The Maturity Lengthening Role of National Development Banks*

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Abstract

We analyze why national development banks (NDBs) may provide longer-term loans to firms than to private commercial banks (PCBs). Our baseline model starts with a banking system with PCBs only. Confronted with the problem of maturity mismatch and liquidity risks, PCBs are reluctant to provide long-term finance. We then introduce an NDB to the banking system in which the NDB issues bonds to be purchased by PCBs. If NDB bonds have higher collateral value than bonds issued by PCBs, then NDBs may lend longer term to firms than PCBs. NDBs may enjoy greater collateral value of their bonds than PCBs because the state, the owner of NDBs, provides higher prospects of a recapitalization than private bank owners, in case of difficulties in honoring the issued bank bonds. Moreover, if the relative size of the NDB bond issuance is larger, then the market liquidity of these NDB bonds may be higher, increasing the collateral value of their bonds. Yet poorer monitoring skills and quality of NDBs may undermine the collateral value of their bonds and thus diminish their advantages over PCBs. Our study suggests that NDBs are not substitutes for but complements to PCBs.

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1 Introduction

The availability of long-term finance has a positive and significant impact on long-run growth (Beck, 2012). Moreover, it contributes to higher growth by playing a countercyclical role that lowers macroeconomic volatility (Aghion et al., 2005). When long-term finance is not available for eligible firms, they become vulnerable to rollover risks and may become reluctant to undertake longer-term fixed investments, leading to adverse effects on economic growth and welfare (Diamond, 1991). Despite its significance, long-term finance is in short supply, especially in developing countries.

One way to overcome the scarcity of long-term finance is to establish national development banks (NDBs). NDBs are financial institutions established by central governments with the official mission of fulfilling public policy objectives, such as financing high-risk and long-term projects that go beyond the risk appetite of private commercial banks (Armendáriz de Aghion, 1999). Worldwide, the total assets of all NDBs are as much as nine trillion dollars, accounting for about 10% of global gross domestic product.[1] Moreover, during the recent 2007/2008 financial crisis, NDBs were recognized to have acted in a countercyclical manner, which helped to stabilize the real economy (Brei and Schclarek, 2018).

Using a comprehensive list of NDBs worldwide, matched with bank-level data by Bankfocus (Hu et al., 2020), Figure 1 shows the average ratio of loans to customers longer than 5 years, discriminating among the following bank types: a) NDBs, b) state-owned commercial banks (SCBs), and c) privately owned commercial banks (PCBs). The database consists of a large sample of 1,251 banks, of which 58 are NDBs, 112 are SCBs, and 1,081 are PCBs, across 106 countries between 2011 and 2018. As clearly shown in Figure 1, and supported by the econometric findings of Hu et al. (2020), which control for individual bank-level characteristics and macroeconomic factors, NDBs provide longer-term loans to customers than do both SCBs and PCBs. Another empirical paper on the importance of NDBs for long-term loans is that of de Luna-Martinez and Vicente (2012), which, for a sample of 90 NDBs in 61 countries, discovered that 54% of loans had a maturity of over 10 years, 29% of loans had a maturity of 6-10 years, and only 16% of loans had a maturity of less than 5 years.

{Insert figure 1 here}

One reason why NDBs may provide long-term finance is that they have the official mission to do so because they are development-oriented rather than focusing exclusively on maximizing profits. NDBs may be more willing to internalize certain positive externalities of longer-term loans to firms and take on risks that private banks do not(Brei and Schclarek, 2013, 2015, 2018), and optimally lend longer-term than PCBs. [2] Another explanation is that the maturity-lengthening role of NDBs may be related to the time term of their funding sources (Griffith-Jones et al., 2018). Because PCBs rely predominately on short-term bank deposits, which may be withdrawn at any moment, PCBs are prone to higher maturity mismatch and refinancing risks when providing longer-term loans. By contrast, NDBs have longer-term liabilities, such as bonds, and may rely more on recapitalizations to finance their lending. Therefore, NDBs

[1] Data source: `https://financeincommon.org/pdb-database`, accessed 15 March 2021.

[2] It is worth noting that key preconditions for providing long-term financing are, among others, that NDBs have a proper corporate governance; good technical, financial and monitoring skills; sound liquidity and risk management; transparency; and efficiency. NDBs often fail in practice because of poor governance or undue political intervention.

are able to grant longer-term credits without incurring substantial maturity mismatch and refinancing risks.

In our paper, we build on the above insights and draw on additional insights from in-depth interviews with practitioners from NDBs to propose a novel explanation for the maturity-lengthening role of NDBs. Our core argument is that NDBs may lend longer term to firms than PCBs can, if NDB bonds have higher collateral value than bonds issued by PCBs. Our baseline model starts with a banking system containing PCBs only. PCBs suffer from maturity mismatch between loans to firms and deposits and thus faces liquidity risks, which may require them to issue bonds, or, equivalently, to obtain interbank loans to settle interbank payments (the survival constraint). If we consider that collateral is needed to secure promises because promises without collateral may be broken and difficult to enforce, the maximum amount that banks may obtain by issuing bonds (i.e. the collateral value of the bonds issued by banks) is primarily determined by the collateral capacity of banks' assets (or loans to firms). The collateral value of bank bonds is negatively related to the maturity of the bank loans to firms because long-term loans are often riskier than short-term ones. Thus, PCBs will optimally choose the maturity of loans to firms so that the collateral value of their bonds is high enough to overcome the survival constraint. Next, we introduce an NDB that finances its lending to firms by issuing bonds bought by PCBs. In case that PCBs need to settle interbank payments (the survival constraint), they may sell the NDB bonds instead of issuing their own bonds or, equivalently, requesting an interbank loan.

Our main proposition is that a banking system with both NDBs and PCBs may provide longer-term lending to firms compared with a banking system with PCBs only, if NDB bonds have higher collateral value than bonds issued by PCBs. One reason why NDB bonds may enjoy greater collateral value is that NDBs are owned by the government, which may have a higher recapitalization willingness and capacity than private bank owners in case of difficulties in honoring the issued bank bonds. Another advantage may be that NDBs finance themselves through bond issuance rather than deposit-creation and -taking, which may imply that the trading volume of NDB bonds is higher than that of any other commercial bank, thus enhancing the market liquidity of NDB bonds. However, if NDBs have a lower level of monitoring skills and quality than PCBs because of undue political intervention, their advantages over PCBs would be reduced in terms of their maturity-lengthening role. In addition, even if both NDBs and SCBs are owned by governments, NDBs may even have an advantage over SCBs in terms of the maturity of loans to firms, if NDB bonds have higher market liquidity than SCB bonds.

Regarding the related literature, the underlying money and banking theory that we use is the "money view" theory, as in Mehrling (2011), and Mehrling (2012). Our reason for using this theory instead of the conventional financial-intermediation theory of banking is that the money view theory is especially suitable for analyzing liquidity problems and the use of bank bonds or interbank loans to settle interbank payments (the survival constraint), in particular when bank deposits are not withdrawn from the banking system as a whole. For the limitations of the conventional financial-intermediation theory of banking regarding this point about the withdrawal of bank deposits, see, among others, Skeie (2008). Furthermore, we enrich the literature on assets' collateral capacity, as in Adrian and Boyarchenko (2012), Brunnermeier and Pedersen (2009), and Geanakoplos and Fostel (2008), by explicitly linking the collateral capacity of bank loans to firms with the maturity of those bank loans. To the best of our knowledge, our paper is the first to analyze this link between collateral capacity of bank loans and loan maturity. In addition, our paper is also based on the bank-monitoring literature, as in Diamond (1984), and Holmstrom and Tirole (1997); and on the market-liquidity literature, as in Amihud et al. (2006), Bao et al. (2011), Pagano (1989), and Vayanos and Wang (2013). Although an extensive banking literature has studied both monitoring and market liquidity, to the best of our knowledge our paper is the first to link these factors with the maturity of bank loans to firms. Finally, our paper follows the literature on the role of the government as liquidity provider, as in Gorton and Huang (2004) and Holmstrom and Tirole (1998).

The rest of the paper is organized as follows. We present the baseline model in section 2, where we first analyze a banking system with PCBs only. Next we introduce an NDB to the banking system and compare how the different prospects for a bank recapitalization affect the collateral value of bonds and thus the optimal maturity of bank lending to firms. In section 3 and section 4, we explore the consequences for the collateral value of bonds and thus for the maturity of lending by banks, of introducing heterogeneity in both the monitoring skills and quality of banks and the market liquidity of the bonds issued by banks. Finally, in section 5, we conclude with key findings and policy implications.

2 Baseline model

In this section, our baseline model starts with a banking system with PCBs only. We analyze the determinants of the optimal maturity of bank lending to firms when this lending creates liquidity risks for banks, and interbank payments may be settled by paying with liquid assets or by lending to each other through bank bonds or, equivalently, by making interbank loans. Our results show that the maturity of commercial bank lending to firms is positively related to both the amount of liquid assets held by PCBs and the recapitalization willingness (or perceived willingness) and the recapitalization capacity of private banks' owners. Then we introduce an NDB to the banking system in which the NDB finances its lending to firms by issuing bonds to be purchased by commercial banks. We show that NDB bonds may enjoy greater collateral value than those issued by PCBs. The reason is that the government has greater recapitalization capacity and willingness (or perceived willingness) than that of the private bank owners. Thus, we conclude that a banking system with both an NDB and PCBs can lend longer term to firms than can a banking system with PCBs only.

2.1 PCBs-Only Model

Our model starts by analyzing the case in which there are only PCBs that optimally choose the maturity of their lending to firms. The economy is characterized by a simple model in which decisions are made in the initial period 0; some of the uncertainty is revealed in the intermediate period 1, with its consequences; and the rest of the uncertainty is revealed and all the payoffs are settled in the final period T. Note that the final period T is a decision variable for PCBs, as the maturity of the lending to firms is of a variable length spanning T periods between period 0 and period T.

