated by the fact that a loan may be screened.

I also analyze the impact of stricter regulatory capital requirements, λ, on the results in Proposition 1. If a bank follows the screening strategy, it only grants a loan and, hence, incurs regulatory costs in case the loan is of high type. With the non-screening strategy, the bank bears regulatory costs for both types as the loan is granted anyway. Because larger regulatory capital costs render the non-screening strategy relatively less attractive compared to the screening-strategy, the screening condition in Inequality (3) is relaxed. As a result, the probability that a bank screens, p_S, increases, which makes it more likely that a low loan type is detected and rejected. Hence, tighter regulatory capital requirements stimulate the lending discipline. A stricter lending discipline decreases the probability that a loan is granted, and increases the expected quality of an accepted loan, i.e.,

$$\frac{\partial p_G}{\partial \lambda} = -(1 - \mu)^2 \delta < 0, \tag{7}$$

and

$$\frac{\partial p_Q}{\partial \lambda} = \frac{\mu(1 - \mu)^2 \delta}{\big(1 - p_S(1 - \mu)\big)^2}(p_H - p_L) > 0. \tag{8}$$

4.2 Lending discipline with centrally cleared credit risk transfer

I now introduce unrestricted credit risk transfer via credit default swap (CDS) on a centrally cleared market. In a CDS, the bank pays a certain credit spread (via central counterparty) to the protection seller (investor). In case of default, the latter compensates the loss of the reference loan's nominal to the bank through the central counterparty. The attribute "unrestricted" means that the loan originating bank faces no restrictions regarding its access to the centrally cleared credit risk transfer market, and no disclosure requirements concerning its hedging activity.

The expected profit from granting a loan and transferring the corresponding credit risk through an unrestricted centrally cleared market without screening is given by

$$\Pi^U_{NS} = i - (1 - p^U_Q) - \delta m. \tag{9}$$

The superscript "U" indicates that the loan originating bank only has access to an unrestricted centrally cleared credit risk transfer market. The term δm captures the regulatory costs of a granted loan that is hedged via central clearing. Any granted loan's credit risk is traded by market participants on the centrally cleared market. Hence, the credit spread corresponds to $1 - p^U_Q$, in which p^U_Q is the expected loan repayment probability in the equilibrium. If $\Pi^U_{NS} \geq 0$, the bank grants the loan.

Next, I analyze the screening strategy. Because only standardized contracts are tradable with the central counterparty, the loan originating bank can not signal loan quality on a centrally cleared market by offering a customized contract. Suppose the bank has detected a low loan type. Because the protection seller can not distinguish loan quality, the fair credit spread to insure this loan corresponds to $(1 - p^U_Q)$. If $i - (1 - p^U_Q) - \delta m > 0$, the bank grants the loan. Next, assume the bank has detected a high loan type. It can accept this loan and transfer the corresponding credit risk, which yields an expected profit of $i - (1 - p^U_Q) - \delta m$. The credit spread $(1 - p^U_Q)$ may be larger than the true expected loss of $(1 - p_H)$ because the bank has no mean to signal the high quality of the loan. The bank can alternatively grant the high loan and keep the associated credit risk on its own balance sheet, which yields an expected profit of $i - (1 - p_H) - \delta\lambda > 0$. If the difference between the credit spread and the true expected loss is larger than the capital costs saved by transferring the credit risk, i.e., if $p_H - p_Q^U \geq \delta(\lambda - m)$, the bank prefers to keep the credit risk of a high loan on its own book. The expected profit of the screening strategy for a given loan, Π_S^U, corresponds to

$$\begin{array}{ll} \mu(i - (1 - p_H) - \delta\lambda) + (1 - \mu)(i - (1 - p_Q^U) - \delta m) - C & if \quad p_H - p_Q^U \geq \delta(\lambda - m), \\ i - (1 - p_Q^U) - \delta m - C & if \quad p_H - p_Q^U < \delta(\lambda - m). \end{array} \tag{10}$$

The first term in the first line of Expression (10) is the expected profit from granting and maintaining the credit risk of an accepted high loan on the balance sheet times the probability of detecting a high loan. The second term corresponds to the expected profit from granting and transferring the credit risk of a low loan times the probability of finding a low loan type. Hence, the first line is the bank's expected profit of the screening strategy if it is optimal to keep a high loan's credit risk on the own book. The second line of Expression (10) corresponds to the expected profit of the screening strategy if it is optimal for the bank to transfer the credit risk of both loan types.

The unique equilibrium satisfying the Intuitive Criterion of Cho and Kreps (1987) associated with these strategies is the pooling equilibrium in which the bank always accepts a loan. The beliefs affiliated with this equilibrium are that a loan is always granted, inducing a credit spread of $(1 - p_Q^U) = (1 - p_\mu)$ on the credit risk transfer market. Given this credit spread, the bank makes a profit from granting the loan within each strategy.

To derive the condition under which screening is optimal, I compare Π_S^U to Π_{NS}^U. Obviously, it is never optimal to screen a loan if $p_H - p_Q^U < \delta(\lambda - m)$ because $C > 0$. Comparing the first line of Expression (10) to Π_{NS}^U in Equation (9) yields the bank's condition for screening:

$$C \leq \mu(p_H - p_\mu - \delta(\lambda - m)). \tag{11}$$

The right hand side of Inequality (11) is the expected profit from screening. It corresponds to the probability of detecting a high loan, times the bank's expected gain from bearing a granted high loan's credit risk on its own book instead of transferring it on the market. This gain is the difference between the credit spread $(1 - p_\mu)$ on the market and the expected default costs $(1 - p_H)$, minus the additional capital costs $\delta(\lambda - m)$ incurred when keeping a granted loan's risk on the own balance sheet. From Inequality (11), the probability that a bank screens is simply given by $p_S^U = \frac{\mu(p_H - p_\mu - \delta(\lambda - m))}{1}$.

INSERT FIGURE 2 NEAR HERE

Figure 2 depicts the lending and hedging decisions of the bank. It shows that the motivation for a bank to screen a loan is to avoid the overpriced credit spread for a detected high loan on the credit risk transfer market, and not to reject a low loan as in Figure 1 of Section 4.1. As any loan is granted in the equilibrium, the introduction of a centrally cleared market for credit risk jeopardizes lending discipline. The probability that a loan is accepted increases from p_G to $p_G^U = 1$, and the expected quality of a granted loan decreases from p_Q to $p_Q^U = p_\mu$ compared to the case without credit risk transfer in Proposition 1.

The capital requirements for retained or hedged credit risk determine the bank's expected benefit from keeping a detected high loan's risk on the own balance sheet, and, hence, the probability p_S^U that it screens a loan. The presented analysis, however, shows that tighter regulatory capital requirements, as currently discussed under Basel III, do not induce a stricter lending discipline on the primary loan market. The reason is that, independent of the size of the regulatory capital costs, any loan type is granted if the bank has access to a centrally cleared credit risk transfer market.

4.3 Lending discipline with restricted centrally cleared credit risk transfer

This section demonstrates that it is crucial to regulate central clearing to mitigate the lending discipline problem caused by unrestricted credit risk transfer.

Suppose a bank must keep at least a fraction θ^R if it transfers the credit risk of a loan it originates, and disclose its hedging activity. The superscript "R" indicates that the bank only has access to such a restricted centrally cleared credit risk market. The idea of the retention provision is to discipline the lending behavior by requiring a bank to maintain stakes in the credit exposure it originates. The fraction θ^{R*} that maximizes the expected bank profit and simultaneously maintains a separating equilibrium in which a bank screens and rejects a detected low type loan is obtained by solving the following program:

$$\max_{\theta^R} \quad i - \theta^R(1-p_H) - (1-\theta^R)(1-p_B^R) - (1-\theta^R)m\delta - \theta^R\delta\lambda \tag{12}$$

s.t.

$$\begin{aligned}&\mu\left(i - \theta^R(1-p_H) - (1-\theta^R)(1-p_B^R) - (1-\theta^R)m\delta - \theta^R\delta\lambda\right) - C \geq \\ &i - \mu\theta^R(1-p_H) - (1-\mu)\theta^R(1-p_L) - (1-\theta^R)(1-p_B^R) - (1-\theta^R)m\delta - \theta^R\delta\lambda\end{aligned} \tag{13}$$

Expression (12) is the expected profit of a bank granting a high loan that maintains a fraction θ^R of the corresponding credit risk on its own book, and hedges the fraction $1-\theta^R$ on the centrally cleared credit risk market. The per unit credit spread $1-p_B^R$ to be paid for the hedge on the restricted market depends on the participants' beliefs about the underlying loan quality. Inequality (13) is the incentive compatibility constraint. The first line reflects the expected profit of a bank that screens the loan at cost C, grants a high loan and retains the fraction θ^R of the corresponding credit risk, and rejects a low loan. The second line is the expected profit of a mimicking bank that just grants any loan type without screening. It also retains the fraction θ^R to pretend having detected a high loan.

The Program (12) to (13) is valid for $\theta^R \leq 1$. For $\theta^R > 1$, it can be derived analogously. The following proposition shows the smallest fraction θ^{R*} such that the screening strategy still dominates the mimicking strategy.

Proposition 2. *The optimal mandatory fraction of credit risk to be retained by the loan originating bank is given by*

$$\theta^{R*} = \begin{cases} \frac{i-(1-p_H)-m\delta+C/(1-\mu)}{p_H-p_L+\delta(\lambda-m)} & if \quad \theta^{R*} \leq 1, \\ \frac{i-(1-p_H)+\delta(\epsilon-\lambda)+C/(1-\mu)}{p_H-p_L+\delta\epsilon} & if \quad \theta^{R*} > 1. \end{cases} \tag{14}$$

This fraction induces a separating equilibrium in which a bank with a detected high loan grants and partially hedges the loan, and rejects a detected low loan type. The market participants' *beliefs are such that if a loan is granted and partially hedged it is of high type with probability one.*

Proof. See the Appendix. □

The fraction θ^{R*} is optimal because it maximizes the expected profit of a bank with a detected high loan, while still maintaining the separating equilibrium. Maximizing this expected profit simultaneously maximizes the attractiveness of the screening strategy, and, hence, the screening incentives.[7]

As market participants know that a fractionally hedged loan is of high type, a protection seller demands a per unit credit spread of $(1-p_B^R) = (1-p_H)$ to insure the associated credit risk on the centrally cleared transfer market. Hence, using Expression (12), the expected profit of the screening strategy for a given loan with optimal risk retention can be expressed as

$$\Pi_S^R = \begin{cases} \mu(i-(1-p_H)-(1-\theta^{R*})m\delta-\theta^{R*}\delta\lambda)-C & if \quad \theta^{R*}\leq 1, \\ \mu(i-(1-p_H)-\lambda\delta-\epsilon\delta(\theta^{R*}-1))-C & if \quad \theta^{R*}>1. \end{cases} \tag{15}$$

The alternative strategy is to just grant the loan without screening and to keep the entire credit risk on the own book.[8] Section 4.1 shows that this non-screening strategy has an expected profit of

$$\Pi_{NS}^R = i-(1-p_\mu)-\delta\lambda. \tag{16}$$

Comparing Π_S^R in (15) to Π_{NS}^R in (16) yields the condition for screening:

$$\begin{array}{ll} (1-p_L-i+\delta\lambda)(1-\mu)+\mu(1-\theta^{R*})\delta(\lambda-m)\geq C & if \quad \theta^{R*}\leq 1 \\ (1-p_L-i+\delta\lambda)(1-\mu)-\mu\epsilon\delta(\theta^{R*}-1)\geq C & if \quad \theta^{R*}>1 \end{array} \tag{17}$$

From Condition (17), one can directly derive the following proposition.

