The Maturity Lengthening Role of National Development Banks*

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Abstract

This paper theoretically analyses why state-owned national development banks (NDBs) may be better at providing longer-term lending to firms in comparison with private-owned commercial banks (PCBs). The reason is that NDB bonds have more value than bonds issued by PCBs, thus allowing banks to better cope with interbank payments. NDB bonds have more value than those of PCBs because of state ownership, hence increasing recapitalization willingness and capacity. Another advantage is that NDBs finance themselves through bond issuance rather than deposit-creation and -taking, which increases the market liquidity of their bonds. Regarding the drawbacks of NDBs, monitoring quality is analyzed.

JEL classification: G01; G21; G28; H81; E51; E44

Keywords: Bank lending; Maturity lengthening; Debt or collateral capacity; Asset-based leverage; Interbank markets; Recapitalization; Monitoring quality; Market liquidity; National development banks.

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1 Introduction

The availability of long-term finance has a positive and significant impact on long-run growth and a negative impact on income inequality (Beck, 2012). Moreover, it contributes to higher growth by playing a countercyclical role that lowers macroeconomic volatility (Aghion et al., 2005). For firms and households, long-term finance is related to better firm performance and improved household welfare (Campbell, 2006). 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). Without long-term financial instruments, households cannot smooth income over their life cycle, for example, by investing in housing or education, and may not benefit from higher long-term returns on their savings.[1]

Despite its significance, long-term finance is in short supply for several reasons. First, extending long-term finance often implies larger risks for providers and greater information asymmetry. Thus, credit rationing is likely to be more severe for long-term finance (Stiglitz and Weiss, 1981). Second, financial intermediaries with greater maturity mismatch are subject to larger liquidity risks and potential runs (Martin et al., 2014). Third, the absence of a stable political and macroeconomic environment tends to reduce the amount of long-term finance because it undermines the ability of economic agents to predict the risks and returns associated with the long-term finance (World Bank, 2015). Fourth, a relationship often exists between underdeveloped financial systems and lack of long-term development (Demirguc-Kunt and Maksimovic, 1999). Fifth, the regulation regime, such as the Basel Accord, may have unintended consequences, and incentivize banks to reduce the supply of long-term loans (Financial Stability Board, 2013). Sixth, coordination failures among lenders can result in a "maturity rat race" in which all lenders shorten the maturity of contracts to protect their claims when the seniority of claims is not well enforced and lenders cannot coordinate their actions (Brunnermeier and Oehmke, 2013). In addition, the financial system sometimes suffers from short-termism partly because of perverse managerial incentives (Narayanan, 1985). Last, but not least, a poor legal and institutional framework and weak contract enforcement can also excessively limit the supply of long-term finance, causes financiers to avoid long-term lending and rely on short-term contracts to discipline borrowers and ensure repayment (World Bank, 2015).

One way to overcome the scarcity of long-term finance is to establish national development banks (NDBs), especially for developing countries. NDBs are financial institutions often established by 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). For instance, the German NDB, Kreditanstalt fur Wiederaufbau (KfW), was created in 1948 to finance the long-term reconstruction of Germany after World War II, and by the end of 2017 had a 5:1 ratio of long-term loans vis-a-vis short-term

[1] Yet, recognizing the significance of long-term finance does not deny that short-term finance may have positive effects. Short-term finance has a stronger disciplinary role, mitigating moral hazard and agency problems in lending. The lender's ability to monitor borrowers may be improved with short-term financing contracts because short-term debt must be negotiated frequently and creditors can cut financing if they are not satisfied with the borrower's performance (Rey and Stiglitz, 1993). Under certain circumstances, short-term finance is desirable from the perspective of borrowers. Borrowers with high credit ratings prefer short-term debt, and those with somewhat lower ratings prefer long-term debt (Diamond, 1991). Another advantage of short-term financing is that a firm, while in good financial health, can readjust its maturity structure more quickly in response to changes in the value of its assets (Brunnermeier and Oehmke, 2013).

loans. Moreover, most of the long-term loans have a maturity longer than five years. In 2019, total assets of KfW were 506 billion euro (equivalent to 546 billion USD) accounting for 14% of the German GDP. Another example is the Brazilian NDB, Banco Nacional de Desenvolvimento Economico e Social (BNDES), founded in 1952, which has served as the main instrument of the Brazilian federal government for long-term financing and investment in all segments of the economy. In 2019, the total assets of BNDES accounted for 728 billion R$ (181 billion USD equivalent), accounting for 10% of Brazilian GDP. A relatively newcomer is the Chinese NDB, China Development Bank (CDB), established 1994, which has financed basic infrastructure and pillar industries in China and has become a key provider of long-term infrastructure financing in developing countries. In 2018, its total assets reached 16 trillion RMB (2.2 trillion USD equivalent), accounting for almost a fifth of Chinese GDP. Total assets of CDB are even larger than those of the World Bank and traditional multilateral development banks combined. Moreover, Hu et al. (2020) econometrically find that the maturity of NDB loans is higher than that of commercial bank loans, a finding that is statistically significant after controlling for macroeconomic and bank-level factors. The authors' database consists of individual bank data from BankFocus for a large sample of 1253 banks across 106 countries between 2011 and 2018. In addition, de Luna-Martinez and Vicente (2012) analyzed a panel of 90 NDBs in 61 countries, discovering that 54% of granted loans had a maximum maturity of over 10 years, 29% of granted loans had a maximum maturity of 6-10 years, and only 16% of granted loans had a maximum maturity of less than 5 years.