Following Allen and Gale (1998), Brei and Schclarek (2015), and Holmstrom and Tirole (1997), among others, we assume a firm or investor with a real investment project that must be funded through borrowing from banks in the initial period 0 and that pays off in the final period T. We assume that the firm has no liquid assets. Thus, to implement a real investment project of scale I, the firm must borrow I from bank j in the initial period 0. With the funds obtained in the initial period 0, the firm makes all the necessary payments to other agents, such as suppliers and staff, in the intermediate period 1. The real investment project has a stochastic per-period net rate of return $R(T)$, which is increasing in time because we assume that longer-term real investment projects have a higher per-period rate of return. We assume that $R(T)$ is equal to $R \cdot T$, where R is the stochastic net rate of return of a project of one period of length spanning period 0 and period 1 ($T = 1$). Then, the expected per-period net rate of return of a real investment project of maturity T is $T \cdot E(R)$, and the variance of the per-period net rate of return is $T^2 \cdot V(R)$. Note that the longer the maturity T of the real investment project, the higher the variance of the per-period net rate of return. Thus, longer-term real investment projects are more risky. Furthermore, and for purposes of simplicity, we assume that all payoffs of the investment project from the different periods materialize in the final period T.

Following the "money view" monetary theory, presented in Mehrling (2011, 2012); Mehrling et al. (2015), PCBs grant loans by creating bank deposits that the firm or investor will use to make payments (see line 1 of Table 1, where we present the balance sheets of the different agents using T-accounts: that is, assets on the left-hand side and liabilities on the right-hand side, following the "money view" monetary theory.)[3] It is assumed that PCB j decides to grant a fixed and given amount of lending D to the firm and creates the amount D of bank deposits in the initial period 0.[4] Bank j, however, must optimally choose the maturity T_j of the lending D in the initial period 0. Note that we are assuming that the maturity of the lending to the firm determines the maturity of the investment project. Thus, it is the optimal decision of bank j that will determine the maturity of the real investment project, which is T_j; the expected per-period net return of the real investment project, which is $T_j \cdot E(R)$; and its variance, which is $T_j^2 \cdot V(R)$. We also assume that bank deposits do not pay interest (i.e., they have no cost for bank j).[5]

Instead, bank j earns a per-period interest rate $i_L(T_j)$ for the lending to the firm, which is increasing in the maturity T_j of the lending because there is a term premium. Specifically, we assume that the per-period interest rate charged, $i_L(T_j)$, is equal to $T_j \cdot i_L$, where i_L is the interest rate charged for a loan of maturity 1 (i.e., that spans period 0 and period 1 ($T = 1$)).

In addition, we assume that $E(R) - i_L \geq 0$, so that the real investment project is risky but has an expected per-period rate of return that is enough to pay back the loan and the interest to the bank. Note that the larger the difference $E(R) - i_L$, the higher the expected per-period profits after paying interest, and thus the lower the probabilities that the firm will default on the loan. Note also that the probability that the firm will default on the loan is higher, and thus the loan is riskier, the longer the maturity T_j of the lending to the firm. The reason is that the longer the maturity T_j, the larger the variance of the per-period net return of the real investment project. In addition, we assume that the firm will only default on its loan in the final period T_j if the realized returns are not enough to pay back the loan capital and interest. Furthermore, we assume that all the capital and interest are paid in the last period T_j, when

[3]As will become clearer below, the process of lending to firms by creating bank deposits does not imply that PCBs can create bank deposits without limit. Among other limits, the liquidity risk that this process creates is a key constraint for commercial banks. In addition, there may also be prudential regulations that limit this process, such as the requirement that banks holds a certain amount of central bank deposits in proportion to the bank deposits. As our paper aims to offer a basic theoretical explanation of why NDBs are better able to provide long-term finance than PCBs, we will not analyze these limits given by prudential regulation.

[4]Note that we are assuming a fixed amount D, instead of taking D as a decision variable, to concentrate exclusively on the determination of the variable T. However, this simplifying assumption does not affect our main results.

[5]This simplifying assumption does not affect our main results.

the rest of the payoffs are realized and settled. All these assumptions imply that PCBs have an incentive to grant longer-term loans to increase the per-period interest rate that they charge to firms on their lending, but this will also increase the risk that firms default on their loans.

{Insert Table 1 here}

The chances of a maturity mismatch between a PCB's assets and liabilities resulting in its liquidity problems hinges on the probability of a net payment by that PCB to another PCB. Specifically, the creation of bank deposits by bank j in period 0 implies a promise to the firm (the deposit holder) that it will be able to use those bank deposits D to settle payments with other agents, such as suppliers and staff, in the intermediate period 1. If the deposit holder pays an agent who has a bank account in the same bank j, bank j has no liquidity problem because it makes no payment to another bank in the intermediate period 1. However, if the payment recipient has a bank account in a different bank k, bank j must make a payment to bank k in the intermediate period 1 to get bank k to credit the payment to the recipient's bank account (see lines 2 and 3 of Table 1). Note that if the payment from bank j to bank k is not settled, bank j cannot fulfill the promise made to the deposit holder that it may settle its payments. Consequently, bank j would probably suffer a bank run and bankruptcy. Thus, when bank j provides lending to the firm and creates bank deposits in the initial period 0, it is suffering a maturity mismatch between its assets and liabilities and is exposing itself to liquidity risk in the intermediate period 1. Note, finally, that bank k may also need to make a payment to bank j in the same period in which bank j must make a payment to bank k. This means that it is *net* payments from bank j to bank k that cause liquidity problems for bank j.

As far as liquidity problems for bank j are concerned, we can establish three possibilities regarding the net flow of payments with bank deposits between banks or the required net payments between banks j and k in the intermediate period 1. We assume that, following a categorical distribution, there is a probability α that there is a net outflow of deposits D from bank j to bank k, which requires a net payment D from bank j to bank k; a probability β that there is a net inflow of deposits D into bank j from bank k, which implies a net payment from bank k to bank j of D; and a probability $1 - \alpha - \beta$ that both banks j and k must make payments to each other and that the payments cancel out, so there is no net payment between the banks.[6]

In the case of a net outflow of deposits from bank j to bank k in the intermediate period 1, which requires a net payment of D from bank j to bank k, bank j can pay with the liquid assets A_j that it has available in the intermediate period 1. Alternatively, bank j can settle the payment to bank k by issuing bonds that it hands over to bank k or, equivalently, by getting an interbank loan from bank k (see lines 2 and 3 of Table 1).[7] This payment or survival constraint

[6] Note that we are assuming that the net payment involves the whole amount of deposits D, and not a fraction of those deposits, to minimize the different possibilities of payments between banks. This simplifying assumption has no consequences for our main results.

[7] Note, however, that solving the liquidity problems still hinges on the *willingness* of the other PCBs to receive the bonds to settle the payment or, equivalently, to grant the interbank loans. For simplicity reasons, we assume away these willingness concerns and assume that banks will always be able to settle interbank payments by issuing bonds as long as the collateral value of their assets is high enough. Thus, we assume that the payment system is well functioning and stable, without credit or market freezes or bank runs. This means that there is no need for a central bank to act as a lender of last resort when others do not want to lend, or as a dealer of last resort when others do not want to buy the assets. Further, also for simplicity reasons and without affecting our conclusions about the role of NDBs, we do not explicitly model interbank payments with central bank deposits.

in the intermediate period 1 implies that $D \leq B_j + A_j$, where B_j is the amount obtained by issuing the bonds and handing over them to bank k in the intermediate period 1.

We assume that the bonds issued by bank j pay a coupon rate or interest rate $i_B(T_j)$, which is increasing in the maturity T_j of the bonds. Specifically, we assume that the per-period interest rate that is charged $i_B(T_j)$ is equal to $T_j \cdot i_B$ for a bond of maturity T_j, where i_B is given and the interest rate $i_B(T_j)$ is increasing in T_j. In addition, for the purpose of simplicity and without affecting our results, we assume that the interbank loan or the bonds are of maturity $T_j - 1$ (i.e., spanning the intermediate period 1 and the final period T_j, when bank j obtains the proceeds from the loan to the firm). Thus, the per-period interest rate that is charged is $(T_j - 1) \cdot i_B$. Note that bank j could also issue bonds with maturity 1 and roll over the bonds $T_j - 1$ times to minimize the per-period interest rate that it is charged, which would be i_B. However, we assume away this possibility because, in this paper, we are not interested in analyzing the trade-offs between a lower per-period interest rate and the problems that arise when there are rollover risks.[8] Regarding the liquid assets A_j, we clarify some further aspects below in this same subsection.

We now turn to analyzing what determines the maximum amount of funds that bank j may obtain when issuing bonds and handing them over to bank k in the intermediate period 1, or equivalently, the maximum amount of the interbank loan from bank k to bank j. Following, among others, Adrian and Boyarchenko (2012), Brunnermeier and Pedersen (2009), Fostel and Geanakoplos (2014), and Geanakoplos and Fostel (2008), the maximum amount of funds that a bank can obtain by issuing bonds is related to the value of the assets that explicitly or implicitly backs or guarantees those bonds. Note that the reason for demanding collateral when lending is to secure promises because promises without collateral may be broken and difficult to enforce. Furthermore, any asset has a value as collateral determined by the asset's collateral capacity (i.e., the maximum amount that can be borrowed using that asset as collateral). In addition, the collateral capacity ratio of an asset is the asset's value as collateral divided by the fundamental value of that asset (Geanakoplos and Fostel, 2008). Thus, the maximum amount that bank j may obtain by issuing bonds and handing over them to bank k in the intermediate period 1 is determined by the collateral capacity of bank j's loans to the firm. Note that when referring to the collateral capacity of the bank loan to the firm, the bonds may be explicitly or implicitly guaranteed or backed by the bank loan to the firm. In this paper, we refer to this maximum amount as the collateral value of the bonds issued by bank j given by the collateral capacity of the loan to the firm.

Specifically, the collateral value of the bonds issued by bank j given by the collateral capacity of the loan to the firm is $B_j^L = \tau(T_j) \cdot \frac{((T_j-1)\cdot i_B)^{(T_j-1)}}{((T_j-1)\cdot i_D)^{(T_j-1)}} \cdot D$, where $\tau(T_j)$ is the collateral capacity ratio of the loan to the firm, where $0 \leq \tau(T_j) \leq 1$, and where $\frac{((T_j-1)\cdot i_B)^{(T_j-1)}}{((T_j-1)\cdot i_D)^{(T_j-1)}} \cdot D$ is the present value of the loan to the firm in the intermediate period 1 and $((T_j - 1) \cdot i_D)$ is the per-period discount rate that is increasing in T_j because of a term premium. Furthermore, we assume that the collateral capacity ratio is a negative function of the variance of the per-period net return of the real investment project, $T_j^2 \cdot V(R)$, which is a measure of the riskiness of the lending to

We make this simplification, not to deny the paramount role that central banks have, but to focus the analysis on situations where PCBs can settle payments among one another without the need for central bank deposits.