Proposition 3. *If there are regulatory capital requirements $\epsilon > 0$ for unhedged centrally cleared credit risk exposures, the probability p_S^R that a bank screens a loan, the probability p_G^R*

[7] It is assumed that the regulator can observe the screening cost C to determine the optimal retention rule.

[8] The strategy in which the bank screens, keeps the entire credit risk of a high loan on its own book, and rejects a low loan type yields an expected profit of $\mu(i-(1-p_H)-\delta\lambda)-C$. As this expected profit is always smaller than the one in the first line of Expression (15) for $\lambda > m$, the strategy can not be optimal for $\theta^{R*}\leq 1$.

that a loan is granted, and the expected quality p_Q^R of a granted loan with restricted centrally cleared credit risk transfer are identical to the case without credit risk transfer.

Proof. See the Appendix. □

The intuition for this result is as follows: Retaining risk is more costly for a mimicking bank than for a bank that has screened because the former must retain unscreened credit exposure on its own book. The larger the screening cost, the higher the θ^{R*} necessary to prevent a bank from mimicking. The case without credit risk transfer, i.e., with $\theta^{R*} = 1$, shows that screening is profitable if $C \leq (1-p_L-i+\delta\lambda)(1-\mu)$. Hence, a screening cost above this level requires a retention $\theta^{R*} > 1$ to prevent mimicking. Any $\theta^{R*} > 1$, however, imposes additional regulatory capital costs $\epsilon\delta(\theta^{R*} - 1) > 0$ due to the unhedged fraction $\theta^{R*} - 1$. These additional regulatory costs always render the screening strategy less attractive than the non-screening strategy. Hence, as in the case without credit risk transfer, screening is not the optimal strategy if $C > (1 - p_L - i + \delta\lambda)(1 - \mu)$, which induces $p_S^R = p_S$, $p_G^R = p_G$, and $p_Q^R = p_Q$.

INSERT FIGURE 3 NEAR HERE

Figure 3 shows that lending discipline is established because, as in Figure 1, a bank optimally rejects a low loan type along the path "screen and detect a low loan" with restricted central clearing. It also illustrates why tighter regulatory capital requirements induce a stricter lending discipline. As $\frac{\partial p_S^R}{\partial \lambda} = \delta(1 - \mu) > 0$, the probability that a low loan is detected and rejected increases with λ. The marginal effects of regulatory capital requirements on the probability p_G^R that a loan is granted, and on the expected quality p_Q^R of a granted loan are identical to the case without credit risk transfer (see Expressions (7) and (8)).

If an originating bank's hedging activity is not disclosed, market participants do not know whether an outstanding loan corresponds to a bank that has detected and fractionally hedged a high loan, or to a bank that has granted an unscreened loan without hedging. Without this information, a protection seller demands a unitary credit spread of $(1 - p_B) = (1 - p_Q^{R,ND})$ to insure a granted loan's credit risk on the centrally cleared transfer market. The superscript

"R,ND" indicates that the bank only has access to a centrally cleared credit risk transfer market in which it has to retain a certain fraction $\theta^{R,ND}$, but the hedging activity is not disclosed. The probability $p_Q^{R,ND} = Q^{R,ND} p_H + (1 - Q^{R,ND}) p_L$ is the protection seller's expected probability of repayment of a granted loan in this "non disclosure" case. Analogously to the proof of Proposition 2, it can be shown that the smallest fraction to be retained to avoid the mimicking strategy is given by

$$\theta^{R,ND*} = \begin{cases} \frac{i-(1-p_Q^{R,ND})-m\delta+C/(1-\mu)}{p_Q^{R,ND}-p_L+\delta(\lambda-m)} & if \quad \theta^{R,ND*} \leq 1, \\ \frac{i-(1-p_Q^{R,ND})+\delta(\epsilon-\lambda)+C/(1-\mu)}{p_Q^{ND}-p_L+\delta\epsilon} & if \quad \theta^{R,ND*} > 1. \end{cases} \tag{18}$$

By comparing the expected profit of the corresponding screening strategy to the one of the non-screening strategy, I derive the results in the following proposition.

Proposition 4. *Without disclosure of the hedging activity of the loan originating bank, the probability $p_S^{R,ND}$ that a bank screens a loan, the probability $p_G^{R,ND}$ that a loan is granted, and the expected quality $p_Q^{R,ND}$ of a granted loan are identical to the case with public information if $\epsilon \geq \frac{(p_H-p_L)(1-\hat{Q^{R,ND}})}{\delta}$, with $\hat{Q^{R,ND}} = \frac{\mu}{1-p_S^{R,ND}(1-\mu)}$, and $p_S^{R,ND} = (1-p_L-i+\delta\lambda)(1-\mu)$.*

Proof. See the Appendix. □

Proposition 4 shows that the signal about the hedging activity of a loan originating bank is not necessary to induce the same lending discipline as in the case without credit risk transfer. The intuition is that without disclosure, the hedging costs of a bank with a detected high loan on the centrally cleared credit risk transfer market increase from $(1-p_H)$ to $(1-p_Q^{R,ND})$. At the same time, however, this increase in hedging costs renders mimicking less attractive, which admits a lower $\theta^{R,ND*}$. A lower $\theta^{R,ND*}$ induces a larger expected profit of a bank with a high loan. The two effects cancel out such that the advantage from detecting a high loan, and, hence, the screening incentives, remain unchanged. What drives the lending discipline is not the signal, but the fact that a bank prefers to maintain stakes in a high loan type than in a loan of which it does not know the quality. This driver is not affected by public disclosure of the hedging activity.

Note that without disclosure, risk retention only admits an equilibrium if the regulatory requirements for unhedged credit exposures, ϵ, are larger or equal to $\frac{(p_H - p_L)(1 - Q^{\widehat{R,ND}})}{\delta}$. The reason is that the bank has insider information that market participants do not have, namely whether it maintains credit risk or not. A bank with a detected high loan, consequently, knows that the fair credit spread corresponds to $(1 - p_H)$, while an investor assigns a credit spread $(1 - p_Q^{R,ND})$ to any granted loan. If ϵ is too low, the bank can attain an infinite expected profit by selling an infinite amount of credit exposure, which prevents any equilibrium.

4.4 Lending discipline with cleared and uncleared credit risk transfer

The literature describes a number of ways in which a bank can signal loan quality on the uncleared OTC market (see, e.g., Duffee and Zhou 2001; Nicolò and Pelizzon 2008). The basic idea is that banks tailor a credit derivative structure to signal the underlying loan's quality to the counterparty. To capture this approach in a simple general framework, I assume that tailoring a credit derivative to signal a loan quality that is higher than the true quality causes cost $\Omega(.,.)$, in which the first argument is the pretended and the second the true quality.[9] I describe the case in which $\Omega(.,L) > i - (1 - p_H) - \delta m$, and $\Omega(H,\mu) > p_H - p\mu$.

I start by analyzing the historical market infrastructure, in which a bank only has access to an uncleared OTC market to hedge a loan. The originating bank's expected profit of the optimal screening strategy for a given loan applicant is given by

$$\Pi_S^O = \mu(i - (1 - p_H) - \delta\gamma) + (1 - \mu)0 - C. \tag{19}$$

The superscript "O" indicates that the bank only has access to an uncleared OTC market. The first term in Equation (19) is the bank's profit of granting the loan, tailoring the credit derivative contract, and hedging the loan at a premium $(1 - p_H)$ on the uncleared OTC market. The second term shows that a detected low loan type is rejected because tailoring the contract to pretend hedging a higher type loan is too costly, i.e., $i - (1 - p_H) - \delta\gamma - \Omega(H,L) < 0$ and $i - (1 - p_\mu) - \delta\gamma - \Omega(\mu,L) < 0$. The optimal non-screening strategy consists of just

[9] An example for this cost is the penalty of credit default basket contracts described in Nicolò and Pelizzon (2008) for defaults above a certain level. The penalty entails a higher expected cost for low quality loans.

granting the loan, and hedging it on the uncleared OTC market with a tailored contract. Comparing Π_S^O of Equation (19) to the expected profit of the optimal non-screening strategy, $\Pi_{NS}^O = i - (1 - p_\mu) - \delta\gamma > 0$, yields the screening condition

$$(1 - p_L - i + \delta\gamma)(1 - \mu) \geq C. \tag{20}$$

Hence, the probability that a bank with access to an uncleared OTC market screens a loan is given by $p_S^O = \frac{(1-p_L-i+\delta\gamma)(1-\mu)}{1}$, which leads to Proposition 5.

Proposition 5. *If a bank has only access to an uncleared OTC market, there is lending discipline. The probability p_G^O that a loan is granted is larger, and the expected quality p_Q^O of a granted loan is lower than in the case without credit risk transfer.*

Proof. See the Appendix. □

Lending discipline with access to the uncleared OTC market maintains because the tailoring cost is too large for a bank with a detected low type to profitably grant, tailor, and hedge the loan. Not tailoring the contract induces a credit spread of $(1 - p_L)$ on the uncleared OTC market as the protection seller anticipates that the underlying loan of such a credit derivative is of low type with probability one. Therefore, a bank with a detected low type prefers to reject the loan. The incentive to screen a loan arises because a bank anticipates that it can tailor a credit derivative on a detected high loan type to pay a low credit spread on the uncleared OTC market. The lending discipline, however, is lower than in the case without credit risk transfer in Section 4.1. As the bank bears regulatory capital costs for both loan types with the non-screening strategy, but only for a high loan type with the screening strategy, lower regulatory capital costs tend to increase the relative attractiveness of the non-screening strategy. Hence, because $\gamma < \lambda$ the uncleared OTC market access reduces a bank's incentive to screen a loan. An implication of this result is that the regulator can increase lending discipline by raising the regulatory capital requirement for uncleared OTC hedges.