The reason why NDBs provide long-term finance may not only be that they have the official mission to do so; they may also possess certain characteristics that make it advantageous for them to provide long-term financing in comparison with commercial banks (CBs) or mutual funds.[2] For example, following Brei and Schclarek (2015) and Brei and Schclarek (2018), NDBs may have a different objective function and may be more willing to take on more risks than CBs because they internalize certain externalities that private bankers don't, and thus, it may be optimal for NDBs to provide longer-term loans to firms in contrast to CBs. Griffith-Jones et al. (2018) also argue that an explanation may be related to the funding source of NDBs, which have longer-term liabilities, such as bonds issued to longer-term investors and/or NDBs relying more on recapitalization by the owners (the state) to finance their lending, in contrast to the reliance on short-term bank deposits by CBs.

This paper's objective is to study the theoretical determinations of the maturity of the bank lending to firms or investors. Our model links the maturity lengthening role of banks with the value of the bonds that banks issue in the interbank market. This argument is our paper's main original contribution to the banking literature. The way we model the behavior of the different agents in this paper combines elements from the "money view" theory, as in Mehrling (2011), and Mehrling (2012); the asset-based leverage literature, as in Adrian and Boyarchenko (2012), Brunnermeier and Pedersen (2009), and Geanakoplos and Fostel (2008); the bank monitoring literature, as in Diamond (1984) and Holmstrom and Tirole (1997); the market liquidity literature, as in Bao et al. (2011), Pagano (1989), and Vayanos and Wang (2013); and the literature on the role of the government as liquidity provider, as in Gorton and Huang (2004) and Holmstrom and Tirole (1998).

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

Concretely, in our model, CBs lend to firms by creating bank deposits, which imply an increase in the long-term assets of CBs and an increase in their short-term liabilities. This maturity mismatch creates liquidity risk for CBs because bank deposits may be withdrawn at any time and transferred to other CBs. Bank transfers to other CBs, whereby a deposit holder in one CB wishes to deposit those bank deposits in another CB, imply also that the CB from which the bank transfer is made must make an interbank payment to the CB that receives the bank transfer to get that CB to credit the bank account of the bank transfer receiver. CBs settle payments with one another by granting interbank loans to one another and/or by trading financial assets with one another (for example, bonds). The ability to settle that interbank payment is what we call the payment or survival constraint of CBs. Note that in this paper we assume a well functioning and stable payment system, without credit or market freezes, bank runs, or refinancing risks, and, thus, there is no need for a lender of last resort who lend when other do not want to, or a dealer of last resort who would buy the assets when others do not want to. This is why we do not incorporate a central bank or central bank deposits into our model because its presence per se could not solve any of the problems we analyze in this paper.

In contrast to CBs, NDBs are not in the payment system, do not create bank deposits, and finance their lending to firms with the issuance of NDB bonds sold to CBs. CBs buy those NDB bonds by creating bank deposits that they credit the NDBs, which the NDBs, in turn, use to grant lending to firms. Note that although it is the NDBs that lend to the firms, and not the CBs directly (as it is CBs that create bank deposits to finance the NDBs), it is still the case that CBs face liquidity risks because bank deposits may be withdrawn at any time. Therefore, when in need of liquidity, CBs may now sell their NDB bonds rather than issuing their own bonds to settle interbank payments and meet the payment or survival constraint. These features imply that NDBs are not so much substitutes for but complements to CBs and that the policy discussion is not so much about CBs vs. NDBs as about a banking system with only CBs vs. a banking system with CBs and NDBs.

Regarding the value of bonds issued by banks, both CBs and NDBs, one of its main determinants is the debt or collateral capacity of the loans granted to firms by banks that are assets for these banks. The debt or collateral capacity is increasing in the expected financial or productive return of the investment projects of firms financed by the loans, decreasing in the riskiness of these investment projects, and decreasing in the maturity of those loans to firms. The reason for this last assumption is that longer-term loans to firms are riskier than shorter-term loans. In addition, the value of bonds is also positively related to the recapitalization willingness (or perceived willingness) and the financial capacity of the bank owners. The reason is that if firms default on loans, banks may still be able to repay their issued bonds if the banks' owners bail them out or recapitalize them. Further, the value of bonds is also positively related to the degree of market liquidity of these bonds. This is because a lower market liquidity for a bond implies also a greater discount in the price of that bond in case it must be sold in the secondary market. Finally, the value of bonds is higher for those banks that have higher monitoring quality, in terms of valuating projects, screening borrowers, and collecting repayments from borrowers, because it is expected that banks will face lower lending risks.