[8]Note also that the results and conclusions of this paper are not affected or driven by the fact that although the loan carries a per-period interest rate of $T_j \cdot i_L$ spanning T_j periods, the bonds issued by bank j pay a per-period interest rate of $(T_j - 1) \cdot i_B$ spanning $T_j - 1$ periods.

the firm, and thus affects the prospects for paying back the bonds issued by bank j. The exact functional form that is assumed for the collateral capacity ratio is $\tau(T_j) = 1 - \gamma \cdot T_j^2 \cdot V(R)$.[9] Note that the collateral capacity ratio of the lending to the firm is negatively related to the maturity T_j of the loan to the firm. The negative relationship between the collateral capacity of an asset and the variance of its return is also highlighted in Brunnermeier and Pedersen (2009) and Fostel and Geanakoplos (2014), among others.

Finally, we assume that the per-period discount rate is equal to the per-period interest rate paid by the bonds (i.e., $i_D = i_B$). We make this assumption to simplify the mathematical model and avoid non-linearities, but it does not affect the main conclusions of this paper. Then, the collateral value of the bonds issued by bank j given by the collateral capacity of the loan to the firm is $B_j^L = (1 - \gamma \cdot T_j^2 \cdot V(R)) \cdot D$, which is lower than D. Moreover, the longer the maturity of the lending of bank j determined in the initial period 0, the lower the collateral capacity of the lending to the firm in the intermediate period 1.

In addition, we assume that the maximum amount that bank j may obtain by issuing bonds and handing them over to bank k in the intermediate period 1 is also determined by the prospects that bank j will be bailed out or recapitalized by its owner in the final period T_j if it does not have enough liquid funds to pay back the issued bonds in full.[10] The default on the bank bonds could happen if, for example, the firm partially or totally defaulted on the granted bank loan. Thus, the prospects of a recapitalization affect the collateral value of the bank bonds (i.e., the maximum amount that banks may obtain through issuing bonds). We refer to this contribution to the total collateral value of the bank bonds as the collateral value of the bank bonds given by the prospects of a recapitalization, B_j^C. Although we do not discuss the exact form of the bailout or recapitalization, besides arguing that the recapitalization of the bank implies the availability of new liquid assets in period T_j that may be used to pay back the issued bonds, several papers have discussed the best way to carry out bank recapitalizations, such as Beccalli and Frantz (2016), Brei et al. (2013), and Enoch et al. (2001). Moreover, Beccalli and Frantz (2016) and Berger and Bouwman (2013), among other papers, have discussed the possible reasons for a bailout or recapitalization.

Specifically, the collateral value given by the prospects of a recapitalization B_j^C depends on the bank owners' financial capacity and availability of funds or assets in the final period T_j. Furthermore, even if bank j is fully willing to pay back the bonds, bondholders can be certain of being repaid only if there is a credible commitment from the bank's owners to recapitalize the bank in case there are not enough funds to pay back the bonds in the final period T_j. Thus, the collateral value given by the prospects of a recapitalization B_j^C also depends on the bank's owners' willingness (or perceived willingness) to recapitalize bank j in the final period T_j.[11][12] Then, we assume that the collateral value given by the prospects of a recapitalization is

[9] Note that the collateral capacity ratio should also be positively related to the difference between the expected per-period return of the investment project, $E(R)$, and the per-period interest rate of the lending to the firm, i_L, given that this difference also affects the probability of the firm defaulting on the loan and, thus, the riskiness of the bond issued by bank j. However, for simplicity reasons and without affecting our main results, we omit these factors.

[10] Note that in reality the bailout or recapitalization may be carried out by the current owners, new owners, or the government.

[11] We will further discuss the issue of the willingness and financial capacity for a bank recapitalization in subsection 2.2, when we introduce the NDB and the government, which is its owner.

[12] Although, to the best of our knowledge, no literature analyzes the willingness and financial capacity for a bank recapitalization, there is a large body of literature, including Sandleris (2016), which analyzes the willingness

$B_j^C = \omega_j \cdot C_j$, where ω_j captures the recapitalization willingness (or the perceived willingness) of the owner of bank j in the final period T_j, and C_j is the recapitalization capacity of the owner of bank j in the final period T_j. Furthermore, we assume that $0 \leq \omega_j \leq 1$, implying that the collateral value given by the prospects of a recapitalization B_j^C adopts values between 0 and a maximum value of C_j, the maximum recapitalization capacity for bank j in the final period T_j.

To conclude, the collateral value of the bonds issued by bank j in the intermediate period 1, B_j (i.e., the maximum amount that bank j may obtain by issuing bonds) is equal to the sum of the collateral value given by the collateral capacity of the bank loan to the firm B_j^L and the collateral value given by the prospects of a recapitalization B_j^C (i.e., $B_j = B_j^L + B_j^C$). Note that the fundamental value of the bonds issued by a bank is related to the present value of the bonds' future interest payments, which is a function of the coupon rate (in this paper $i_B(T_j)$), and of the bonds' value upon maturity, also known as its face value or par value (in this paper B_j or $D - A_j$). However, because we follow the above-mentioned literature on the importance of collateral, the maximum amount that the bank may obtain by issuing bonds is not given by the fundamental value of these bonds but by the collateral value of these bonds. This is so because the fundamental value is related to the promise of what you will get if that promise is honored, whereas the collateral value is what you can be certain to get back in the future. Thus, we have that

$$B_j = (1 - \gamma \cdot T_j^2 \cdot V(R)) \cdot D + \omega_j \cdot C_j. \tag{1}$$

From equation 1, it is clear that the longer the maturity of the loans to firms T_j, the lower the collateral capacity of these loans, and the lower the collateral value of the bonds that bank j issues B_j. In addition, the higher the recapitalization willingness (or the perceived willingness) of the owner of bank j in the final period T_j ω_j and the higher the recapitalization capacity of the owner of bank j in the final period T_j C_j, the higher the collateral value of the bonds that bank j issues B_j. Thus, we have the following lemma.

Lemma 1. *B_j is decreasing in T_j and increasing in ω_j and C_j.*

Then, in the case of a net outflow of deposits from bank j, and taking into account the collateral value of the bonds that bank j can issue in the intermediate period 1 and the liquid assets A_j that it has available in the intermediate period 1, the payment or survival constraint in the intermediate period 1 requires that $D \leq (1 - \gamma \cdot T_j^2 \cdot V(R)) \cdot D + \omega_j \cdot C_j + A_j$. Regarding the liquid assets A_j, these can be thought of as bank deposits in another bank, central bank deposits, or, more generally, any real or financial assets whose return is non-stochastic, which implies that their return has a zero variance and, thus, a collateral capacity ratio of 1.[13]

Finally, in the case of a net inflow of deposits to bank j from bank k, the amount of inflows D, the maturity of the direct lending by bank k T_k, and the liquid asset holdings of bank k A_k are given. Furthermore, assuming that bank j grants the interbank loan to bank k in the intermediate period 1, bank j is getting a per-period interest income of $(T_k - 1) \cdot i_B \cdot (D - A_k)$.

With this setup, we can now analyze the optimal behavior of bank j when it must decide the optimal maturity of its lending to the firm in the initial period 0 T_j^*. We assume that the

and financial capacity of governments to pay their issued bonds.

[13]Even more generally, the liquid assets could be real or financial assets whose return is stochastic, but given their collateral capacity have a collateral value of A_j.

expected utility of banks depends on the mean of the portfolio return given by $E(U) = E(R_P)$, where R_P is the return of the portfolio. Then banks' maximization problem, analyzed as the maximization of the per-period return, is

$$\begin{aligned}
&\max_{T_j} \quad \alpha \cdot (T_j \cdot i_L \cdot D - \frac{(T_j - 1)}{T_j} \cdot (T_j - 1) \cdot i_B \cdot (D - A_j)) + \beta \cdot (T_j \cdot i_L \cdot D \\
&+ \frac{(T_k - 1)}{T_k} \cdot (T_k - 1) \cdot i_B \cdot (D - A_k)) + (1 - \alpha - \beta) \cdot T_j \cdot i_L \cdot D \qquad (2) \\
&s.t. \\
&D \leq (1 - \gamma \cdot T_j^2 \cdot V(R)) \cdot D + \omega_j \cdot C_j + A_j,
\end{aligned}$$

where the first term is the expected per-period return when there is a net outflow of bank deposits in the intermediate period 1, the second term is the expected per-period return when there is a net inflow of bank deposits in the intermediate period 1, and the third term is the expected per-period return when there is no net payment between the banks in the intermediate period 1. Note that we introduce the fractions $\frac{(T_j - 1)}{T_j}$ and $\frac{(T_k - 1)}{T_k}$ to capture the fact that these interbank loans accrue interest between periods 1 to T_j or T_k, which imply one period less than the lending to the firm, which spans periods 0 and T_j or T_k. Finally, $D \leq (1 - \gamma \cdot T_j^2 \cdot V(R)) \cdot D + \omega_j \cdot C_j + A_j$ is the survival constraint.

The maximization problem (2) implies that the optimal maturity of lending by bank j to the firm T_j^* is infinite if the payment or survival constraint is not binding. The reason is that the partial derivative of the objective function in (2) is always positive under a reasonable assumption about the relationship between i_L and i_B. Denote $U(T_j)$ as the objective function of (2); thus $\frac{\partial U(T_j)}{\partial T_j} = i_L \cdot D - \alpha \cdot i_B \cdot (D - A_j) \cdot (1 - \frac{1}{T_j^2}) > 0$ as long as $\frac{i_L}{i_B} > \alpha \cdot (1 - \frac{A_j}{D})$ given that $T_j \geq 1$. Actually, the requirement $\frac{i_L}{i_B} > \alpha \cdot \left(1 - \frac{A_j}{D}\right)$ is weak and easily satisfied: first, if $i_L \geq i_B$, then the condition is always satisfied; second, when $i_L < i_B$, given that $0 < \alpha < 1$, $0 < \frac{A_j}{D} < 1$, it is still fine as long as i_L is not too much smaller than i_B.[14] Thus, under the reasonable assumption that the absolute difference between i_L and i_B is not too absurdly large, the optimal T_j^* is infinite if the payment or survival constraint is not binding.