Next, I introduce unrestricted central clearing into the setting with an uncleared OTC market. On the centrally cleared market, contracts can not be tailored. Hence, the bank must pay the same credit spread for each loan type hedged via central clearing. The equilibrium satisfying the Intuitive Criterion of Cho and Kreps (1987) associated with this setting can be described as follows: A bank with a detected low type anticipates that it can hedge the loan (untailored) on the centrally cleared market. Market participants realize that any loan type is granted, which induces a credit spread $(1 - p_\mu)$ on the centrally cleared market. This spread makes it worthwhile to grant and centrally hedge a low loan type. A bank with a detected high type grants the loan, and decides between hedging on the uncleared or the cleared market. A bank that does not screen optimally goes to the centrally cleared market.

The expected profit of the optimal screening strategy in this equilibrium, $\Pi_S^{U,O}$, corresponds to

$$\begin{array}{lll} \mu(i-(1-p_H)-\delta\gamma)+(1-\mu)(i-(1-p_\mu)-\delta m)-C & if & p_H-p_\mu \geq \delta(\gamma-m) \\ i-(1-p_\mu)-\delta m-C & if & p_H-p_\mu < \delta(\gamma-m). \end{array} \tag{21}$$

The superscript "U,O" indicates that the bank has access to both an unrestricted centrally cleared credit risk transfer market and an uncleared OTC market. In the first line of Expression (21), a bank with a detected high loan type prefers to hedge on the uncleared OTC market on which it pays a spread $(1 - p_H)$ for the tailored contract. A bank with a low type hedges the granted loan exposure on the centrally cleared market at a spread $(1 - p_\mu)$. In the second line of Expression (21), it is optimal to hedge both loan types on the centrally cleared market. The expected profit of the optimal non-screening strategy in the equilibrium corresponds to $\Pi_{NS}^{U,O} = i - (1 - p_\mu) - \delta m$. Comparing $\Pi_S^{U,O}$ to $\Pi_{NS}^{U,O}$ shows that the bank screens if

$$C \leq \mu(p_H - p_\mu - \delta(\gamma - m)). \tag{22}$$

Inequality (22) shows that a bank may decide to screen a loan to profit from the lower credit spread of a tailored contract on the uncleared OTC market for a detected high type. The fact that any loan is granted in the equilibrium, however, induces that $p_G^{U,O} = 1$, and $p_Q^{U,O} = p_\mu$. Hence, with access to both an uncleared OTC market and centrally cleared credit risk transfer, there is no lending discipline. The possibility to trade untailored credit derivative contracts via central clearing without thereby revealing the loan type deteriorates the lending discipline compared to the case with only OTC hedging.

Finally, I analyze whether introducing restricted centrally cleared credit risk transfer into a market with uncleared OTC trading also hampers the lending discipline. "Restricted" means that a bank must keep at least a fraction $\theta^{R,O}$ of the originated credit risk it transfers on the centrally cleared market, and disclose its centrally cleared hedging activity. The superscript "R,O" indicates that the bank has access to both a restricted centrally cleared credit risk transfer market and an uncleared OTC market. The separating equilibrium satisfying the Intuitive Criterion of Cho and Kreps (1987) associated with this setting can be described as follows: A bank with a detected low type rejects the loan. The reason is that granting, tailoring, and hedging the loan on the uncleared OTC market yields a profit below zero due to the large tailoring cost. Additionally, the fraction $\theta^{R,O*}$ is chosen such that it is not profitable to grant and hedge a low type loan on the centrally cleared market. Compared to the case without an uncleared OTC market in Section 4.3, an additional condition must be satisfied such that a bank does not grant a low loan: The expected profit of the strategy of granting a low loan, hedging it on the centrally cleared market by retaining the required fraction $\theta^{R,O*}$, and silently hedging this fraction on the uncleared OTC market by tailoring the credit derivative contract must be smaller than zero. $\theta^{R,O*}$ also needs to ensure that a bank optimally screens a loan if it participates in the centrally cleared market, given that $\theta^{R,O*}$ can be silently hedged on the uncleared OTC market. A bank with a detected high type loan fractionally hedges on the centrally cleared market, and transfers the remaining fraction $\theta^{R,O*}$ on the uncleared OTC market. The expected profit of the optimal screening strategy can be expressed as

$$\Pi_S^{R,O} = \begin{cases} \mu(i-(1-p_H)-(1-\theta^{R,O*})\delta m-\theta^{R,O*}\delta\gamma)-C & if \quad \theta^{R,O*} \leq 1, \\ \mu(i-(1-p_H)-\delta\gamma-\epsilon\delta(\theta^{R,O*}-1))-C & if \quad \theta^{R,O*} > 1. \end{cases} \tag{23}$$

The optimal non-screening strategy of granting a loan without screening and hedging the entire credit exposure on the uncleared OTC market with a tailored contract yields a profit of $\Pi_{NS}^{R,O} = i - (1 - p_\mu) - \delta\gamma$. Comparing $\Pi_S^{R,O}$ to $\Pi_{NS}^{R,O}$ gives the screening condition

$$\begin{aligned} &(1 - p_L - i + \delta\gamma)(1-\mu) + \mu(1 - \theta^{R,O*})\delta(\gamma - m) \geq C \quad if \quad \theta^{R,O*} \leq 1, \\ &(1 - p_L - i + \delta\lambda)(1-\mu) - \mu\epsilon\delta(\theta^{R,O*} - 1) \geq C \qquad\qquad if \quad \theta^{R,O*} > 1. \end{aligned} \tag{24}$$

Figure 4 summarizes the bank's lending and hedging decisions.

INSERT FIGURE 4 NEAR HERE

Proposition 6. *If a bank has simultaneously access to an uncleared OTC market and a restricted centrally cleared credit risk transfer market, the probability $p_G^{R,O}$ that a loan is granted and the expected quality $p_Q^{R,O}$ of a granted loan are equal to the case in which a bank has only access to an uncleared OTC market.*

Proof. See the Appendix. □

The intuition for Proposition 6 is that because an originating bank can silently hedge on the uncleared OTC market any fraction that it must retain from a hedge on the centrally cleared market, the incentives to detect and reject a low loan type are, ultimately, determined by the incentives for lending discipline induced by the uncleared market. If, for example, opacity in the uncleared OTC market reduces the tailoring (signaling) cost, $\Omega(., L)$, of a bank with a low type loan to pretend hedging a higher type, or induces a large tailoring cost for a bank hedging a high type to signal its loan quality (see, e.g., Nicolò and Pelizzon 2008), the outcome is a pooling equilibrium without lending discipline even if the bank also has access to a restricted centrally cleared market for credit risk.

5 Discussion of the results

The presented analysis has several important policy implications for the lending discipline, and for systemic risk considerations.

5.1 Lending discipline

My results speak to the ongoing discussion among academics, practitioners, and regulators about how the negative impact of credit risk transfer on excessive lending, and on the loan quality could be addressed (see, e.g., Berndt and Gupta 2009). Section 4.4, however, shows that the widely suggested introduction of unrestricted central clearing into the historical market setting in which banks only have access to an uncleared OTC market reduces the lending discipline. As a consequence, the loan volume is expected to increase, and the loan quality to decrease. The reason is that the opportunity to trade centrally cleared contracts that can not be tailored at favorable regulatory conditions induces an equilibrium credit spread that allows an originating bank to profitably grant and hedge each loan type. Mandatory risk retention on the centrally cleared market restores screening incentives only if the uncleared OTC market is not too opaque. Otherwise, the regulator must additionally prohibit uncleared OTC hedging, which induces the same lending discipline as in the case without credit risk transfer (see Proposition 3 of Section 4.3).

Risk retention is a practicable mechanism. While this approach has already been established in different markets such as the syndicated loan market (see, e.g., Sufi 2007), central clearing should facilitate its implementation for credit derivative trading. According to Stulz (2010), regulators could identify the counterparties to trades through concentrated data provided by the clearinghouse. Hence, they should be capable of preventing banks from hedging exposures beyond the required retention-fraction. Moreover, the risk retention mechanism can be implemented with standard CDSs by simply restricting the notional of a loan that the originating bank is allowed to centrally hedge. The mechanism does not rely on complex signaling contracts that may not be liquid enough to be centrally cleared.

My work also addresses the regulator's current plan to increase the capital requirements for financial institutions under Basel III to strengthen the stability of the financial system. Sections 4.2 and 4.4 show that with unrestricted centrally cleared credit risk transfer, tighter regulatory capital requirements (λ, γ, or m) influence a bank's incentive to screen a loan. They do, however, not change the fact that any loan type is always granted. Hence, stricter regulatory capital requirements per se can not stimulate the lending discipline on the primary loan market as long as a bank has access to unrestricted central clearing. They only increase the lending discipline if central clearing is adequately restricted, as shown in Section 4.3. Similarly, Section 4.4 illustrates that if a bank has access to both the uncleared OTC market and the restricted centrally cleared market, the probability that a low loan is detected and rejected (lending discipline) increases with the regulatory capital requirements γ for a loan hedged on the uncleared market.

It is currently widely discussed how to stimulate banks to centrally clear their OTC trades. Duffie et al. (2010), for example, suggest to materially lower the regulatory capital requirements for a financial institution's derivative positions that are centrally cleared, a proposal implemented in the current Basel III framework. At the same time, there are concerns that more appealing conditions for credit risk transfer could jeopardize the lending discipline of loan originating banks (see, e.g., Cebenoyan and Strahan 2004; Berndt and Gupta 2009; Purnanandam 2011). Section 4.3, however, shows that with a risk retention provision the probability that a bank screens a loan, i.e., $(1 - p_L - i + \delta\lambda)(1 - \mu)$, is independent of the regulatory costs $m\delta$ for the centrally hedged loan fraction. The intuition for this implication is that at the largest possible C that still induces the bank to screen a loan, the optimal risk retention fraction is given by $\theta^{R*} = 1$ (full risk retention). As a consequence, the expected bank profit of the screening strategy without hedging, and hence without regulatory costs $m\delta$, determines the probability that a loan is screened. The same intuition applies to Section 4.4: If a bank has simultaneous access to a restricted centrally cleared market and an uncleared OTC market, the probability that a bank screens a low loan is independent of m. These results suggest that the regulator can implement more appealing regulatory capital conditions for centrally cleared hedges without jeopardizing the lending discipline if central clearing is appropriately regulated.