When both CBs and NDBs choose the optimal maturity of their lending to firms, they must take into account CBs' payment or survival constraints. Such a survival or payment constraint implies that the chosen maturity of loans to firms must be such that the value of these banks' bonds, in conjunction with the liquid assets that CBs possess, are high enough that CBs can settle interbank payments without problems. Both CBs and NDBs must take into account this trade-off between the maturity of the lending to firms and the value of the bonds that they issue. Moreover, it is the determinants of the value of bonds, other than the maturity of loans, that define which banking system can provide longer-term loans to firms: the banking system with CBs only or the banking system with CBs and NDBs.

Our main result is that a banking system with CBs and state-owned NDBs may provide longer-term lending to firms in comparison with a banking system with only private-owned commercial banks (PCBs) because NDB bonds are more valuable than bonds issued by PCBs, thus allowing banks to better cope with maturity mismatch risks and liquidity problems in case of needing to make interbank payments. One reason NDB bonds have more value than the bonds issued by PCBs is that NDBs are owned by the government, hence there is a higher recapitalization willingness and capacity compared to private bank owners. Another advantage is that NDBs finance themselves through bond issuance rather than deposit-creation and -taking, which increases the market liquidity of their bonds. However, if NDBs have a lower monitoring quality than PCBs, this reduces the advantages of NDBs over PCBs in terms of their maturity-lengthening role. In addition, because the NDB bonds have higher market liquidity, NDBs may even have an advantage over state-owned CBs (SCBs) in terms of the maturity of loans to firms, even when SCBs have similar characteristics in terms of the recapitalization capacity and willingness (or perceived willingness) to recapitalize the bank by the government or state, and the monitoring quality.

The rest of the paper is organized as follows. In section 2, we graphically analyze the balance sheets of the different agents and the financial and monetary effects and consequences of their behavior. We present the mathematical model in section 3, where we explain the assumptions, model setup, optimal behavior, and main arguments in more detail. In particular, we analyze the relationship between the maturity of lending by CBs and NDBs and the value of the bonds issued by these banks. Further, we analyze how the recapitalization willingness (or perceived willingness) and the recapitalization capacity of banks' owners determine the value of the bonds, and thus, the maturity of the lending to firms. In section 4, we explore the consequences of assuming heterogeneity in the monitoring quality of banks and its effects on the value of bonds, and thus, the maturity of lending by banks. In section 5, we explore the consequences of assuming heterogeneity in the market liquidity of the bonds issued by banks and its effects on the value of bonds, and thus, the maturity of lending by banks. Finally, in section 6, we present our conclusions.

2 Balance-Sheet Presentation

In this section, we explain the model's basic setup by graphically analyzing the financial and monetary consequences of the lending to firms (investors) by banks, and the different payments and settlements, in particular interbank payments, that arise between these agents. We explicitly model these transactions by analyzing, at each point in time, the balance sheets of the 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, presented in Mehrling (2011, 2012); Mehrling et al. (2015). Understanding these monetary mechanisms, in particular the maturity mismatch and the liquidity risk for banks that arise when banks lend to firms, will make it easier to understand the mathematical model in section 3.

First, in figure 1, we analyze the process of lending to a firm (investor) through bank deposits creation by a CB. In the initial period, period 0, agents have no assets or liabilities. In period

1, the CB grants a loan to the firm (investor) to finance the investment project, by agreeing on a legal contract whereby the firm promises the CB to pay back the loan capital and interest in the future. Immediately, in period 2, the CB creates bank deposits by crediting the amount of the loan to the bank account of the firm (investor) at the CB. The firm (investor) will use these bank deposits to make the necessary payments for its investment project.[3] The final situation of this process of lending through bank deposit creation implies that the balance sheet of the firm (investor) has been expanded by increasing the asset-side with the bank deposit at the CB and increasing the liability-side with the loan from the CB. Conversely, the balance sheet of the CB has been expanded by increasing the asset-side with the loan to the firm and increasing the liability-side with the firm's bank deposit.