However, if the survival constraint is binding and we assume that banks always want to be able to settle payments in the case of a net outflow of deposits in the intermediate period 1, the optimal maturity of lending by bank j to the firm T_j^* is determined by $D = (1 - \gamma \cdot T_j^{*2} \cdot V(R)) \cdot D + \omega_j \cdot C_j + A_j$. This means that bank j will choose the maturity of its loans to the firm in the initial period 0 so that the collateral value of its bonds in the intermediate period 1 is high enough for bank j to use them, in conjunction with its liquid assets A_j, to settle net payment of D with bank k. Note that bank j must take into account this trade-off between the maturity of the lending to the firm and the collateral value of the bonds that it issues. Then, the maximum maturity of the lending to the firm by bank j in the initial period 0, T_j^*, is

$$T_j^* = \frac{\sqrt{\gamma \cdot V(R) \cdot D \cdot (\omega_j \cdot C_j + A_j)}}{\gamma \cdot V(R) \cdot D}. \qquad (3)$$

From Equation (3), we have the following proposition.

[14] Recall that i_L and i_B are taken as given and that their market determination is beyond the scope of this paper.

Proposition 1. *The maximum maturity of the lending to the firm by bank j in the initial period 0, T_j^*, is: a) negatively related to $V(R)$; b) negatively related to γ; c) positively related to C_j; d) positively related to ω_j; e) positively related to A_j; and f) negatively related to D.*

From Proposition 1, we have the following results, *ceteris paribus*:

(1) from point a) and b) of the proposition, a higher variance of the per-period rate of return of a real investment project of maturity 1 (i.e., an increase in the riskiness of the project), $V(R)$, and a higher γ imply a lower collateral capacity ratio of the lending to the firm and a lower collateral value given by the collateral capacity of the bank loan to the firm in the intermediate period 1, B_j^L; thus, the maturity of the lending in the initial period 0 is shortened;

(2) from point c) and d) of the proposition, a higher recapitalization capacity of the owner of bank j, C_j, and a higher recapitalization willingness (or perceived willingness) by the owner of bank j, ω_j, imply a higher collateral value given by the prospects of a recapitalization in the intermediate period 1, B_j^C; thus, the maturity of the lending in the period 0 is lengthened;

(3) from point e) of the proposition, larger holdings of liquid assets by bank j in the intermediate period 1, A_j, imply that there are more liquid assets to settle payments in the case of a net outflow of deposits in the intermediate period 1; thus, the maturity of the lending in the period 0 is lengthened; and

(4) from point f) of the proposition, a lower amount of bank j's lending to the firm in the initial period 0, D, implies that less funds are needed to settle payments in the case of a net outflow of deposits in the intermediate period 1; thus, the maturity of the lending in the period 0 is lengthened.

2.2 Model with an NDB

In this subsection, we introduce an NDB that is wholly owned by the government or the state. We assume that the NDB finances its lending to the firms by issuing NDB bonds and selling them to commercial banks to obtain bank deposits at the PCBs. Then, the NDB uses those bank deposits at the PCBs to lend them out to the firms.[15][16] Next, we compare the optimal determination of the maturity of loans to the firms for this banking system with an NDB and PCBs with the alternative banking system with only PCBs that was analyzed in subsection 2.1.

{Insert Table 2 here}

Concretely, we assume that PCB j invests in NDB bonds in the initial period 0 by creating bank deposits D, which are used to pay the NDB (see line 1 of Table 2). With these bank deposits, the NDB grants lending D to the firm in the initial period 0 and transfers its deposits

[15] Note that although NDBs may also create bank deposits, as PCBs can, here we concentrate on analyzing an NDB that does not participate in the retail payment system and therefore cannot create bank deposits to be used in the retail payment system. This assumption is similar to assuming that the NDB creates bank deposits but the firms that get those bank deposits operate their payments through PCBs and, thus, will inevitably transfer all those bank deposits from the NDB to a PCB in the initial period 0. Therefore, the NDB will inevitably have to issue bank bonds in the initial period 0, or equivalently request an interbank loan, in order to settle that interbank payment with the PCB.

[16] Note that with the adding of NDB bonds, PCBs have two options for investing: they can either lend directly to the firms, as analyzed in the last subsection 2.1, or they can buy NDB bonds. In this paper, the setup of the model is such that PCBs are completely indifferent between these two options. Thus, we are not analyzing the optimal portfolio choice of PCBs in terms of choosing the proportions of lending directly to the firms and holding NDB bonds.

D in PCB j to the firm's account in PCB j (see line 2 of Table 2). In the intermediate period 1, if there is a net outflow of deposits D from PCB j, requiring a net payment D from PCB j to PCB k, PCB j may settle its payments to PCB k by selling its NDB bonds rather than obtaining an interbank loan or issuing its own bonds to bank k, as in subsection 2.1, and using its own liquid assets available in the intermediate period 1 A_j (see lines 3 and 4 of Table 2). Then, the binding survival constraint in the intermediate period 1 for PCB j, analyzed in the last subsection 2.1, is $D \leq B_{NDB} + A_j$.

In the intermediate period 1, the collateral value of the NDB bonds B_{NDB} is determined by the collateral value given by the collateral capacity of the NDB's loan to the firm $B^L_{NDB} = (1 - \gamma \cdot T^2_{NDB} \cdot V(R)) \cdot D$, which is negatively related to the maturity of this lending to the firm, just as in subsection 2.1. Further, it is also determined by the collateral value given by the prospects of a recapitalization B^C_{NDB}, dependent on both the willingness (or the perceived willingness) to recapitalize the NDB ω_{NDB} and the recapitalization capacity of the government (the owner of the NDB) in the final period T_{NDB} C_{NDB}, as analyzed in subsection 2.1. In addition, the collateral value of the NDB bonds is also determined by the NDB's liquid asset holdings $B^A_{NDB} = A_{NDB}$. These liquid asset holdings of the NDB serve as collateral to the NDB bonds, meaning that these liquid assets guarantee the repayment of the NDB bonds once they mature and thus increase the collateral value of the NDB bonds. Here we assume that the collateral capacity ratio of these liquid assets is 1 and thus increases the collateral value of the NDB bonds by A_{NDB}. Recall that we assumed that PCBs use their liquid assets to directly settle payments with other PCBs, but we could also have assumed that PCBs used those liquid assets as collateral to increase the collateral value of their bonds. Thus, the collateral value of the NDB bonds in the intermediate period 1, B_{NDB}, is

$$B_{NDB} = (1 - \gamma \cdot T^2_{NDB} \cdot V(R)) \cdot D + \omega_{NDB} \cdot C_{NDB} + A_{NDB}. \tag{4}$$

From equation 4, it is clear that the longer the maturity of the loans to firms T_{NDB}, the lower the collateral capacity of these loans, and the lower the collateral value of the bonds that the NDB issues B_{NDB}. In addition, the higher the recapitalization willingness (or the perceived willingness) of the government in the final period T_{NDB} ω_{NDB} and the higher the recapitalization capacity of the government in the final period T_{NDB} C_{NDB}, the higher the collateral value of the bonds that the NDB issues B_{NDB}. Thus, we have the following lemma.

Lemma 2. *B_{NDB} is decreasing in T_{NDB} and increasing in ω_{NDB} and C_{NDB}.*

In the initial period 0, when the NDB issues its NDB bonds and must decide the maturity of its loans to the firm, the NDB must take into account the collateral value of the NDB bonds in the intermediate period 1 from equation 4 and the payment or survival constraint of PCB j in the intermediate period 1 $D \leq B_{NDB} + A_j$. Note that although it is the NDB that lends to the firm, and not PCB j directly, because it is PCB j that creates bank deposits to finance the NDB in the initial period 0, it is still the case that PCB j faces liquidity risks when buying NDB bonds because bank deposits from PCB j may be transferred in the intermediate period 1 to PCB k, as analyzed in subsection 2.1. Thus, in the initial period 0, the optimal maturity of lending by the NDB to the firm is determined by $D = (1 - \gamma \cdot {T^*_{NDB}}^2 \cdot V(R)) \cdot D + \omega_{NDB} \cdot C_{NDB} + A_{NDB} + A_j$, meaning that the NDB will choose the maturity of its loans to the firm in the initial period 0 so that the collateral value of the NDB bonds in the intermediate period 1 is high enough for PCB j to be able to use them, in conjunction with its liquid assets A_j, to settle net payment of

D with PCB k. Note that the NDB must take into account this trade-off between the maturity of the lending to the firm and the value of the bonds that it issues.[17] Then, the maximum maturity of the lending to the firm by the NDB in the initial period 0, T^*_{NDB}, is

$$T^*_{NDB} = \frac{\sqrt{\gamma \cdot V(R) \cdot D \cdot (\omega_{NDB} \cdot C_{NDB} + A_{NDB} + A_j)}}{\gamma \cdot V(R) \cdot D}. \quad (5)$$

Note that in equation 5 we not only have the liquid assets of the NDB, A_{NDB}, but also the liquid assets of the PCB j, A_j, because A_{NDB} is used as collateral for the bond issuance, as discussed above, and A_j is used by PCB j to directly settle its payment with PCB k in the intermediate period 1 if needed. Thus, if we compare T^*_{NDB} from equation 5 with T^*_j from equation 3, as long as $A_{NDB} > 0$, it is clear that $T^*_{NDB} > T^*_j$, meaning that the NDB will provide longer-term loans to the firm than the PCB would. However, this is not an advantage per se of the banking systems with an NDB and PCBs over the alternative banking system with only PCBs but rather the consequence of there just being more liquid assets in the system as a whole. If the NDB had no liquid assets, then it would no longer necessarily be true that $T^*_{NDB} > T^*_j$.

From Equation (5), we have the following proposition.