Finally, the analysis emphasizes that the Basel III capital requirements, and the regulatory framework for centrally cleared credit risk transfer jointly affect the lending discipline. They, consequently, need to be regulated in a comprehensive approach that incorporates their interaction. According to Section 4.3, for example, the regulator should consider the disclosure requirements on the market for centrally cleared credit risk transfer when determining the capital requirements, ϵ, for speculative positions. Similarly, the optimal retention provision in Section 4.3 directly depends on the regulatory capital requirements for unhedged and centrally hedged loan exposures. In particular, $\frac{\partial \theta^{R*}}{\partial \lambda} < 0$ for any θ^{R*}, $\frac{\partial \theta^{R*}}{\partial m} < 0$ for $\theta^{R*} \leq 1$, and $\frac{\partial \theta^{R*}}{\partial m} = 0$ for $\theta^{R*} > 1$. The optimal fraction θ^{R*} decreases with the regulatory capital requirements λ and m because for a mimicking bank, capital costs accrue for both loan types as it grants any loan. In contrast, a bank that screens only faces these costs if it detects and grants a high loan. Hence, stricter regulatory capital requirements reduce the attractiveness of the mimicking strategy compared to the screening strategy, which allows the regulator to reduce θ^{R*} while still inducing the bank to screen and reject a detected low loan. If a bank has additional access to an uncleared OTC market (Section 4.4), the optimal retention provision depends on the regulatory capital requirements for loan exposures hedged on the centrally cleared and uncleared OTC market.

5.2 Systemic risk

Systemic risk has become an overwhelming theme after the recent financial crisis, particularly when it comes to embellishing regulatory capital requirements, risk transfer structures, and the linkage between the two pillars. According to Huang et al. (2011) and Acharya et al. (2011), the fundamental elements of a systemic risk measure are exposure size, probability of default, and the correlation of losses with systemic downturns. The additivity property discussed in Huang et al. (2011), i.e., the property that the systemic risk of a portfolio equals the marginal contributions to systemic risk from each subportfolio, suggests to analyze the marginal contribution to systemic risk from a loan that is considered to be granted by a bank.

I investigate how central clearing affects the marginal systemic risk from a considered loan. To this end, I dissect the impact of a bank's hedging activity and lending behavior on the three fundamental elements of systemic risk. In particular, the results in Section 4 allow me to endogenously derive the marginal effect of the lending behavior on exposure size, and the default probability. I exogenously determine the third element driven by the hedging activity by assuming that η^O and η^C capture the marginal systemic risk from the correlation of losses with systemic downturns per unit of risk hedged OTC and via central clearing, respectively. The marginal systemic risk from a considered loan in a certain market infrastructure is calculated as follows: First, the expected loss on each hedging channel is obtained by multiplying the expected exposure size that is hedged through that channel with the expected probability of default. This expected loss is multiplied by η^O for an OTC hedge, and by η^C for a centrally cleared hedge to obtain the marginal systemic risk on each channel. The marginal systemic risk in a market infrastructure then simply corresponds to the expected marginal systemic risk, in which the expectation is taken over the probability that a certain hedging channel is used.

In the historical uncleared OTC market infrastructure of Section 4.4, the marginal contribution from a considered loan to systemic risk corresponds to

$$p_S^O \mu(1-p_H)\eta^O + (1-p_S)(1-p_\mu)\eta^O. \tag{25}$$

Adding unrestricted central clearing to this infrastructure changes the systemic risk to

$$p_S^{U,O}\mu(1-p_H)\eta^O + p_S(1-\mu)(1-p_L)\eta^C + (1-p_S)(1-p_\mu)\eta^C. \tag{26}$$

The solid line in Figure 5 depicts the marginal contribution to systemic risk from a considered loan in the historical market infrastructure for a range of η^C, the dashed line the corresponding marginal contribution in the infrastructure with simultaneous access to both OTC and unrestricted central clearing. To draw the figure, p_H is set to 0.974, and p_L to 0.656. These numbers correspond to the average cumulative issuer-weighted global ten year survival rates of investment, respectively speculative grade corporate bonds and loans between 1970 and 2010 (Moody's 2011).[10] The parameter μ is set to 0.5, and δ to 0.06. According to BIS (2011), the total of all components of regulatory capital must exceed 8% of the risk weighted assets. Hence, as corporate exposures receive a risk weight of 100%, I set λ to 0.08. The risk weight to central counterparties is currently 2% (BIS 2012). Therefore,

[10] A broad quality range for loans such as a rating category can comprise borrowers with widely differing survival probabilities. For example, Lehman Brothers still had an investment grade rating one day before its bankruptcy.

I fix m at 0.0016. For the risk weight of OTC trades, I assume that the counterparty is a bank that has a risk weight of 20%, which yields $\gamma = 0.016$. The screening cost per loan is assumed to be uniformly distributed between 0 and 0.2. I choose $\eta^O = 0.03$. As I only derive comparative results with respect to the relative size of the systemic risk in the different market infrastructures, the absolute size of η^O is not important for my analysis.

INSERT FIGURE 5 NEAR HERE

Figure 5 reveals an important trade-off from introducing central clearing into the historical market infrastructure. On the one hand, central clearing may reduce the marginal systemic risk from hedging a given expected loss exposure. On the other hand, central clearing hampers the lending discipline on the primary loan market, which increases the expected loss exposure from a considered loan due to the higher expected exposure size and the larger expected probability of default. The pure impact of the reduced lending discipline can be seen by comparing the solid and dashed lines for $\eta^C = 0.03$, i.e., at the point at which the third element of systemic risk from hedging centrally cleared exposures is equal to the one from hedging exposures on the uncleared OTC market. The marginal contribution to systemic risk from a loan considered in the market infrastructure with access to both uncleared and centrally cleared hedging is much larger (+56.4%) than in the setting in which a bank only has access to uncleared OTC hedging. Figure 5 also shows that to overcome the impact of the reduced lending discipline on systemic risk, η^C needs to be more than 37.3% below η^O. Hence, only for very low levels of η^C (< 0.0189) compared to $\eta^O = 0.03$, the introduction of unrestricted central clearing into the historical market infrastructure reduces the marginal contribution of a considered loan to systemic risk.

An important regulatory question is which market infrastructure minimizes systemic risk. To answer this question, I additionally calculate the marginal contribution to systemic risk from a considered loan in the market infrastructure of Section 4.4 with bank access to both restricted central clearing and uncleared OTC hedging. It is given by

$$\mu(1-p_H)\int_0^{0.2p_S^{R,O}} (1-\theta^{R,O*})\eta^C + \theta^{R,O*}\eta^O \mathrm{d}C + (1-p_S^{R,O})(1-p_\mu)\eta^O. \tag{27}$$

The marginal contribution to systemic risk in the market infrastructure of Section 4.3, in which the bank is not allowed to hedge OTC but only has access to restricted central clearing, is obtained by replacing $p_S^{R,O}$ in Equation (27) with p_S^R, $\theta^{R,O*}$ with θ^{R*}, and η^O with η^U. η^U is the third element of systemic risk per unit of unhedged exposure.

Figure 6 shows the minimal attainable marginal systemic risk from a considered loan for each value of η^C. If $\eta^C < 0.0187$, bank access to both OTC and centrally cleared hedging entails the lowest systemic risk. The advantage from restricting central clearing to systemic risk is the stronger lending discipline. The main disadvantage is that an unscreened loan is hedged OTC instead of via central clearing, which increases the third element of systemic risk. For $0.0187 \leq \eta^C < 0.03$, the advantage from this restriction dominates, such that the systemic risk is minimized with bank access to OTC and restricted central clearing. Finally, for $\eta^C \geq 0.03 = \eta^O$, the lowest marginal systemic risk results from the historical market infrastructure, in which the bank can only hedge a loan OTC. Resigning restricted central clearing does not affect the lending discipline in this case (see Section 4.4). The fraction, however, of a high type loan that is centrally hedged with access to restricted central clearing needs to be OTC hedged without this access. Hence, the marginal systemic risk in the historical market infrastructure is larger than with additional access to restricted central clearing if $\eta^C < \eta^O$, and lower if $\eta^C \geq \eta^O$. The market infrastructure of Section 4.3 with restricted central clearing but without bank access to uncleared OTC hedging never minimizes the marginal systemic risk for reasonable values of η^U, even though this setting maximizes the lending discipline.[11] The reason is that an unscreened loan and part of a high loan remain unhedged (see Figure 3), which raises the marginal systemic risk compared to the infrastructure with additional bank access to uncleared OTC hedging.

INSERT FIGURE 6 NEAR HERE

The η^C thresholds for the market infrastructures that minimize systemic risk depend on the parameter choice. With a higher difference between p_H and p_L, and a lower screening

[11] It is reasonable to assume that η^U is larger than η^O or η^C. Already for $\eta^U > 0.031$, however, the marginal systemic risk with restricted central clearing but without bank access to uncleared OTC hedging is larger than in the market infrastructure with only OTC access.

cost, the lending discipline is particularly effective in reducing the marginal systemic risk. Hence, the market infrastructure with joint access to OTC hedging and restricted central clearing that induces lending discipline becomes more attractive for a regulator that plans to minimize systemic risk compared to the one with access to OTC hedging and unrestricted central clearing without lending discipline. For a larger default probability of the high loan, $1 - p_H$, the market infrastructure with joint access to OTC hedging and restricted central clearing becomes more attractive compared to the one with only OTC access. The reason is that the fraction of the expected loss of the high loan that can be cleared centrally in the former infrastructure determines the difference in the marginal systemic risk between the two settings.

For example, if $p_H = 0.799$ and $p_L = 0.2762$, i.e., if the default probabilities are calibrated to Baa and Caa-C ratings, respectively, the market infrastructure with joint access to OTC hedging and restricted central clearing minimizes the marginal systemic risk for $0.0124 \leq \eta^C < 0.03$. The reduction in systemic risk is up to 4.1% compared to the market infrastructure with the second lowest systemic risk. With an additional decrease of the screening cost to $C \in (0, 0.15)$, the market infrastructure with joint access to OTC hedging and restricted central clearing minimizes the marginal systemic risk for $0.0045 \leq \eta^C < 0.03$, mitigating the systemic risk up to 11.6% compared to the market infrastructure with the second lowest systemic risk. In this parameter setting, central clearing can have dramatic consequences. If $\eta^C = \eta^O$, for example, the introduction of unrestricted central clearing into the historical market infrastructure increases the marginal systemic risk by more than 200%.

A number of recent papers argues that central clearing mitigates the systemic risk from banks' hedging activities (Duffie and Zhu 2011; Acharya and Bisin 2014; Duffie et al. forthcoming; Zawadowski 2013). I add a novel aspect to this discussion by suggesting that the total systemic risk is not only determined by banks' hedging activities but also by their lending behavior. My analysis shows that the marginal systemic risk from granting and hedging a new loan is only mitigated by the introduction of unrestricted central clearing if adding central counterparties to the OTC market infrastructure strongly reduces the systemic risk from the hedging activities. Arora et al. (2012), however, empirically illustrate that the current

CDS risk mitigation techniques on the uncleared OTC hedging market, such as the standard practice among dealers of having their counterparties fully collateralize the swap liabilities or the usage of the ISDA master agreements structure that facilitates netting in the event of a counterparty default, are largely successful in addressing the counterparty credit risk concerns of the market participants. In particular, market participants price counterparty credit risk in uncleared OTC CDS contracts as if it were only a minor concern. If central clearing only slightly reduces the systemic risk from banks' hedging activities, however, my results imply that the introduction of central clearing should be complemented by appropriate risk retention endorsements to address the lending discipline problem. Otherwise, the total systemic risk from loan granting and hedging may even increase, particularly when the information asymmetry problem is large (high difference in loan quality), when banks have a low screening cost, or when the default probabilities are high such as during recession.