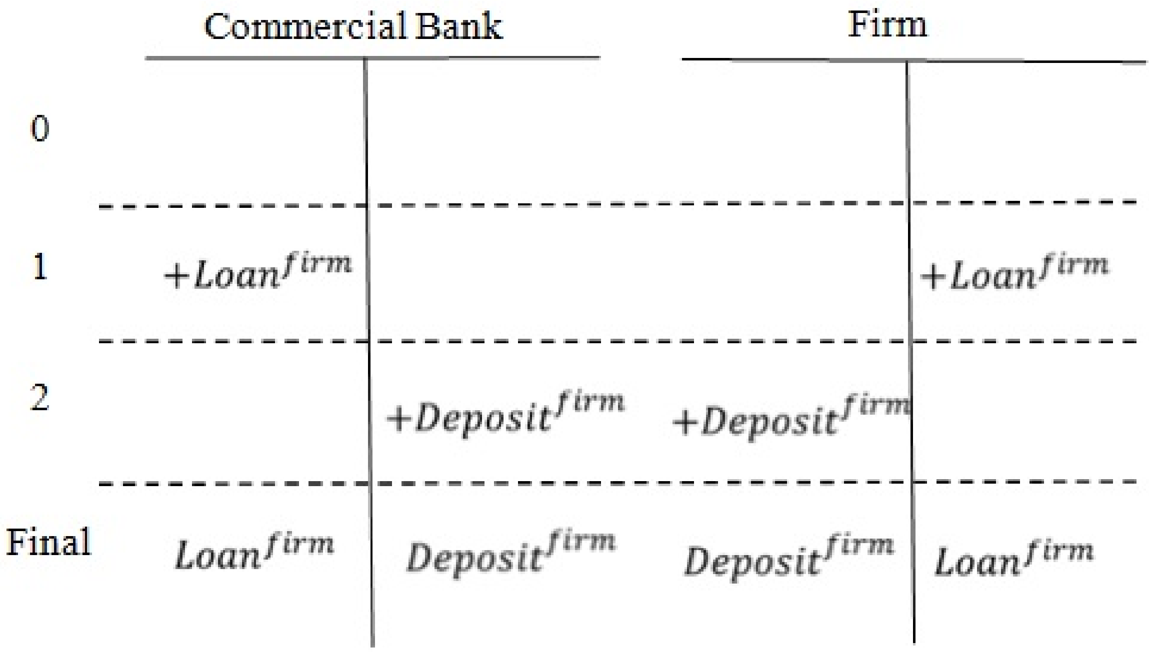

Figure 1: The Process of Lending to Firms through Bank Deposits Creation by Commercial Banks

Consider, however, that the CB exposes itself to liquidity risk as it grants loans to firms. For the CB, the loan to the firm is a long-term asset because it will generate money inflows in the long-term when the firm pays back the lending capital and interest. In contrast, bank deposits are a short-term liability for the CB because bank deposit creation implies a promise by the CB that the firm will be able to use those bank deposits at any moment to make payments to other agents. Thus, the process of lending to firms by creating bank deposits generates a maturity mismatch and a liquidity risk for the CB. Profit is the motive for incurring this liquidity risk because the interest earned on the lending is greater than the interests, if any, paid to the bank deposits. Note also, as will become clearer below, that the process of lending to firms

[3]Note that we are assuming that the firm (investor) holds the bank deposits in the same CB that is granting the lending. In reality, it is true that the firm (investor) has the liberty to withdraw and transfer the bank deposits obtained from the lending to another CB, which the firm (investor) uses preferentially for making and receiving payments. This assumption has no consequences for our results.

by creating bank deposits does not imply that the CB can create bank deposits without limit. Among other limits, the liquidity risk this process creates is a key constraint for the bank.[4]

Still, the maturity mismatch does not *necessarily* result in liquidity problems for the CB. In figure 2, we analyze the case when the maturity mismatch causes no liquidity problems for the CB because the firm makes a payment to another agent with a bank account in the same CB. In the initial period 0, Firm 2 has (intermediate) goods that Firm 1 needs for its investment project (alternatively, Firm 2 could represent workers ready to provide the labor force needed for the investment project, in exchange for a salary). In period 1, Firm 1 obtains bank deposits from a loan granted by Bank 1, following the process explained in figure 1. In period 2, Firm 1 pays to Firm 2, using the bank deposits at Bank 1, and obtains the (intermediate) goods. Bank 1 can fulfill the payment, without needing any assets, because both Firm 1 and Firm 2 have bank accounts at Bank 1. Thus, Bank 1 just debits the bank account of Firm 1 (the original deposit holder) and credits the bank account of Firm 2 (the new deposit holder). Note that even if Bank 1 still suffers from a maturity mismatch in the final period, it has been possible to perform the trade and payment of the (intermediate) goods without causing any liquidity problems for Bank 1.