Proposition 2. *The maximum maturity of the lending to the firm by the NDB in the initial period 0, T^*_{NDB}, depends on the same factors as in the case of the PCB j, T^*_j, from proposition 1.*

We now turn to compare the maximum maturity of lending to the firm by the NDB, T^*_{NDB}, with that by the PCB j, T^*_j. If the recapitalization capacity of the bank owner C and the willingness (or perceived willingness) to recapitalize the bank by its owner ω are higher for the owner of the NDB, the government or state, than for the private bank owners, implying that $C_{NDB} > C_j$ and $\omega_{NDB} > \omega_j$, then the maximum maturity that the NDB may choose for its lending to the firm in the initial period 0, T^*_{NDB}, is longer term than the maximum maturity that the CB j may choose for its lending to the firm in the initial period 0, T^*_j. Note that this result holds even when $A_{NDB} = 0$. Thus, the higher recapitalization capacity and the willingness (or perceived willingness) to recapitalize the NDB by its owner, the government, in comparison with the private bank owners imply a real advantage of banking systems with an NDB and PCBs over the alternative banking system with only privately-owned CBs, analyzed in subsection 2.1. This result is our key explanation for the maturity-lengthening role of NDBs.

Corollary 1. *If $C_{NDB} > C_j$ and $\omega_{NDB} > \omega_j$, then, from equations 3 and 5, we have that $T^*_{NDB} > T^*_j$.*

{Insert Figure 2 here}

[17]Note that we are assuming that, in the initial period 0, the NDB bonds are issued at the same time that the NDB is granting its lending to the firm and choosing the maturity of the lending to the firm, which determines the collateral value of the NDB bond in the intermediate period 1. If the NDB bonds are issued before the NDB determines the maturity of its lending to the firm, the NDB needs to credibly commit to respecting the constraint $D \leq B_{NDB} + A_j$. If the NDB cannot commit to respecting that constraint, CBs will undertake additional liquidity risks when buying NDB bonds, and, thus, will reduce its collateral valuation of the NDB bonds. This case is not studied in this paper.

To clarify the results above, in Figure 2 we compare the collateral value of the bonds issued by the NDB, B_{NDB}, from equation 4, with the collateral value of the bonds issued by PCB j, B_j, from equation 1, representing the maturity of the lending to the firm in the horizontal axis. Note that we assume that the NDB has no liquid assets ($A_{NDB} = 0$) to compare two banking systems that have the same total amount of liquid assets. Clearly, in figure 2, whereas point X, which represents the case of the PCB, implies the same collateral value (the vertical axis) as point Y, which represents the case of the NDB, point Y implies a longer maturity of the lending to the firm (the horizontal axis) than point X. This longer maturity of the lending to the firm by the NDB in comparison with the PCB j is the result of its higher collateral value given by the prospects of a recapitalization than that of the PCB j.

In addition, given a certain maturity of the lending to the firms by either the PCB j or the NDB, the collateral value of the bonds issued by the NDB is greater than the collateral value of the bonds issued by the PCB j. This result is depicted in Figure 2 by comparing point X (PCB j) and point Z (NDB). This result implies that, given a certain maturity of the lending to the firms, PCB j is better able to cope with interbank payments when holding NDB bonds than issuing its own bonds. Note, finally, that for both the NDB and PCB j, for low values of the maturity of the lending to the firm, there initially is a negative relationship between the collateral value of the bank bonds and the maturity of the lending to the firm, but at high values of the maturity of the lending to the firm, the relationship is horizontal. This horizontal relationship occurs when the collateral value given by the collateral capacity of the bank loan to the firm is zero and the full collateral value of the bank bonds is determined by the collateral value given by the prospects of a recapitalization by the owner of the bank.

The justification for the higher recapitalization capacity of the owner of the NDB, the government, in comparison with that of the owners of the PCBs, following the arguments by Brei and Schclarek (2015), Brei and Schclarek (2018), Gorton and Huang (2004), and Holmstrom and Tirole (1998), among others, is that the government has access to more liquid assets in the final period T than the private bank owners. This is because the government may not only have more existing liquid assets in the final period T but can also get additional liquid assets by taxing the different agents, especially successful investment projects and the banks granting loans for the funding of such projects. Instead, the private owners may also have existing liquid assets in the final period T with which to recapitalize their banks, but they cannot tax other agents to get additional liquid assets. Note that this argument hinges not only on the size of the government in comparison with the private bank owners, in terms of owning liquid assets, but also fundamentally on the ability to raise taxes given by the legal power of the state. In addition, related to the taxation argument, the government may find it easier and cheaper than private bank owners to access additional capital by borrowing from national or international financial markets.

Regarding the recapitalization willingness (or perceived willingness), it is very likely that the government is more willing to recapitalize the NDB than private bank owners are to recapitalize their PCBs.[18] Given that a bank's failure may have externalities by affecting other banks through contagion and the economy as a whole, affecting social welfare, the government has more to lose than the private owners. Whereas the private bank owners lose only their own capital in the failing banks, the government may, among other consequences, have to increase

[18] If the government is not credible or has a track record of breaking its promises, a more profound credibility analysis should be made, but this is out of the scope of this paper and is left for future research. Further, the possibility of future recapitalization also raises moral hazard considerations that are not analyzed in this paper.

unemployment benefits, obtain lower tax revenues, lose elections because of voters' dissatisfaction, or not be able to foster more innovative and strategic sectors that require long-term financing. Furthermore, the government may be more eager to recapitalize the NDB to foster and preserve state capacities, such as in-house financial and industrial expertise, that would be lost in case of default and closure of the NDB (Fernández-Arias et al., 2020).

Moreover, this greater willingness (or perceived willingness) of the government to recapitalize banks is evident when considering that in many instances the government has even been willing to bail out private banks to avoid their closure. Among the literature that analyzes bailouts of the private banking system, see, among others, Beccalli and Frantz (2016), Brei et al. (2013), Diamond and Rajan (2005), and Gorton and Huang (2004). Note, however, that these government bailouts of private banks are usually carried out not to save private bank owners, creditors, or bondholders but rather to avoid deposit runs and save small deposit holders. Thus, even if the government bails out private banks, it should be expected that private bank owners, creditors, and bondholders will suffer some losses even if the private banks are eventually recapitalized. This will undermine the collateral value of private bank bonds, given the probable losses of bondholders. Consequently, even if the government's willingness to bail out private banks, especially big, systemically important, and interconnected private banks, is high, it is not unreasonable to expect that the willingness to bailout a government-owned bank is always higher. Note also that, although out of this paper's scope, if for some reason agents have difficulty in correctly evaluating the recapitalization capacity and willingness of the government and the private bank owners, the government may try to correct this imperfect-information problem through banking regulations, such as NDB bonds enjoying zero-risk weighting in its valuation.

Finally, note that if the government issues its own bonds to PCBs, and these bonds have a higher collateral value than NDB bonds because of a higher recapitalization willingness (or perceived willingness), a superior result, in terms of the maturity of lending to the firms other than those in the case analyzed above, may be achieved. In this case, it may be better if the government issues its bonds to PCBs and uses those bank deposits to recapitalize the NDB so that that the NDB can, in turn, lend to the firms. However, a possible argument in favor of the NDB financing its lending to firms through issuing its own bonds, rather than the government's recapitalization, even when government bonds have a higher collateral value than NDB bonds, is that NDB bonds do not increase the government debt burden and that fiscal constraints would not appear for the government. Further, the financing of NDB lending through NDB bonds may even exert some market discipline on the management of the NDB because if their lending decisions are not good enough (lending to bad firms or projects), this would be reflected in the collateral value of NDB bonds.

3 Monitoring quality and the maturity of bank lending

In this section, following the literature on bank monitoring, which include, among others, Diamond (1984), Eslava and Freixas (2016), Holmstrom and Tirole (1997), and Cetorelli and Peretto (2012), we add to the model of the last section the assumption that each bank has idiosyncratic monitoring skills. Note that the monitoring skills include skills such as evaluating projects, screening borrowers, and collecting repayments from them. As will be clarified below, the monitoring skills, which determine the monitoring quality of the banks, affect the collateral value of the bonds issued by those banks and thus affect the maturity of the lending to firms by those banks. Through this mechanism, and if we assume that the monitoring quality of state-owned banks is lower than that of private-owned banks, we add a new channel through which the advantages of state-owned banks, presented in the last section, are reduced and those of private-owned banks are increased. In this sense, the double-edged sword of state ownership is highlighted here.

Specifically, we now assume that the variance of the per-period net rate of return for an investment project, $T^2 \cdot V(R)$, is not known with certainty. Thus, banks must assess the true or correct variance of the per-period net rate of return for an investment project. We assume that the idiosyncratic monitoring quality of banks affects their evaluation and discovery of the true variance of the per-period net rate of return for an investment project. Further, we assume that only the bank that is actively involved in the lending to the investment project is able to assess directly the true variance of the investment project. The other banks, which are not actively involved in the lending to the investment project but may later lend to or buy bonds from the active bank, will assess indirectly the true variance of the investment project of the active bank. They will consider the estimation of the true variance of the investment project by the active bank but will also take into consideration the active bank's monitoring skills and quality, which we assume are known by all.[19] Therefore, when a certain bank j estimates that the variance of the per-period net rate of return for an investment project is $T_j^2 \cdot V(R)$, other banks will infer that the true variance of the investment project is $T_j^2 \cdot V(R) \cdot q_j$, where $q_j \geq 1$ is a measure of the monitoring quality of bank j and where the greater value for q_j corresponds to lower monitoring quality. Thus, the lower the monitoring quality of bank j (i.e., the greater the value of q_j), the larger the true variance inferred by the other banks. Note that following this reasoning, the analysis in the last section can be interpreted as a case where bank j is perfect at monitoring ($q_j = 1$) and thus the other banks will be certain that the variance estimated and informed by bank j is the true one.