My analysis generates two additional recommendations for the regulatory design of central clearing. First, Section 4.3 suggests to publicly disclose information about the hedging activity of loan originating banks on the centrally cleared market. The risk retention mechanism without disclosure only works if it is combined with large capital requirements for speculative credit exposures that prevent the exploitation of insider information.[12] Such large capital requirements, however, could impose an unnecessary burden on banks' daily trading activities. Second, Duffie and Zhu (2011) argue that margin requirements can mitigate systemic risk by lowering the likelihood that defaults propagate from counterparty to counterparty. My model does not incorporate counterparty risk, and, hence, can not calculate the impact of margin requirements on systemic risk. What my results, however, suggest is that with restricted centrally cleared credit risk transfer, margin requirements should be designed to adequately address the systemic risk concerns from banks' hedging activities without worrying about their impact on the lending discipline. The reason is that the margin cost for a loan originating bank has no impact on the lending discipline in the primary loan market. The intuition is the same as for the impact of regulatory capital costs, $m\delta$, discussed in the previous Section 5.1: A bank does not need to pay a margin with the largest fraction $\theta^{R*} = 1$

[12] Of course, the regulator could also adapt strict insider trading rules instead of large capital requirements.

that determines the screening probability.

6 Conclusion

This paper models a bank with access to credit risk transfer that can grant a risky loan. I analyze how the lending discipline of the bank on the primary loan market is affected by central clearing.

I first show that the introduction of a centrally cleared market for credit risk adversely affects the incentive of a bank to detect and reject a low loan applicant. This reduced lending discipline aggravates the excessive lending and loan quality problems. The lending discipline is not stimulated by simply tightening regulatory capital requirements. It is, additionally, necessary to regulatively design central clearing with respect to risk retention rules, disclosure standards, and the access to the uncleared OTC market. With the appropriate market design, the regulator can establish the same lending discipline as in the case without credit risk transfer. My results suggest that the regulator should consider the interaction between the regulatory design of the credit risk transfer market and the capital requirements when addressing the lending discipline problem.

The presented analysis of banks' lending behavior implies that when evaluating the impact of central clearing on systemic risk, it is crucial to incorporate the extent to which central clearing affects the lending discipline. A fruitful extension of my model would be to incorporate multiple banks. By modeling their interaction, one could additionally endogenize network effects of central clearing that influence both the lending discipline on the primary loan market and the banks' credit risk transfer activities. I leave this extension to future research.

Appendix

Proof of Proposition 1.

Proof. As the screening cost is standard uniformly distributed, the ex-ante probability that a bank screens a loan is given by

$$p_S = \frac{(1 - p_L - i + \delta\lambda)(1 - \mu)}{1} = (1 - p_L - i + \delta\lambda)(1 - \mu), \tag{28}$$

and that it does not screen by $(1 - p_S)$. The probability that a granted loan (G) is of high type (H) can be calculated from

$$P(H \mid G) = \frac{P(H \cap G)}{P(G)} = \frac{\mu}{1 - p_S(1 - \mu)} = \frac{\mu}{p_G} = Q. \tag{29}$$

Hence, the expected repayment probability of a granted loan p_Q is simply given by $Qp_H + (1 - Q)p_L$.

It remains to be shown that $1 > p_G > \mu$, and $p_H > p_Q > p_\mu$: From $i < 1 - p_L + \delta m < 1 - \delta(\lambda - m)$, and $\lambda > m$, it follows that $p_S \in (0, 1)$. Hence, $p_G = p_S\mu + (1 - p_S) \in (\mu, 1)$. From Equation (29), $p_G \in (\mu, 1)$ induces $1 > Q > \mu$ which yields $p_H > p_Q > p_\mu$. $\square$

Proof of Proposition 2.

Proof. I show that there exists an optimal fraction that induces a separating equilibrium in which a bank with a detected high loan retains this fraction of the originated loan's risk, and a bank with a detected low loan rejects the loan. The fraction is optimal if it maximizes the ex-ante incentive of a bank to screen a loan.

A separating equilibrium has to satisfy both the participation constraint of the investor and the self selection criterion of the bank. The problem to solve for $\theta^R \leq 1$ is given by the following program

$$\max_{\theta^R} \quad i - \theta^R(1 - p_H) - (1 - \theta^R)(1 - p_B^R) - (1 - \theta^R)m\delta - \theta^R\delta\lambda \tag{30}$$

s.t.

$$\begin{aligned}&\mu\left(i-\theta^R(1-p_H)-(1-\theta^R)(1-p_B^R)-(1-\theta^R)m\delta-\theta^R\delta\lambda\right)-C\geq\\&i-\mu\theta^R(1-p_H)-(1-\mu)\theta^R(1-p_L)-(1-\theta^R)(1-p_B^R)-(1-\theta^R)m\delta-\theta^R\delta\lambda.\end{aligned}\tag{31}$$

The participation constraint is implicitly satisfied because the credit risk transfer market is assumed to be competitive, i.e., a bank has to pay the fair credit spread $(1-p_B^R)$ according to the protection seller's beliefs to hedge one unit of a loan. Beside the incentive compatibility constraint (31), it must also be satisfied that

$$i-\theta^R(1-p_L)-(1-\theta^R)(1-p_B^R)-(1-\theta^R)m\delta-\theta^R\delta\lambda\leq 0,\tag{32}$$

i.e., that a bank that has screened and detected a low type prefers to reject the loan instead of mimicking to be granting and hedging a high type. Inequality (31) is more restrictive than Inequality (32) as long as $C>0$. Hence, it is sufficient to consider the incentive compatibility constraint (31) in the optimization problem. The expected profit of a bank granting a detected high loan in Expression (30) is monotonically decreasing in the retained fraction θ^R. Hence, the smallest fraction θ^{R*} that still allows for a separating equilibrium maximizes this expected profit. It is the optimal fraction from the point of view of the regulator because maximizing the expected profit of a bank with a detected high loan maximizes the bank's ex-ante incentive to screen a loan. Due to the linearity of the problem, the solution to the program for $\theta^R\leq 1$ is obtained by solving the incentive compatibility constraint (31) as equality for θ^R, which yields

$$\theta^{R*}=\frac{i-(1-p_H)-m\delta+C/(1-\mu)}{p_H-p_L+\delta(\lambda-m)}.\tag{33}$$

The separating equilibrium satisfying the Intuitive Criterion of Cho and Kreps (1987) is given by the bank with a high loan retaining θ^{R*}, and by a loan rejection of the bank with a low loan.[13] As a fractional hedge of a bank is publicly observable, the unique equilibrium beliefs

[13]The Intuitive Criterion of Cho and Kreps (1987) can be explained as follows: Suppose the bank follows an out-of-equilibrium strategy. It does so based on a certain conjecture about how the market participants react. The Intuitive Criterion suggests to assign probability one to a bank having a high loan, if and only if given the investor's most optimistic conjecture, the bank finds it optimal to follow this strategy and to deviate from the equilibrium, while a bank with a low type does not.

of the protection seller are such that a granted loan is of high-type with probability one, i.e., $p_B^R = p_H$, if it is fractionally hedged.[14]

In the case in which $\theta^R > 1$, a bank completely hedges the loan and additionally sells a fraction $(\theta^R - 1)$ of credit protection. On this fraction, it earns a protection fee of $(\theta^R - 1)(1 - p_B^R)$. Suppose there are regulatory capital or margin requirements $\epsilon > 0$ imposed on any fraction of unhedged credit risk sold by the originating bank on the centrally cleared market. The expected profit of a bank that screens and retains $\theta^R > 1$ of a high type loan is given by

$$\mu(i - \theta^R(1 - p_H) - \lambda\delta - \epsilon\delta(\theta^R - 1) + (\theta^R - 1)(1 - p_B^R)) - C. \tag{34}$$

The incentive compatibility constraint (31) in the program must be replaced by

$$\begin{aligned} &\mu(i - \theta^R(1 - p_H) - \lambda\delta - \epsilon\delta(\theta^R - 1) + (\theta^R - 1)(1 - p_B^R)) - C \geq \\ &i - \mu\theta^R(1 - p_H) - (1 - \mu)\theta^R(1 - p_L) - \lambda\delta - \epsilon\delta(\theta^R - 1) + (\theta^R - 1)(1 - p_B^R). \end{aligned} \tag{35}$$

The smallest θ^R that permits a separating equilibrium with $p_B^R = p_H$ is given by

$$\theta^{R*} = \frac{i - (1 - p_H) + \delta(\epsilon - \lambda) + C/(1 - \mu)}{p_H - p_L + \delta\epsilon}. \tag{36}$$

□

Proof of Proposition 3.

Proof. First, consider $C \in (0, (1 - p_L - i + \delta\lambda)(1 - \mu)]$. The first term in the screening condition with restricted credit risk transfer, i.e., in

$$(1 - p_L - i + \delta\lambda)(1 - \mu) + \mu(1 - \theta^{R*})\delta(\lambda - m) \geq C, \tag{37}$$

corresponds to left hand side of the screening condition without credit risk transfer in Inequality (3). The second term of Inequality (37), $\mu(1 - \theta^{R*})\delta(\mu - m)$, is non-negative if

[14]Note that I do not explicitly consider a participation constraint for the protection seller. It is implicitly included in the assumption that the credit spread corresponds to $(1 - p_B^R)$, i.e., that the credit risk transfer market is competitive.

$\theta^{R*} \in (0,1]$. The denominator of the expression for θ^{R*} in (33) is greater than zero because $p_H > p_L$, and $\lambda > m$. The nominator is larger than zero because, by assumption, $i - (1 - p_\mu) - \lambda\delta > 0$, $p_H > p_\mu$, and $C > 0$. As a consequence, $\theta^{R*} \in (0,1]$ if $i - (1 - p_H) - m\delta + C/(1 - \mu) \leq p_H - p_L + \delta(\lambda - m)$, or, by rearranging, if

$$(1 - p_L - i + \delta\lambda)(1 - \mu) \geq C. \tag{38}$$

Hence, if $C \in (0, (1 - p_L - i + \delta\lambda)(1 - \mu)]$, the left hand side of Inequality (37) is always larger or equal than $(1 - p_L - i + \delta\lambda)(1 - \mu)$. As a consequence, the bank optimally screens.