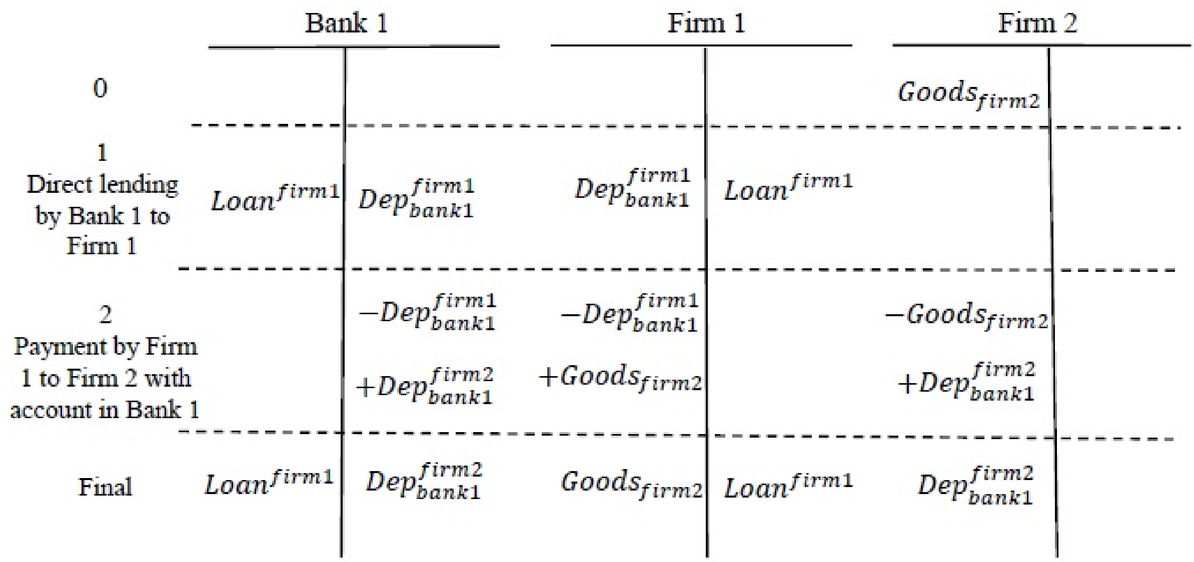

Figure 2: Maturity Mismatch Causing No Liquidity Problems when Payment is made to the Same Bank

In contrast, as figure 3 demonstrates, both the maturity mismatch and the liquidity risk are troublesome for a CB (Bank 1) when the payment is made to an agent (Firm 2) with a bank account in a different CB (Bank 2). In contrast to the situation analyzed in figure 2, the payment by Firm 1 (the original deposit holder) to Firm 2 (the new deposit holder) in period 2 is not just settled by debiting and crediting bank accounts on its balance sheet. In this case, in order to fulfill Firm 1's payment to Firm 2, Bank 1 must make a payment to Bank 2 to get

[4] 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 CBs, these limits given by prudential regulation will not be analyzed in this paper.

Bank 2 to credit the bank account of Firm 2.

In our paper, we assume that CBs settle payments among one another by granting interbank loans to one another and/or by trading financial assets with one another (for example, bonds).[5] In this setup, CBs get interbank loans when holding assets with sufficiently high debt and collateral capacity (Acharya et al., 2011; Brunnermeier and Pedersen, 2009; Fostel and Geanakoplos, 2014; Geanakoplos and Fostel, 2008; Simsek, 2013).[6] Furthermore, they will also be able to settle payments by trading assets with sufficiently high market liquidity (Brunnermeier and Pedersen, 2009).[7] Note, however, that the chances that a CB would solve the liquidity problems still hinge on the *willingness* of the other CBs to grant the interbank loans or to receive an asset to settle the payment. For simplicity, in this paper, we assume away these willingness concerns about granting loans and refinancing risks, and assume that banks will always be able to settle payments as long as the value of their assets is high enough. Therefore, when CBs hold assets with sufficient debt and collateral capacity, and market liquidity the payment system is well functioning and stable, without credit or market freezes, or bank runs. In other words, in our model there is no need for a lender of last resort who would lend when other do not want to, or a dealer of last resort who would buy the assets when others do not want to. This is why we do not incorporate a central bank or central bank deposits to our model: its presence could not solve any of the problems we analyze in this paper.

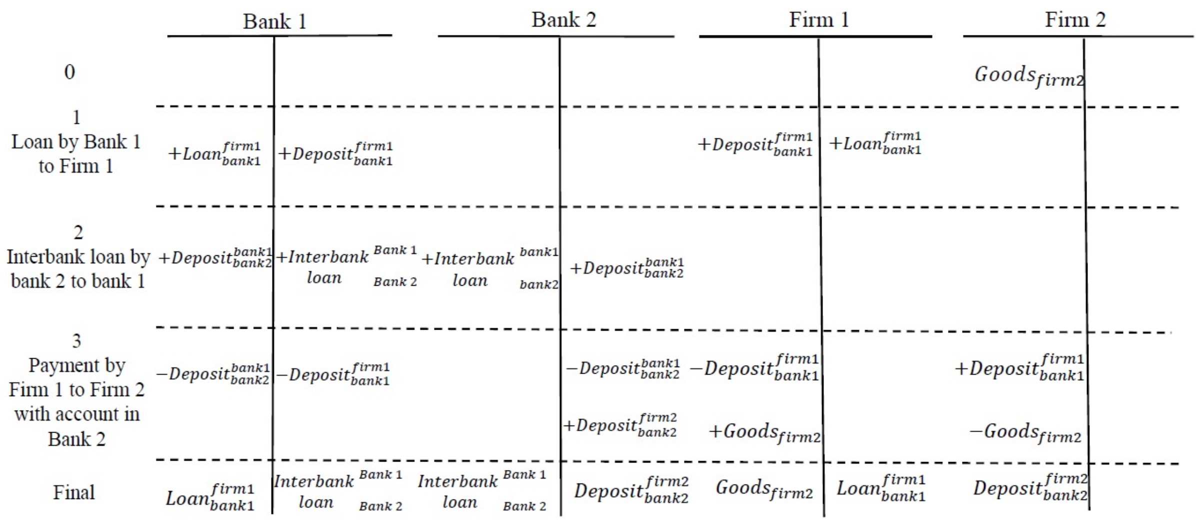

Figure 3: Maturity Mismatch Causing Liquidity Problems when Payment to a Different Bank