With this new assumption about the monitoring quality of banks, the collateral value of the bonds issued by bank j with monitoring quality q_j in the intermediate period 1, $B_j(q_j)$, is

$$B_j(q_j) = (1 - \gamma \cdot T_j^2 \cdot V(R) \cdot q_j) \cdot D + \omega_j \cdot C_j. \tag{6}$$

Thus, given a certain $T_j^2 \cdot V(R)$, banks with better monitoring quality will also be able to issue bonds with higher collateral value. The reason is that the other banks perceive that the collateral value given by the collateral capacity of the bank loan to the firm, $B_j^L(q_j) = (1 - \gamma \cdot T_j^2 \cdot V(R) \cdot q_j) \cdot D$, has a higher value because of the lower perceived variance of the per-period net rate of return of the investment project, $T_j^2 \cdot V(R) \cdot q_j$.

Now, and following equation 3, the maximum maturity of the lending to the firm by bank j with monitoring quality q_j in the initial period 0, $T_j^*(q_j)$, becomes

$$T_j^*(q_j) = \frac{\sqrt{\gamma \cdot V(R) \cdot q_j \cdot D \cdot (\omega_j \cdot C_j + A_j)}}{\gamma \cdot V(R) \cdot q_j \cdot D}. \tag{7}$$

From Equation (7), we have the following proposition.

Proposition 3. *$T^*(q_j)$ is decreasing in q_j.*

[19] These assumptions may be justified by asymmetric information or imperfect information arguments.

These results imply that, given a certain collateral value for the bonds issued by the banks, banks with better monitoring quality will be able to lend to firms with longer maturity than banks with lesser monitoring quality. Similarly, given a certain level for the maturity of the lending to the firms, the collateral value of the bonds issued by banks with better monitoring quality is higher than the value of the bonds issued by banks with lesser monitoring quality. In Figure 3 we depict these results by comparing the collateral value of the bonds issued by a bank with high monitoring quality with the collateral value of the bonds issued by a bank with low monitoring quality, representing the maturity of the lending to the firm in the horizontal axis.

{Insert Figure 3 here}

We now turn back to the comparison in subsection 2.2 between a banking system in which the NDB grants the loans to the firms financed by PCBs that buy the NDB bonds with a banking system in which the PCBs directly grant the loans to the firms. The analysis about the idiosyncratic monitoring quality may be used to compare the optimal determination of the maturity of the lending to firms by these two types of banks. If we assume that the NDB has a lower monitoring quality than PCBs, meaning that $q_{CB} < q_{NDB}$, this reduces the NDB's advantage over PCBs in terms of the lengthening of the maturity of lending to firms. Recall that in subsection 2.2, we assumed that the NDB had an advantage over PCBs given by the higher recapitalization capacity and willingness (or perceived willingness) to recapitalize the bank by the government or state over private bank owners (i.e., $C_{NDB} > C_{CB}$ and $\omega_{NDB} > \omega_{CB}$).

Corollary 2. *When monitoring quality is sufficiently low for the NDB, in comparison with the PCBs, the NDB may grant loans of shorter maturity than those of the PCBs, even when* $C_{NDB} > C_{CB}$ *and* $\omega_{NDB} > \omega_{CB}$.

Figure 4 depicts what is expressed in corollary 2 and highlights two subregions where the results are different. In subregion Z, although low monitoring quality puts the NDB at a disadvantage, the NDB still benefits from the higher collateral value given by the recapitalization willingness and capacity and thus can still grant loans of longer maturity in comparison with PCBs, given a certain collateral value for the issued bonds. However, in subregion X, the PCBs will provide loans of longer maturity than the NDB, given a certain collateral value for the issued bonds, because in this subregion the disadvantage of the NDB resulting from the lower monitoring quality is greater than its advantage of higher recapitalization willingness and capacity.

Regarding the possible justification for assuming that the monitoring quality of state-owned banks is lower than that of privately owned banks, that could be related to poor governance, as argued by LaPorta et al. (2002) and Dinc (2005).[20] The poor governance would negatively affect monitoring skills, such as the evaluation of projects, screening of borrowers, or even collection of repayments by borrowers. This worsening in the monitoring quality would, in turn, increase the variance of the per-period net rate of return of the investment project as perceived by the other banks that are not actively involved in the lending to the firm but that may eventually buy the bonds issued by the actively involved bank. Note, however, that in this section we are taking the variance of the per-period net rate return of the investment project estimated by the actively involved bank in the lending to the firm as given and equal for all banks that

[20]The debate on the efficiency of state-owned vs. private-owned banks is not completely settled, as Andrianova et al. (2008), Yeyati et al. (2007) and Rodrik (2012), among others, argue.

are actively involved in lending to the firms. Thus, the argument in this section is not related to the fact that state-owned banks usually have a mandate to finance high-risk projects, but that the government is worse than the private sector in its monitoring quality, which affects the assessment of the true riskiness of an investment project. Note also that we are not arguing that the state should not steer the corporate strategy of NDBs to ensure that they are development-oriented. Instead, we are arguing that undue political intervention at the micro-level bank operation can undermine banks' monitoring skills.

Our conclusion from this analysis is that the quality of monitoring by banks is an important factor that determines banks' maturity-lengthening possibilities. Any improvement in the monitoring quality of a bank will also help the bank in issuing bonds with higher collateral value and thus in being able to lend longer term to firms. Moreover, for NDBs to keep their advantage over PCBs, it is of utmost importance that they improve their monitoring skills, including project evaluation, borrower screening, and repayment collection, and thus achieve high monitoring quality.

{Insert Figure 4 here}

4 Market liquidity of bonds and the maturity of bank lending

In this section, we add to the model of the last two sections the assumption that the market liquidity of the bonds issued by banks is idiosyncratic.[21] As we will clarify below, the market liquidity of the bonds issued by banks determines the collateral value of the bonds issued by these banks and thus affects the maturity of the lending to firms by these banks. Through this mechanism, and if we assume that the market liquidity of the bonds issued by the NDB is higher than that of commercial banks, we add a new channel through which the NDB may have an additional advantage over CBs. Note also that through this channel we are presenting an advantage that the NDB may have over state-owned commercial banks (SCBs). In the last two sections, we assumed that the NDB was the only state-owned bank and that all the commercial banks were privately owned. If we had assumed instead the existence of SCBs, and if these SCBs had the same characteristics as the NDB in terms of recapitalization capacity and willingness and monitoring quality, then there would be no advantage in having an NDB when the banking system also has SCBs. However, with this new assumption about the market liquidity of bonds, we argue for the existence of an NDB, even when there are SCBs in the banking system.

Both the theoretical and empirical literature on market liquidity points out that a bond with lower market liquidity will not only require a higher interest rate at issuance (coupon), but also will be traded at a discount in the secondary market after having been issued (Amihud et al., 2006; Bao et al., 2011; Vayanos and Wang, 2013). Thus, we assume a positive relationship between the market liquidity of bonds and the collateral value of those bonds in the intermediate period 1.[22] Specifically, we assume that the collateral value of the bonds issued by bank j in the intermediate period 1 is a fraction δ_j of the total collateral value given by the collateral capacity

[21]Market liquidity is the ease with which an asset can be sold to obtain liquidity and settle payments.

[22]Note that all through this paper we are taking the interest rate or coupon of bonds as fixed. Thus, we assume away the effect of the market liquidity on the interest rate of these bonds. This is not to deny the importance of the interest rate but to highlight the different mechanisms that affect the collateral value of bonds, in addition to the interest rate or coupon. This means that in our model, when we focus on the effects of market liquidity, we are considering only the effects of market liquidity on the collateral value of bonds and not on the interest rate or coupon of those bonds.

of the bank loan and the recapitalization willingness and capacity. δ_j captures the reduction in the collateral value of the bonds of bank j resulting from the level of market liquidity of the bonds of bank j, where $0 \leq \delta_j \leq 1$. Note that $\delta_j = 1$ means perfect market liquidity and $\delta_j = 0$ means complete market illiquidity. Thus, the collateral value of bonds by bank j with market liquidity δ_j in the intermediate period 1, $B_j(\delta_j)$, is

$$B_j(\delta_j) = \delta_j((1 - \gamma \cdot T_j^2 \cdot q_j \cdot V(R)) \cdot D + \omega_j \cdot C_j). \tag{8}$$

Thus, banks that issue bonds with higher market liquidity will also be able to issue bonds with higher collateral value.

Taking into account this new assumption about the market liquidity of the bonds of bank j, and following equations 3 and 7, the maximum maturity of the lending to the firm by bank j, with market liquidity δ_j, in the initial period 0, $T_j^*(\delta_j)$, becomes

$$T_j^*(\delta_j) = \frac{\sqrt{\delta_j \cdot \gamma \cdot V(R) \cdot q_j \cdot D \cdot (\delta_j \cdot \omega_j \cdot C_j - (1 - \delta_j) \cdot D + A_j)}}{\delta_j \cdot \gamma \cdot V(R) \cdot q_j \cdot D}. \tag{9}$$

From Equation (9), we have the following proposition.

Proposition 4. *$T_j^*(\delta_j)$ is increasing in δ_j.*

These results imply that, given a certain collateral value for the bonds issued by the banks, the bank with the bonds having higher market liquidity will be able to lend to firms with longer maturity than will the banks with bonds with lower market liquidity. Similarly, given a certain level for the maturity of the lending to the firms, the collateral value of the bonds issued by the banks with bonds with higher market liquidity is higher than the collateral value of the bonds issued by the banks with bonds with lower market liquidity. In Figure 5 we depict these results by comparing the collateral value of the bonds issued by a bank with bonds with high market liquidity with the collateral value of the bonds issued by a bank with bonds with low market liquidity, representing the maturity of the lending to the firm in the horizontal axis.

{Insert Figure 5 here}

We now turn back to the comparison in subsection 2.2 between a banking system in which the NDB grants the loans to the firms financed by PCBs that buy the NDB bonds with a banking system where the PCBs directly grant the loans to the firms. The new assumption regarding the idiosyncratic market liquidity of the bonds issued by banks may be used to compare the optimal determination of the maturity of the lending to firms by these two types of banks. If we assume that the NDB bonds have a higher market liquidity than the bonds issued by PCBs, meaning that $\delta_{NDB} > \delta_{CB}$, then this increases the advantage of the NDB over PCBs in terms of the lengthening of the maturity of lending to firms. The higher market liquidity of the NDB bonds could offset the disadvantage of having a lower monitoring quality than PCBs analyzed in last section 3.