Next, I analyze $C > (1 - p_L - i + \delta\lambda)(1 - \mu)$. From Expressions (36) and (38), it is then known that $\theta^{R*} > 1$. The expected profit Π_S^R of a bank that screens and retains $\theta^{R*} > 1$ corresponds to

$$\mu(i - \theta^{R*}(1 - p_H) - \lambda\delta - \epsilon\delta(\theta^{R*} - 1) + (\theta^{R*} - 1)(1 - p_H)) - C = \mu(i - (1 - p_H) - \lambda\delta - \epsilon\delta(\theta^{R*} - 1)) - C. \tag{39}$$

Comparing Expression (39) to the expected profit Π_{NS}^R of the non-screening strategy, $i - (1 - p_\mu) - \delta\lambda$, yields the following screening condition:

$$(1 - p_L - i + \delta\lambda)(1 - \mu) - \mu\epsilon\delta(\theta^{R*} - 1) \geq C, \tag{40}$$

As $-\mu\epsilon\delta(\theta^{R*} - 1) < 0$ for $\theta^{R*} > 1$, the left hand side of Inequality (40) is always smaller than $(1 - p_L - i + \delta\lambda)(1 - \mu)$. Hence, $\Pi_S^R < \Pi_{NS}^R$ because $C > (1 - p_L - i + \delta\lambda)(1 - \mu)$, and no screening takes place.

Because the bank screens if $C \in (0, (1 - p_L - i + \delta\lambda)(1 - \mu)]$, and does not screen if $C > (1 - p_L - i + \delta\lambda)(1 - \mu)$, the probability that the bank screens is given by

$$p_S^R = \frac{(1 - p_L - i + \delta\lambda)(1 - \mu)}{1} = (1 - p_L - i + \delta\lambda)(1 - \mu), \tag{41}$$

which is identical to the probability in the case without credit risk transfer. If it screens, it is optimal to grant and fractionally hedge a high loan, and to reject a low loan. If it does not screen, any loan is granted. Hence, the probability that a loan is granted corresponds to $p_S^R\mu + (1-p_S^R) = 1 - p_S^R(1-\mu) = p_G^R$, and the probability that a granted loan is of high type is $\frac{\mu}{p_G^R} = Q^R$. $\square$

Proof of Proposition 4.

Proof. The expected profit of the screening strategy can be written as

$$\Pi_S^{R,ND} = \begin{cases} \mu(i - \theta^{R,ND*}(1-p_H) - (1-\theta^{R,ND*})(1-p_Q^{R,ND}) \\ -(1-\theta^{R,ND*})m\delta - \theta^{R,ND*}\delta\lambda) - C & if \quad \theta^{R,ND*} \leq 1, \\ \mu(i - \theta^{R,ND*}(1-p_H) + (\theta^{R,ND*}-1)(1-p_Q^{R,ND}) - \lambda\delta - \\ \epsilon\delta(\theta^{R,ND*}-1)) - C & if \quad \theta^{R,ND*} > 1, \end{cases} \tag{42}$$

in which $\epsilon > 0$ is the regulatory capital requirement for unhedged credit risk incurred by the bank on the centrally cleared credit risk transfer market.

The alternative strategy is to just grant the loan without screening and to keep the entire credit risk on the own book. This non-screening strategy yields an expected bank profit of

$$\Pi_{NS}^{R,ND} = i - (1-p_\mu) - \delta\lambda. \tag{43}$$

First, I proof that there is a separating equilibrium with screening for $\frac{(p_H-p_L)(1-\hat{Q}^{R,ND})}{\delta} \leq \epsilon$, with $\hat{Q}^{R,ND} = \frac{\mu}{1-p_S^{R,ND}(1-\mu)}$, and $p_S^{R,ND} = (1-p_L-i+\delta\lambda)(1-\mu)$.

In the case $\theta^{R,ND*} \leq 1$, the smallest fraction such that the screening strategy dominates the mimicking strategy is given by

$$\theta^{R,ND*} = \frac{i - (1-p_Q^{R,ND}) - m\delta + C/(1-\mu)}{p_Q^{R,ND} - p_L + \delta(\lambda - m)}. \tag{44}$$

From Expression (44), it follows that $\theta^{R,ND*} \leq 1$ if $C \leq (1-p_L-i+\delta\lambda)(1-\mu)$. Comparing the first line of Expression (42) to (43) yields that $\Pi_S^{R,ND} \geq \Pi_{NS}^{R,ND}$ if

$$(1-p_L-i+\delta\lambda)(1-\mu) + \mu(1-\theta^{R,ND*})\left(\delta(\lambda-m) - (p_H-p_L)(1-Q^{R,ND})\right) \geq C. \tag{45}$$

Consider $\delta(\lambda - m) \geq (p_H - p_L)(1 - Q^{R,ND})$. The term

$$\mu(1 - \theta^{R,ND*})\left(\delta(\lambda - m) - (p_H - p_L)(1 - Q^{R,ND})\right) \tag{46}$$

is non-negative for $\theta^{R,ND*} \leq 1$. Hence, Inequality (45) is always satisfied as $C \leq (1 - p_L - i + \delta\lambda)(1 - \mu)$.

Next, consider $\delta(\lambda - m) < (p_H - p_L)(1 - Q^{R,ND})$. Under this condition, the expected profit of the screening strategy in the first line of Expression (42) is strictly increasing in $\theta^{R,ND}$. Hence, to maximize the expected profit, the bank will not choose $\theta^{R,ND*}$ after detecting a high loan, but $\theta^{R,ND} = 1$ conditional on the investor's beliefs that it does not increase the bank's expected profit if it chooses $\theta^{R,ND} > 1$.[15] With $\theta^{R,ND} = 1$, $\Pi_S^{R,ND} \geq \Pi_{NS}^{R,ND}$ if

$$(1 - p_L - i + \delta\lambda)(1 - \mu) \geq C. \tag{47}$$

Inequality (47) is satisfied for $\theta^{R,ND*} \leq 1$.

In the case $\theta^{R,ND*} > 1$, the smallest fraction such that the screening strategy dominates the mimicking strategy is given by

$$\theta^{R,ND*} = \frac{i - (1 - p_Q^{R,ND}) + \delta(\epsilon - \lambda) + C/(1 - \mu)}{p_Q^{R,ND} - p_L + \delta\epsilon}. \tag{48}$$

From Expression (48), it follows that $\theta^{R,ND*} > 1$ if $C > (1 - p_L - i + \delta\lambda)(1 - \mu)$. Comparing the second line of Expression (42) to (43) yields that $\Pi_S^{R,ND} \geq \Pi_{NS}^{R,ND}$ if

$$(1 - p_L - i + \delta\lambda)(1 - \mu) + \mu(\theta^{R,ND*} - 1)\left((p_H - p_L)(1 - Q^{R,ND}) - \epsilon\delta\right) \geq C. \tag{49}$$

Inequality (49) can only be satisfied if the term $\mu(\theta^{R,ND*} - 1)\left((p_H - p_L)(1 - Q^{R,ND}) - \epsilon\delta\right)$ is positive because $C > (1 - p_L - i + \delta\lambda)(1 - \mu)$ for $\theta^{R,ND*} > 1$. Hence, for $\frac{(p_H - p_L)(1 - \hat{Q}^{R,ND})}{\delta} \leq \epsilon$, $\Pi_S^{R,ND} \geq \Pi_{NS}^{R,ND}$ if $\hat{Q}^{R,ND} > Q^{R,ND}$. $\hat{Q}^{R,ND} > Q^{R,ND}$ requires that the investor beliefs are

[15] For $\frac{(p_H - p_L)(1 - \hat{Q}^{R,ND})}{\delta} = \epsilon$, any choice of $\theta^{R,ND} \geq 1$ yields the same expected profit as $\theta^{R,ND} = 1$ if $Q^{R,ND} = \hat{Q}^{R,ND}$, and, consequently, induces the same screening condition. For $\frac{(p_H - p_L)(1 - \hat{Q}^{R,ND})}{\delta} < \epsilon$, any $\theta^{R,ND} \geq 1$ yields a lower expected profit than $\theta^{R,ND} = 1$ if $Q^{R,ND} = \hat{Q}^{R,ND}$.

such that $p_S^{R,ND} < (1 - p_L - i + \delta\lambda)(1 - \mu)$.

Given the conditions for screening in the cases $\theta^{R,ND*} \leq 1$ and $\theta^{R,ND*} > 1$, the only equilibrium for $\frac{(p_H - p_L)(1 - \hat{Q}^{R,ND})}{\delta} \leq \epsilon$ satisfying the intuitive criterion is that the bank does not screen if $C > (1 - p_L - i + \delta\lambda)(1 - \mu)$, and screens and rejects a low type if $C \leq (1 - p_L - i + \delta\lambda)(1 - \mu)$. The unique beliefs associated with this equilibrium are such that a loan is screened with probability $p_S^{R,ND} = (1 - p_L - i + \delta\lambda)(1 - \mu)$, and, hence, $Q^{R,ND} = \frac{\mu}{1 - p_S^{R,ND}(1-\mu)}$.

Next, I show that there is no equilibrium satisfying the intuitive criterion for

$$\frac{(p_H - p_L)(1 - \hat{Q}^{R,ND})}{\delta} > \epsilon > 0. \tag{50}$$

First, note that the expected profit of the screening strategy in the second line of Inequality (42) can be rewritten as

$$\mu(i - (1 - p_H) + (\theta^{R,ND*} - 1)((p_H - p_L)(1 - Q^{R,ND}) - \epsilon\delta) - \lambda\delta) - C. \tag{51}$$

If a bank increases $\theta^{R,ND}$ above $\theta^{R,ND*}$, the screening strategy still dominates the mimicking strategy.

A pooling equilibrium without screening can not exist because the associated beliefs are that the probability that a granted loan is of high type is given by μ, i.e., $Q^{R,ND} = \mu$. Given these beliefs, $(p_H - p_L)(1 - \mu) > \epsilon\delta$ for any $\epsilon < \frac{(p_H - p_L)(1 - \hat{Q}^{R,ND})}{\delta}$ as $\mu < \hat{Q}^{R,ND}$. According to Expression (51), a bank would then always deviate from the equilibrium by screening and maintaining an infinite amount of $\theta^{R,ND}$ in case it detects a high loan. This screening strategy yields an infinite expected profit because the expected profit in Expression (51) is strictly increasing in $\theta^{R,ND}$ for $Q^{R,ND} = \mu$. Hence, screening dominates the pooling strategy without screening.