Turning back to figure 3, we exemplify how Bank 1 solves the liquidity problems and settles the payment with Bank 2 in period 2 by having Bank 2 grant an interbank loan to Bank 1, who uses its assets, the loan to Firm 1, as collateral. This operation requires Bank 2 to grant an interbank loan to Bank 1 and to create bank deposits given to Bank 1. Bank 1then uses those

[5]This simplification is done, not to deny the paramount role than central bank deposits have for interbank payments, but to focus the analysis on a primitive payment system where CBs can settle payments among one another without the need for a central bank.

[6]The debt and collateral capacity of an asset is the ability to borrow by using that asset as collateral and is related to asset-based leverage (i.e., the value of the loan divided by the value of the collateral).

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

bank deposits to make the transfer of the bank deposits to firm 2. Importantly, the debt or collateral capacity of the assets that Bank 1 uses as collateral (the loan to Firm 1) determines, to a large extent, the amount of Bank 2's interbank lending to Bank 1. Thus, the characteristics of these assets, especially their expected return, riskiness, and maturity, will affect their debt or collateral capacity and determine how many liquid funds Bank 1 may raise to settle the payment with Bank 2. Note also that Bank 1 may also settle the payment by selling some of its assets and, thus, the assets' market liquidity is also an important characteristic to consider. In section 3, we will analyze in detail, and using an explicit mathematical model, the determinants of the debt or collateral capacity and market liquidity of assets. Note, finally, that although in this paper we have assumed a well-functioning payment system and ruled out concerns about willingness to grant loans and refinancing risks, if Bank 2 would not be willing, or able, to grant Bank 1 an interbank loan, the payment would not be settled and Bank 1 would not fulfill the payment ordered by Firm 1 (the original deposit holder). Then Bank 1 would fail to deliver on its promise to the original deposit holders to make payments at will and would probably trigger a bank-run and tht CB's bankruptcy.

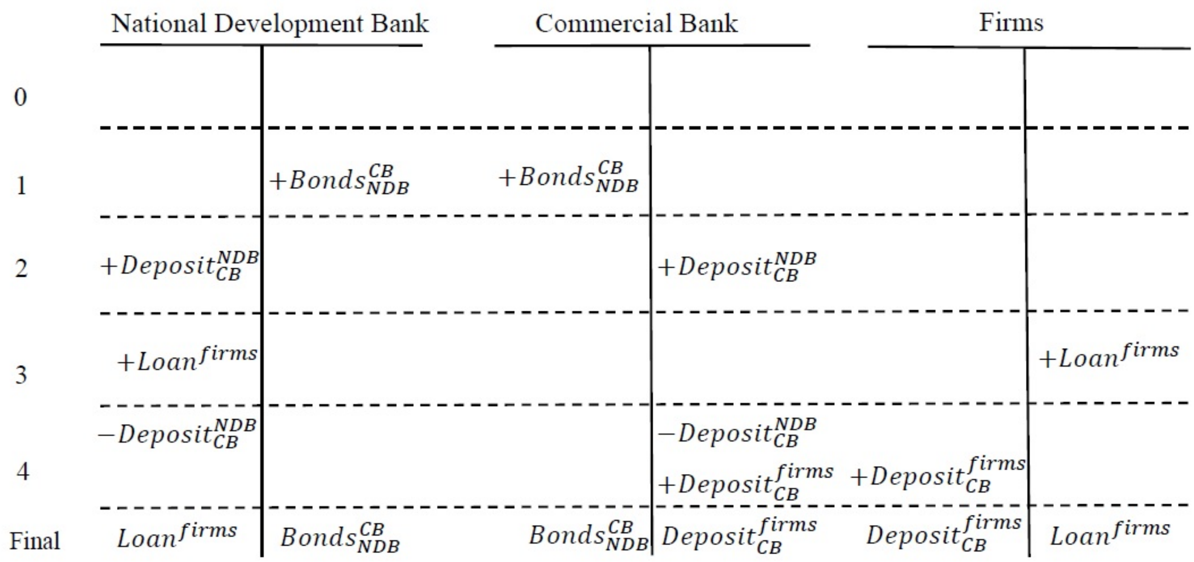

Figure 4: The Process of Lending to Firms by the National Development Bank

Next, we analyze the entry of a National Development Bank (NDB) and its interplay with the firms (investors) and CBs. In figure 4, we study the process by which the NDB lends to the firms, which differs from the process of lending to the firms when only CBs are involved. The NDB is willing to lend directly to the firms but funds its lending to the firms by issuing bonds and selling them to CBs rather than directly creating bank deposits as CBs did. The NDB uses the bank deposits obtained at the CBs to make bank transfers to the firms' bank accounts and settle the granting of the loans to the firms. Note that although NDBs may also create bank deposits, as CBs can, here we concentrate on analyzing a NDB that does not participate in the retail payment system and therefore cannot create bank deposits to be used in the retail payment system.[8]