Corollary 3. *When the market liquidity of the bonds issued by the NDB is sufficiently high, in comparison with the bonds issued by PCBs, the NDB may grant loans of longer maturity than those of the PCBs, even when the NDB has a lower monitoring quality than CBs.*

Figure 6 depicts what is expressed in corollary 3 by comparing a situation where the NDB has a lower monitoring quality than PCBs, which penalizes their ability to lend with longer maturities but has a higher market liquidity for its bonds in comparison with the bonds of the PCBs, which gives them an advantage over PCBs. In that figure it is clear that an NDB with low monitoring quality, but no advantage over PCBs in terms of the market liquidity of its bonds, would not be able to lend longer term than PCBs. However, an NDB that also has a low monitoring quality, but has a high market liquidity for its bonds, would be able to lend with longer maturities in comparison with PCBs with high monitoring quality but low market liquidity for their bonds. Evidently, the market liquidity of bonds is an important factor that explains the collateral value of bonds and thus influences the maturity of the lending by banks to firms.

{Insert Figure 6 here}

Another important proposition that can be made with the introduction of the market liquidity of bonds is to give a rationale for the existence of NDBs even when the banking system has state-owned commercial banks. Note that in the last two sections, we assumed that commercial banks were all privately owned. If we had allowed for the existence of SCBs, and if these banks had had the same characteristics as the NDB, in terms of the recapitalization capacity and willingness (or perceived willingness) to recapitalize the bank by the government or state, as well as the monitoring quality, then the NDB would have no advantage over the SCBs in terms of the lengthening of the maturity of lending to firms. However, if we now assume that the NDB's bonds have a higher market liquidity than the SCBs' bonds, then we still have an argument favoring the existence of NDBs, which finance their lending to firms through issuing bonds to commercial banks, both state- and privately owned. In a sense, all these advantages and disadvantages for the different types of banks allow for and justify a complex banking system with the existence of a diversity of bank types.

Regarding the possible justifications for assuming that the NDB bonds have a higher market liquidity than the bonds issued by commercial banks, both state-owned and privately owned, we can propose several arguments related to the market liquidity literature. Pagano (1989) observed that the volume of trade for an asset is an important factor in explaining the market liquidity for that asset. In this sense, the banking system with an NDB and CBs implies that only one type of bond will be issued, the NDB bonds, and that all commercial banks will buy that bond. The size of the NDB bond issuance will be systemically large. Instead, the banking system with only commercial banks implies that many different types of bonds will be issued, one for each commercial bank that issues bonds in the intermediate period 1, and thus no individual bond issuance will be large enough. Thus, the trading volume for NDB bonds is greater than that of any individual CB in the intermediate period 1; and thus NDB bonds will have a higher market liquidity than commercial banks' bonds.

Note, however, that throughout this paper we have been analyzing pure and extreme examples of banking systems in which either all commercial banks were buying the NDB bonds or no CB was buying NDB bonds and was only buying bonds from other commercial banks. If allowing for a more mixed system, with banks of different types and sizes, we conclude that size matters for market liquidity. Clearly, bigger NDBs, in the sense of their relative bond-issuance size in the banking system, will also be able to issue bonds with higher market liquidity and thus will also be able to lend to firms with longer maturities. Similarly, big commercial banks will also have an advantage over small commercial banks in terms of the market liquidity of their bonds. Note also that the issue of market liquidity is an important argument in favor of NDBs that follow a business model centered on financing themselves by issuing bonds instead of trying to mimic commercial banks that are in the payment system and are deposit creators and takers.

In addition, and also related to the last argument, Vayanos and Wang (2012) argue that agents face costs of market participation (e.g., to monitor market movements and information) to be ready to trade in the secondary bond market. Thus, bonds with lower participation costs will also have higher market liquidity. Now consider the banking system with an NDB that finances its lending by issuing NDB bonds that are bought by commercial banks in the initial period 0. Clearly, all commercial banks must incur the participation costs for the NDB bonds in the initial period 0 to buy them. Therefore, those commercial banks, which face a net deposit inflow in the intermediate period 1 and accept NDB bonds to settle payments with the commercial banks that face net deposit outflows, are already correctly informed for the trade and do not need to incur additional participation costs in the intermediate period 1.

In contrast, consider the banking system with only commercial banks. In this case, commercial banks are not buying bonds from any CB in the initial period 0 and thus will not have incentives to incur any participation costs in the initial period 0. Only in the intermediate period 1 will the commercial banks that face a net deposit inflow from other commercial banks know which bank bond they will trade in the secondary bond market. This means that these commercial banks will have to face the full market participation costs for these bank bonds in the intermediate period 1. Clearly, NDB bonds have an advantage in terms of lower participation cost over bonds issued by other commercial banks in the intermediate period 1, and thus we may expect that NDB bonds have a higher market liquidity than bonds issued by commercial banks.

5 Concluding Remarks

In this paper we have studied the theoretical determinants of the maturity of the lending to firms by banks. Our model links the maturity of bank loans to firms with the collateral value of the bonds that banks issue in the interbank market. The collateral value of the bonds issued by banks (i.e. the maximum amount of funds that they can obtain by issuing bonds) is negatively related to the maturity of the bank loans to firms, because long-term loans are often more risky than short-term ones. Furthermore, the collateral value of the bonds also hinges on the recapitalization willingness (or perceived willingness) and capacity of the banks' owners, the market liquidity of the bonds that the banks issue, and the monitoring skills and quality of the banks.

If NDB bonds have higher collateral value than bonds issued by PCBs because of higher recapitalization willingness (or perceived willingness) and capacity as well as higher market liquidity, NDBs may lend longer term than PCBs, even if PCBs may have higher monitoring skills and quality than NDBs. In our model, NDBs are not substitutes for but complements to PCBs, so the policy discussion is not about PCBs vs. NDBs but rather about a banking system with PCBs only vs. one with PCBs and NDBs. In addition, if the NDB bonds have higher market liquidity than the bonds of commercial banks, NDBs may even have an advantage over SCBs in terms of the maturity of loans to firms, even when SCBs have similar characteristics in terms of the recapitalization willingness (or perceived willingness) and capacity, as well as monitoring skills and quality. These advantages and disadvantages of the different types of banks allow for and justify complex banking systems with the existence of a diversity of bank types.

In terms of policy recommendations, the maturity-lengthening role of NDBs is more important when they have proper liquidity management, possess adequate amounts of liquid asset holdings, and are well capitalized. In addition, the maturity-lengthening role of NDBs is more relevant for countries that have governments with stronger credibility, finances, and net worth than for countries with governments plagued by credibility concerns, over-indebtedness, and excessive fiscal deficits. Moreover, it is important that NDBs are well-governed and have high monitoring skills and quality and that the investment projects that obtain loans from NDBs have sufficiently high expected financial or productive returns and sufficiently low risks.

Poorly managed NDBs, which do not keep out narrow private and politically vested interests, will probably end up in a fragile financial position with high non-performing loans and low credibility. Furthermore, the maturity-lengthening role of NDBs is enhanced by the market liquidity of their bonds if NDBs are bigger in terms of their relative bond issuance size in the banking system, which improves their bond market liquidity. Note also that the issue of market liquidity is an important argument in favor of NDBs that follow a business model centered on financing themselves through bond issuance rather than trying to mimic commercial banks that are in the retail payment system and are deposit creators and takers. Finally, the advantages of NDBs over PCBs, especially in terms of recapitalization willingness and capacity and bond market liquidity, is what makes them more suitable than PCBs to finance high-risk projects or low-return projects with positive externalities. However, NDBs should be aware of the limits that financing such projects pose in terms of the value of their bonds.

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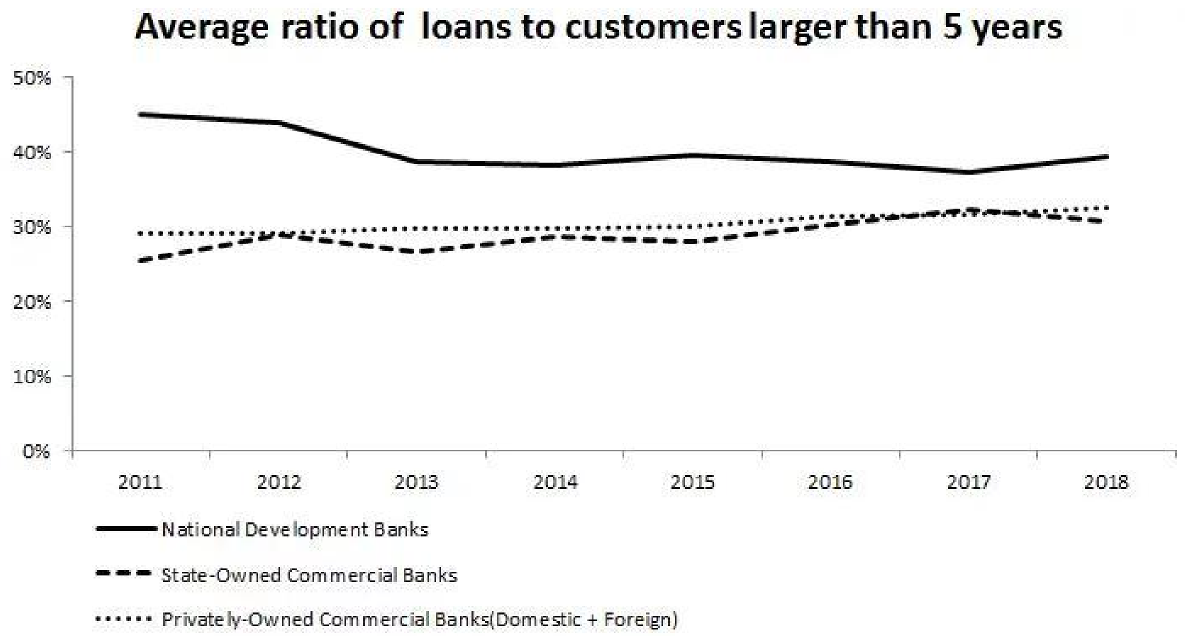

Source: Hu et al. (2020) based on BankFocus data.