A separating equilibrium with screening does also not exist. Due to (51), the bank would hold an infinite amount of $\theta^{R,ND}$ if the investor's beliefs were such that $Q^{R,ND} < 1 - \frac{\epsilon\delta}{p_H - p_L}$ for any $0 < \epsilon < \frac{(p_H - p_L)(1 - \hat{Q}^{R,ND})}{\delta}$. As the corresponding expected profit with a detected high loan is infinite, a bank would screen for any $C \in (0, 1)$. The investor would then anticipate that a loan is always screened. This anticipation induces $Q^{R,ND} = 1$ which is a contradiction to $Q^{R,ND} < 1 - \frac{\epsilon\delta}{p_H - p_L}$. Beliefs $Q^{R,ND} \geq 1 - \frac{\epsilon\delta}{p_H - p_L}$ do also not establish equilibrium beliefs because they induce that $\big((p_H - p_L)(1 - Q^{R,ND}) - \epsilon\delta\big) \leq 0$. According to Inequality (49), screening can then not be optimal for $C > (1 - p_L - i + \delta\lambda)(1 - \mu)$. However, for any $0 < \epsilon < \frac{(p_H - p_L)(1 - \hat{Q}^{R,ND})}{\delta}$, beliefs $Q^{R,ND} \geq 1 - \frac{\epsilon\delta}{p_H - p_L}$ induce that $Q^{R,ND} > \hat{Q}^{R,ND}$, which is a contradiction to the observation that screening may only occur for $C \leq (1 - p_L - i + \delta\lambda)(1 - \mu)$ because $\hat{Q}^{R,ND} = \frac{\mu}{1 - p_S^{R,ND}(1 - \mu)}$ with $p_S^{R,ND} = (1 - p_L - i + \delta\lambda)(1 - \mu)$. Finally, $Q^{R,ND} = 1$ can not be equilibrium beliefs as $(p_H - p_L)(1 - Q^{R,ND}) = 0$ in this case. According to Inequality (49), however, it is then not optimal for a bank to screen if $C > (1 - p_L - i + \delta\lambda)(1 - \mu)$, which establishes a contradiction to beliefs $Q^{R,ND} = 1$ that only maintain if a bank is screening for any $C \in (0, 1)$. □

Proof of Proposition 5.

Proof. The following strategy of the bank is a separating equilibrium satisfying the Intuitive Criterion of Cho and Kreps (1987): If it does not screen, it grants and hedges a loan on the uncleared OTC market. If it screens, the bank grants and hedges a high loan on the uncleared OTC market, and rejects a low loan. The unique beliefs associated with this equilibrium are that the bank that does not screen, and the bank with a high loan tailor the OTC contract to reveal their true type. A bank that does not tailor the contract is believed to be of low type with probability one.

As $\lambda > \gamma$, and $\Omega(H, \mu) > p_H - \mu$, it is optimal for a bank that does not screen to grant, tailor, and hedge the loan on the uncleared OTC market because

$$i - (1 - p_\mu) - \delta\gamma > Max\big(i - (1 - p_\mu) - \delta\lambda, i - (1 - p_H) - \delta\gamma - \Omega(H, \mu)\big), \qquad (52)$$

in which $i - (1 - p_\mu) - \delta\lambda$ is the expected profit of granting an unscreened loan without hedging, and $(i - (1 - p_H) - \delta\gamma) - \Omega(H, \mu)$ is the profit of tailoring the contract to mimic a high type and hedging it at a spread $(1 - p_H)$ on the uncleared OTC market. As $\Omega(., L) > i - (1 - p_H) - \delta m$, it is optimal for a bank with a low type to reject the loan because

$$0 > Max\big(i - (1 - p_\mu) - \delta\gamma - \Omega(\mu, L), i - (1 - p_H) - \delta\gamma - \Omega(H, L)\big), \tag{53}$$

in which $i-(1-p_\mu)-\delta\gamma-\Omega(\mu, L)$ is the profit of tailoring the contract to mimic an unscreened loan and following the optimal non-screening strategy of hedging it at a spread $(1 - p_\mu)$ on the uncleared OTC market, and $i - (1 - p_H) - \delta\gamma - \Omega(H, L)$ is the profit of tailoring the contract to mimic a high type and hedging it at a spread $(1 - p_H)$ on the uncleared OTC market. Finally, a bank with a detected high type optimally grants, tailors, and hedges the loan on the uncleared OTC market because it can not reach a profit above $i - (1 - p_H) - \delta\gamma$ with any other strategy.

Comparing the expected profit of the optimal screening strategy, $\Pi_S^O = \mu(i - (1 - p_H) - \delta\gamma) + (1 - \mu)0 - C$, in the separating equilibrium to the one of the optimal non-screening strategy, $\Pi_{NS}^O = i - (1 - p_\mu) - \delta\gamma > 0$, leads to $p_S^O = \frac{(1-p_L-i+\delta\gamma)(1-\mu)}{1}$. As a detected low loan is rejected, the probability that a loan is granted is $p_G^O = 1 - p_S^O(1 - \mu)$. The expected repayment probability of a granted loan is $p_Q^O = Q^O p_H + (1 - Q^O)p_L$, with $Q^O = \frac{\mu}{p_G^O}$. As $p_S^O > 0$, and a detected low loan type is rejected, there is lending discipline that leads to $p_G^O < 1$ and, hence, to $Q^O > \mu$, which induces $p_Q^O > p_\mu$.

Because $\lambda > \gamma$, $p_S^O < p_S$, which causes $p_G^O > p_G$, and $Q^O < Q$. □

Proof of Proposition 6.

Proof. If the central hedging of a bank is publicly observable, the equilibrium beliefs of participants of the centrally cleared market are that a fractionally hedged loan is of high type with probability one. First, I show that granting a detected low loan type, hedging it on the restricted centrally cleared market by retaining $\theta^{R,O}$, and silently hedging the retained fraction on the uncleared OTC market by tailoring the credit derivative contract is not worthwhile. The profit of this strategy is

$$\begin{aligned} & i-\theta^{R,O}(1-p_L)-(1-\theta^{R,O})(1-p_H)-(1-\theta^{R,O})m\delta-\theta^{R,O}\delta\lambda \\ & +\theta^{R,O}(1-p_L)-\theta^{R,O}(1-p_H)+\theta^{R,O}\delta\lambda-\theta^{R,O}\delta\gamma-\Omega(H,L). \end{aligned} \tag{54}$$

The profit in Expression (54) is always smaller than $\theta^{R,O}\delta(m-\gamma)$, which is, by definition, smaller than zero for any $1 \geq \theta^{R,O} > 0$.[16]

Next, a bank with a detected high type loan fractionally hedges on the centrally cleared market, and transfers the remaining fraction $\theta^{R,O}$ on the uncleared OTC market with a tailored contract. The profit of this optimal strategy, $i-(1-p_H)-(1-\theta^{R,O})m\delta-\theta^{R,O}\delta\gamma$, is larger than the expected profit from hedging on the centrally cleared market and retaining $\theta^{R,O}$ on the own book, or any other strategy.

Finally, I derive the smallest $\theta^{R,O}$ such that the optimal screening strategy still dominates the mimicking strategy. The incentive compatibility constraint is given by

$$\begin{aligned} & \mu\left(i-\theta^{R,O}(1-p_H)-(1-\theta^{R,O})(1-p_H)-(1-\theta^{R,O})m\delta-\theta^{R,O}\delta\gamma\right)-C \geq \\ & i-\mu\theta^{R,O}(1-p_H)-(1-\mu)\theta^{R,O}(1-p_L)-(1-\theta^{R,O})(1-p_H)-(1-\theta^{R,O})m\delta \\ & -\theta^{R,O}\delta\gamma. \end{aligned} \tag{55}$$

The first line of Expression (55) reflects the profit of a bank that screens the loan at cost C, grants a high loan, centrally hedges the fraction $(1-\theta^{R,O})$, and silently hedges the fraction $\theta^{R,O}$ of the corresponding credit risk on the uncleared OTC market. A detected low type loan is rejected. The second and third lines are the profit of a mimicking bank that grants any loan type without screening. It also retains the fraction $\theta^{R,O}$ to pretend having detected a high loan, and silently hedges the remaining fraction on the uncleared OTC market with a tailored credit derivative contract. The optimal fraction of credit risk to be retained from the centrally cleared market is obtained by following the steps in the proof of Proposition 2,

[16] Due to ϵ, there is no screening for $\theta^{R,O} > 1$.

in which λ is replaced by γ. It follows that

$$\theta^{R,O*} = \begin{cases} \frac{i-(1-p_H)-m\delta+C/(1-\mu)}{p_H-p_L+\delta(\gamma-m)} & if \quad \theta^{R,O*} \leq 1 \\ \frac{i-(1-p_H)+\delta(\epsilon-\gamma)+C/(1-\mu)}{p_H-p_L+\delta\epsilon} & if \quad \theta^{R,O*} > 1. \end{cases} \tag{56}$$

Using this $\theta^{R,O*}$ in the screening condition of Expression (24), and following the steps in the proof of Proposition 3 by replacing λ with γ shows that $p_S^{R,O}=p_S^O$, $p_G^{R,O}=p_G^O$, and $p_Q^{R,O}=p_Q^O$. $\square$

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Figures

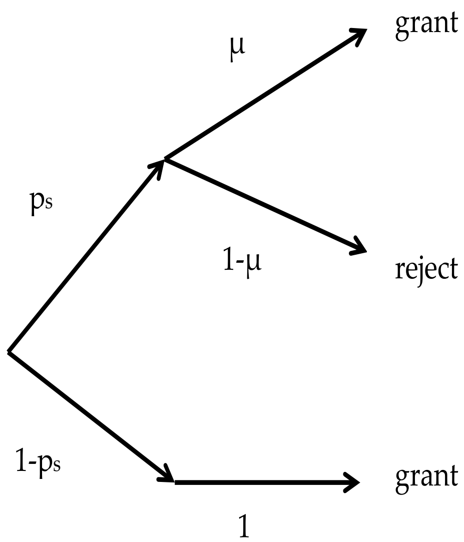

Figure 1: Bank lending decision without credit risk transfer. With probability p_S, the bank screens a loan. If the loan is of high type, which occurs with probability μ, the screened loan is granted. If the bank detects a low type loan, which occurs with probability $1-\mu$, it is rejected. With probability $1-p_S$, the bank does not screen. In this case, the loan is granted with probability one.