[8]Note that the assumption that the NDB does not participate in the retail payment system is equivalently

Hence, in period 1, the NDB issues bonds that the CB buys, which implies that the CB acquires a financial instrument with an attached contract where the NDB promises to pay back the bond's capital and interests in the future to the holder of such bonds. In period 2, the CB pays the NDB for the acquired NDB bonds by creating bank deposits and crediting the price of the bonds in the bank account that the NDB holds in the CB. Then, in period 3, the NDB grants a loan to the firms, implying that such firms agrees contractually to pay back to the NDB both the capital and the interest of the loan in the future. Note that this loan granted by the NDB to the firm, which is a financial asset, may be used, explicitly or implicitly, as collateral for guaranteeing the payback of the issued NDB bonds. Then, in period 4, the NDB settles the granting of the loan and pays to the firm by transferring its bank deposits at the CB to the firm's bank account at the CB. This transfer of bank deposits within the CB implies that the CB just debits the amount of the loan from the bank account of the NDB and credits that same amount into the firm's bank account. The final outcome of this lending process shows that the NDB's lending has increased not only its assets but also its liabilities in the amount of the NDB's bond issuance. The CB has, in turn, observed an increase in its assets by the holding of the NDB bonds and its liabilities from the bank deposit creation.

In the last figure 5, we analyze how a CB may solve the liquidity problems from the maturity mismatch that may arise if its deposit holders make payments to bank accounts in a different CB with the participation of a NDB. In the initial period 0, the only asset-holding agent is Firm 2, which holds intermediate goods that Firm 1 needs for carrying out its investment project. The other agents hold neither assets nor liabilities. Firm 1 must obtain bank deposits through a loan from the NDB to pay Firm 2 for such assets. In period 1, the NDB issues NDB bonds and sells them to CB (Bank 1) and obtains bank deposits at Bank 1. Then, in period 1, the NDB grants a loan to Firm 1 by transferring its bank deposits in Bank 1 to Firm 1. Firm 1 will use such bank deposits to pay Firm 2 to obtain the intermediate goods from Firm 2. In the case that Firm 2 holds a bank account in a different bank, as the example in figure 3 illustrates, Bank 1 will face a liquidity problem. As period 3 depicts, Bank 1 solves its liquidity problem by selling its NDB bonds to Bank 2 and getting bank deposits in Bank 2 as payment for the NDB bonds. Then, in period 4, Bank 1 fulfills, without any inconvenience, the desired payment by Firm 1 to Firm 2, debiting the amount of the payment from Firm 1's bank account at Bank 1 and transferring Bank 1's bank deposits at Bank 2 to Firm 2's bank account at Bank 2. The final outcome is that Firm 1 obtained the desired goods of Firm 2 by getting a loan from the NDB bank, which financed its lending by issuing NDB bonds. Bank 1, which originally bought the NDB bonds, is able to fulfill FIrm 1's payment to Firm 2 by selling the NDB bonds to Bank 2. In this scenario, it is key to establish under which conditions Bank 2 values more the NDB bonds provided by Bank 1 than it values the bonds issued directly by Bank 1 (or granting an interbank loan to Bank 1). In the next section we will use a mathematical model to explain this question in more detail.

to assuming that the NDB creates bank deposits but that the firms that get those loans operate their payments through CBs and, thus, will inevitably transfer all their bank deposits at the NDB to a CB. In the case the NDB grants lending to the firms by creating bank deposits, the NDB will have to request an interbank loan, or issue a bond, to the CB to be able to settle the needed payment to the CB for fulfilling the requested bank transfer by the firms.