Figure 1: Average ratio of loans to customers larger than 5 years

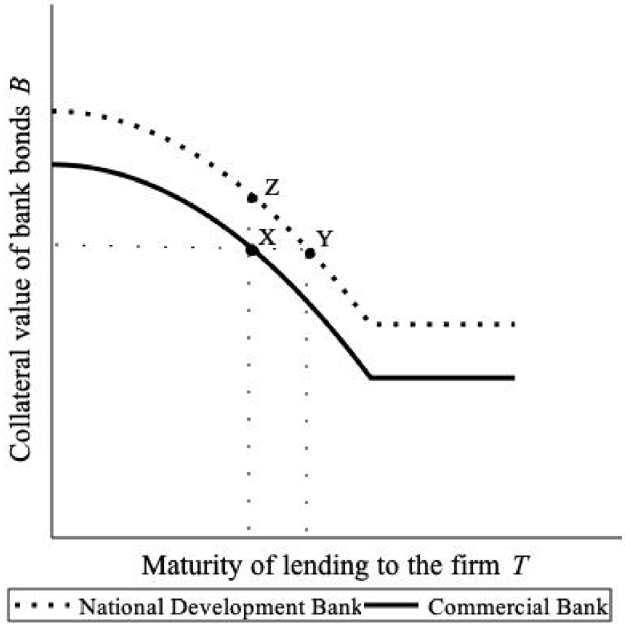

Figure 2: Collateral Value of Bank Bonds and Maturity of Lending to the Firm

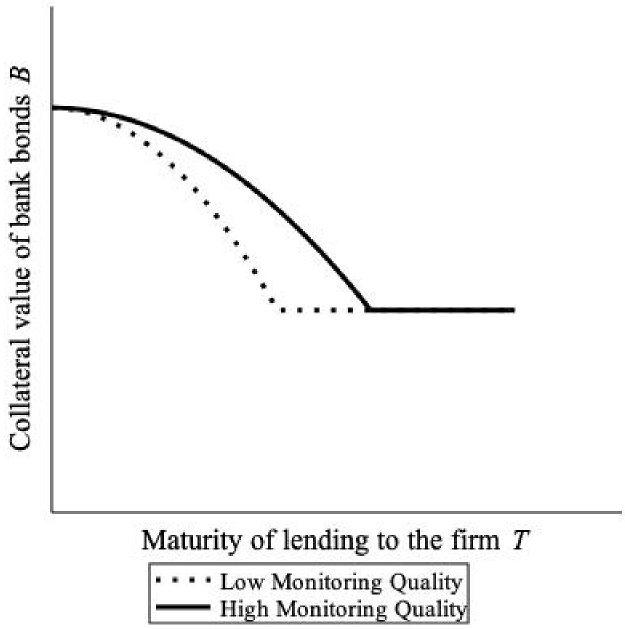

Figure 3: Monitoring Quality, Collateral Value of Bank Bonds, and Maturity of Lending

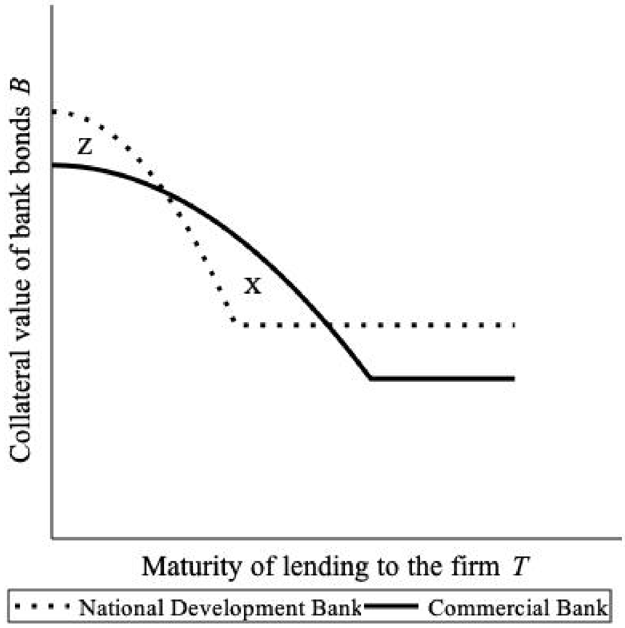

Figure 4: NDB with Low Monitoring Quality, Collateral Value of bank Bonds and Maturity of Lending

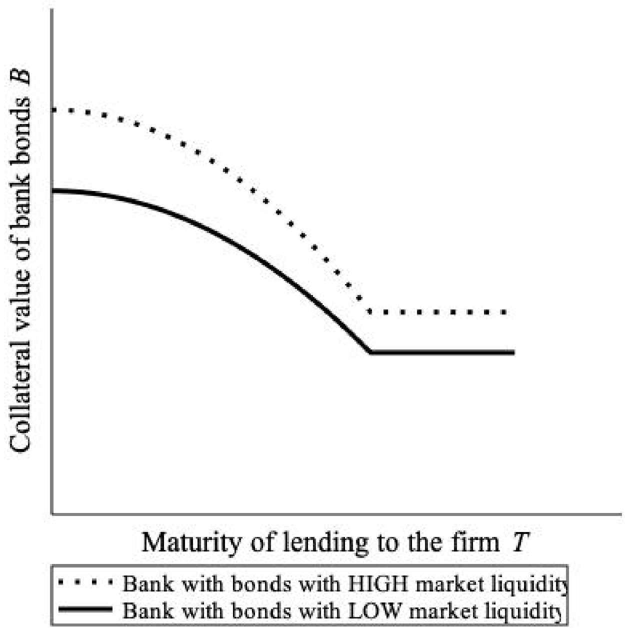

Figure 5: Market Liquidity of Bonds, Collateral Value of Bank Bonds, and Maturity of Lending

T	Bank 1		Bank 2		Firm 1		Firm 2	
	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
0							$Goods_{firm2}$	
1 Loan by Bank 1 to Firm 1	$+Loan_{bank1}^{firm1}$	$+Deposit_{bank1}^{firm1}$			$+Deposit_{bank1}^{firm1}$	$+Loan_{bank1}^{firm1}$		
2 Interbank loan by bank 2 to bank 1	$+Deposit_{bank2}^{bank1}$	$+Inter^{bank1}$ $bankloan_{bank2}$	$+Inter^{bank1}$ $bankloan_{bank2}$	$+Deposit_{bank2}^{bank1}$				
3 Payment by Firm 1 to Firm 2 with account in Bank 2	$-Deposit_{bank2}^{bank1}$	$-Deposit_{bank1}^{firm1}$		$-Deposit_{bank2}^{bank1}$ $+Deposit_{bank2}^{firm2}$	$-Deposit_{bank2}^{bank1}$ $+Goods_{firm2}$		$+Deposit_{bank1}^{firm1}$ $-Goods_{firm2}$	
Final	$Loan_{bank1}^{firm1}$	$+Inter^{bank1}$ $bankloan_{bank2}$	$+Inter^{bank1}$ $bankloan_{bank2}$	$+Deposit_{bank2}^{firm2}$	$Goods_{firm2}$	$Loan_{bank1}^{firm1}$	$Deposit_{bank2}^{firm2}$	

Table 1: Solving the Liquidity Problems and the Interbank Payments by Interbank loans

T	NDB		Bank 1		Bank 2		Firm 1		Firm 2	
	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities	Assets	Liabilities
0									$+Goods_{firm2}$	
1 Bank 1 buys NDB bonds	$+Deposit_{bank1}^{NDB}$	$+Bonds_{NDB}$	$+Bonds_{NDB}$	$+Deposit_{bank1}^{NDB}$						
2 NDB Loan to Firm 1	$+Loan_{NDB}^{firm1}$ $-Deposit_{bank1}^{NDB}$			$-Deposit_{bank1}^{NDB}$ $+Deposit_{bank1}^{firm1}$			$+Deposit_{bank1}^{firm1}$	$+Loan_{NDB}^{firm1}$		
3 Bank 1 sells NDB bonds to Bank 2			$-Bonds_{NDB}$ $+Deposit_{bank2}^{bank1}$		$+Bonds_{NDB}$	$+Deposit_{bank2}^{bank1}$				
4 Firm 1 pays Firm 2 (with bank account in Bank 2)			$-Deposit_{bank2}^{bank1}$	$-Deposit_{firm1}^{bank1}$		$-Deposit_{bank2}^{bank1}$ $+Deposit_{bank2}^{firm1}$	$-Deposit_{bank1}^{firm1}$ $+Goods^{firm2}$		$+Deposit_{bank2}^{firm2}$ $-Goods_{firm2}$	
Final	$Loan_{NDB}^{firm1}$	$Bonds_{NDB}$			$Bonds_{NDB}$	$Deposit_{bank2}^{firm2}$	$Goods_{firm2}$	$Loan_{bank1}^{firm1}$	$Deposit_{bank2}^{firm2}$	

Table 2: Solving the Liquidity Problems and the interbank payments by selling NDB bonds

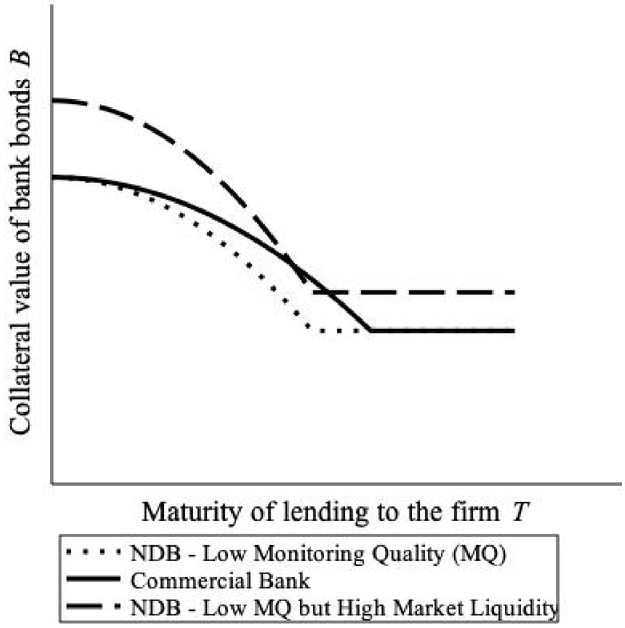

Figure 6: NDB with Low Monitoring Quality and High Market Liquidity of Bonds, and Maturity of Lending