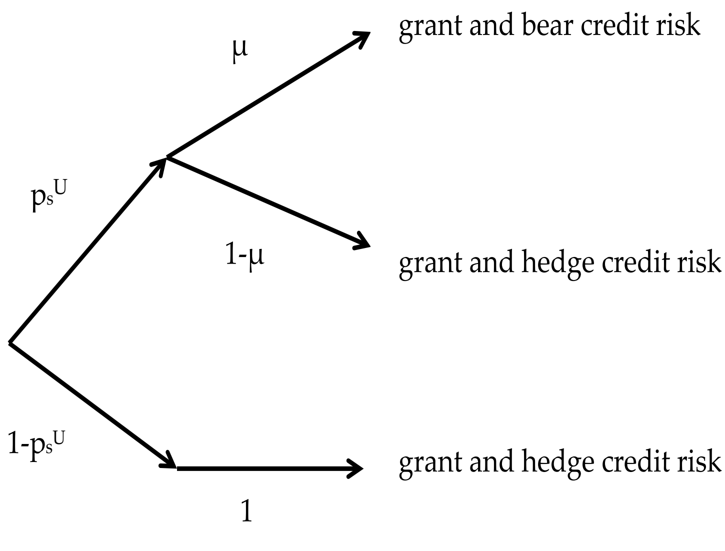

Figure 2: Bank lending and hedging decisions with centrally cleared credit risk transfer. With probability p_S^U, the bank screens a loan. If the loan is of high type, which occurs with probability μ, the screened loan is granted but not hedged. If the bank detects a low type loan, which occurs with probability $1-\mu$, it is granted and hedged. With probability $1-p_S^U$, the bank does not screen. In this case, the loan is granted and hedged with probability one.

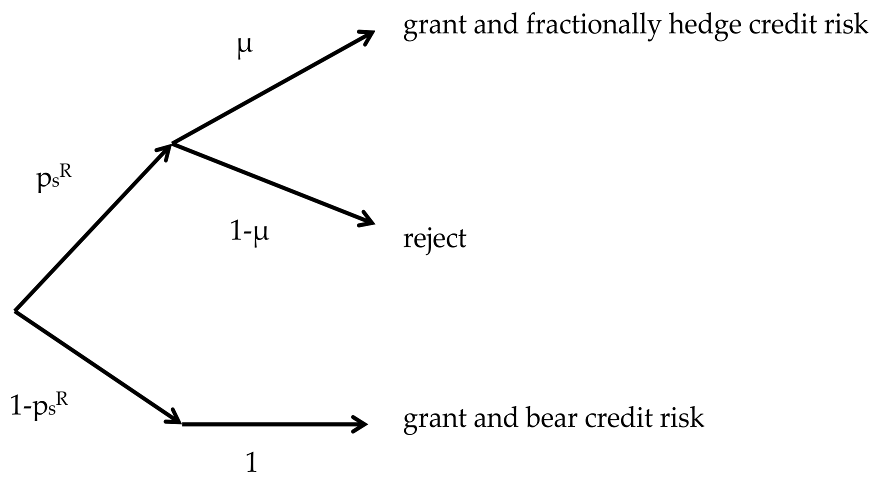

Figure 3: Bank lending and hedging decisions with restricted centrally cleared credit risk transfer. With probability p_S^R, the bank screens a loan. If the loan is of high type, which occurs with probability μ, the screened loan is granted and partially hedged. If the bank detects a low type loan, which occurs with probability $1-\mu$, it is rejected. With probability $1-p_S^R$, the bank does not screen. In this case, the loan is granted without hedging.

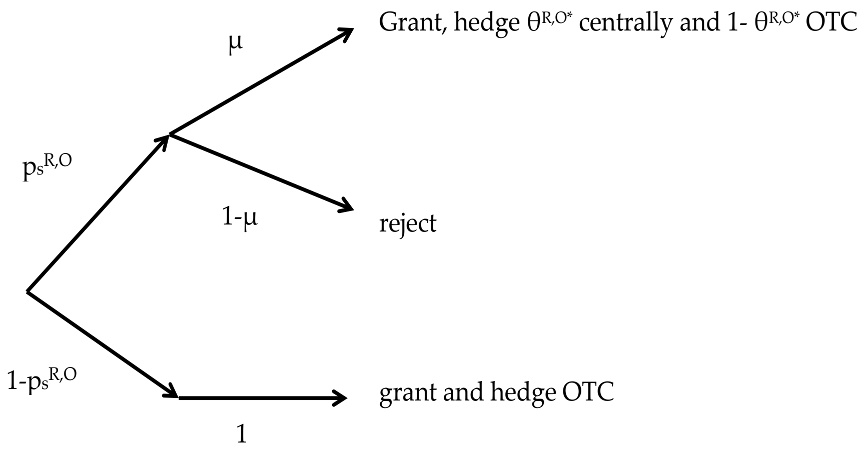

Figure 4: Bank lending and hedging decisions with access to both restricted centrally cleared and uncleared OTC credit risk transfer. With probability $p_S^{R,O}$, the bank screens a loan. If the loan is of high type, which occurs with probability μ, the screened loan is granted. The fraction $\theta^{R,O*}$ is hedged via central clearing, and the fraction $(1-\theta^{R,O*})$ via OTC market. If the bank detects a low type loan, which occurs with probability $1-\mu$, it is rejected. With probability $1-p_S^{R,O}$, the bank does not screen. In this case, the loan is granted and hedged on the uncleared OTC market.

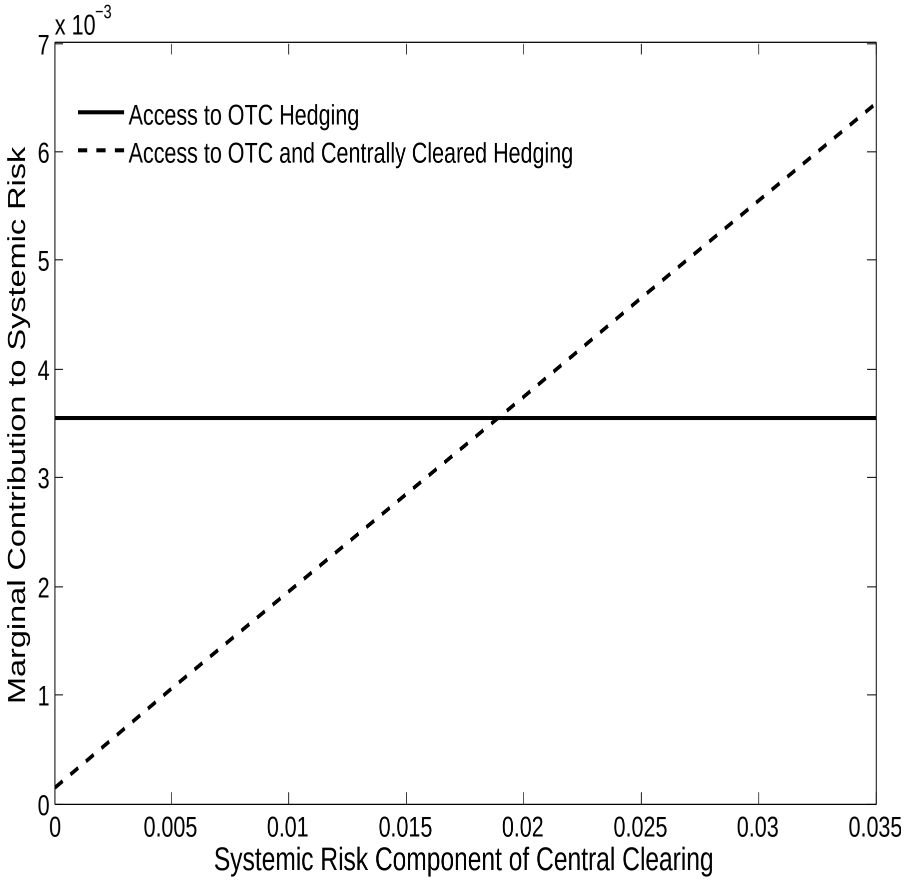

Figure 5: Marginal contributions to systemic risk from a potential loan granting. The solid line shows the marginal contribution to systemic risk from a potential loan granting if the bank only has access to the uncleared OTC market for different values of the systemic risk component of central clearing. The dashed line depicts the corresponding marginal contribution if the bank has access to both the uncleared OTC market and a centrally cleared credit risk transfer market.

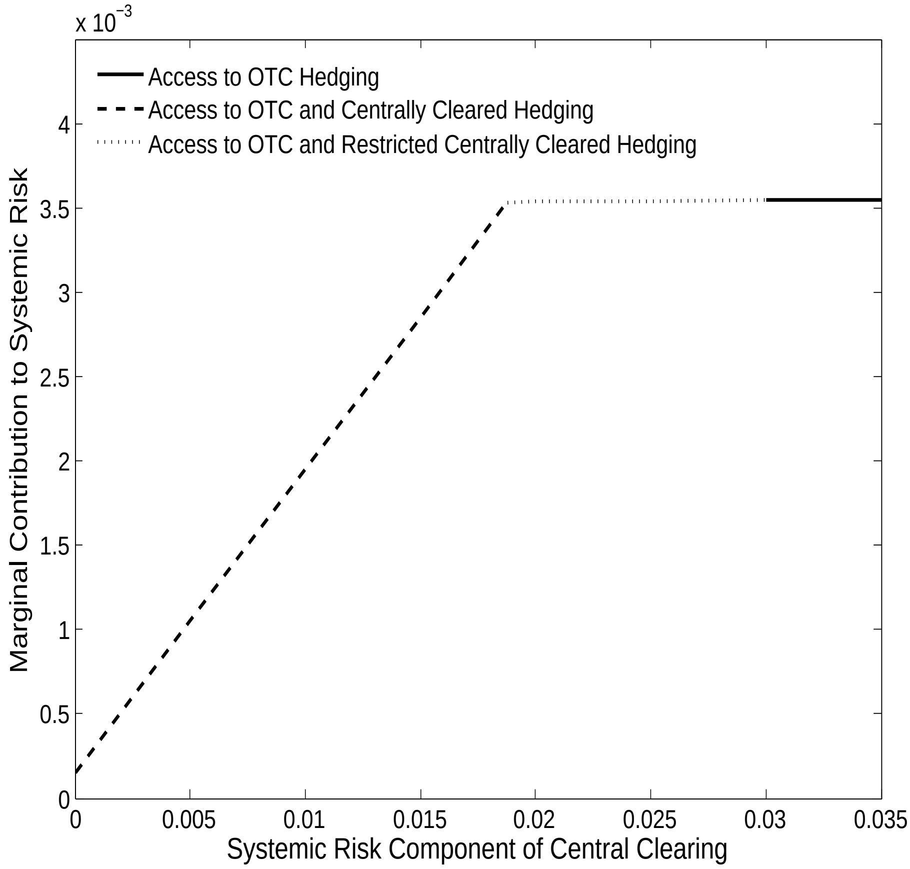

Figure 6: Minimum marginal contribution to systemic risk from a potential loan granting. The solid line shows the marginal contribution to systemic risk from a potential loan granting if the bank only has access to the uncleared OTC market for different values of the systemic risk component of central clearing. The dashed line depicts the corresponding marginal contribution if the bank has access to both the uncleared OTC market and a centrally cleared credit risk transfer market. The dotted line is the marginal contribution with a market infrastructure in which the bank can hedge a loan OTC and via restricted central clearing.