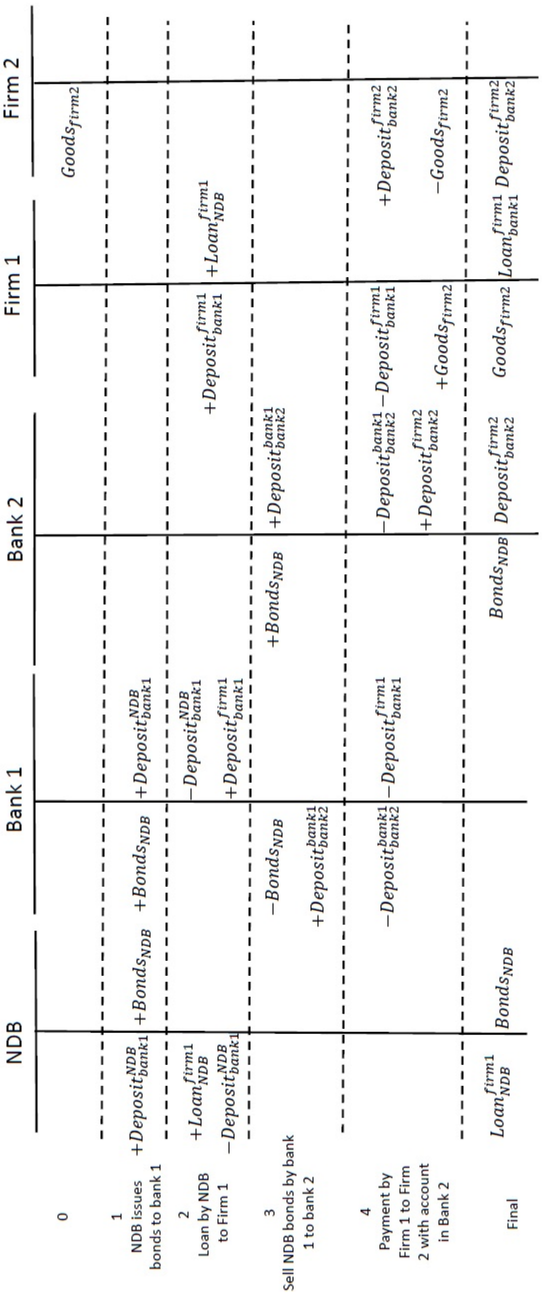

Figure 5: Solving the Liquidity Problem due to Maturity Mismatch by selling NDB bonds

3 Mathematical model

In this section we first model the determinants of the maturity of CB lending to firms when the only possibility of settling payments between CBs is by lending to each other and/or by paying with liquid assets. Our results prove that the maturity of CB lending to firms is positively related to both the amount of liquid assets holdings by CBs and by the debt or collateral capacity of their lending to firms. Furthermore, the recapitalization willingness (or perceived willingness) and the recapitalization capacity of banks' owners also determine the maturity of the lending to firms.

Next, we analyze a model with a NDB that finances its lending to firms by issuing bonds to CBs, who buy those bonds by creating bank deposits. CBs can choose between asset holdings in the form of lending to firms and/or NDB bonds, with the latter having higher liquidity value than the former since the recapitalization capacity and willingness (or perceived willingness) of the owner of NDBs, the government, is higher than that of the private bank owners.

3.1 CBs-Only Model

Our model starts by analyzing the case in which there are only CBs which must optimally choose the maturity of their lending to firms. The economy is characterized by a simple overlapping generation 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 the CBs, which implies that the maturity of the lending to firms is of a variable length, spanning through T periods between period 0 and period T.

Following Allen and Gale (1998), Brei and Schclarek (2015) and Holmstrom and Tirole (1998), among others, we assume there is a firm/investor with a real investment project that must be funded through borrowing from banks in the initial period 0 and 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 it is assumed 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 simplicity reasons, we assume that all the payoffs of the investment project from the different periods T materialize in the final period T.

Following Mehrling (2011), Mehrling (2012) and Mehrling et al. (2015), CBs grant loans by creating bank deposits that the firm/investor will use to make payments (see figure 1). It is assumed that CB 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.[9] Bank j, however, must optimally

[9] Note that we are making this assumption, instead of taking D as a decision variable, to concentrate exclusively

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).[10] 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 interests to the bank. Note that the larger the difference $E(R) - i_L$, the higher the expected per-period profits, after paying interest, of the firm 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, and thus the riskiness of the lending, is higher 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 interests are paid in the last period T_j, when the rest of the payoffs are realized and settled. All these assumptions imply that CBs 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 risks that firms will default on their loans.

As figure 2 shows, the chances of a maturity mismatch resulting in liquidity problems for a CB hinges on the probability of a net payment by that CB to another CB. 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 these 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 does not make any payment to another bank, say, k, in the intermediate period 1. However, if the payment recipient has a bank account in 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. 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; and, thus, bank j would probably suffer a bank-run and bankruptcy. Thus, bank j is exposing itself to liquidity risk in the intermediate period 1 when it provides lending to the firm and creates bank deposits in the initial period 0. 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 causes liquidity problems for bank j.

Therefore, we can establish three possibilities regarding the net flow of payments with bank deposits between banks and, thus, the required net payments between banks j and k in the intermediate period 1. It is assumed that following a categorical distribution, there is a probability α that there is a net outflow of deposits D from bank j, 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,

on the determination of T. However, this simplifying assumption does not affect our main results.

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

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.[11]

In the case of a net outflow of deposits from bank j, which requires a net payment of D from bank j to bank k, bank j can only settle the payment to bank k by getting an interbank loan from bank k in the intermediate period 1 (see figure 3) and/or by paying with the liquid assets A_j that it has available in the intermediate period 1. This survival constraint in the intermediate period 1 implies that $D \leq B_j + A_j$, where B_j is the amount of the interbank loan from bank k to bank j or the value of the bonds issued by bank j in the intermediate period 1. We assume that the interbank loan in the intermediate period 1 materializes when bank j issuing bonds or, equivalently, obtaining an interbank loan, with a maturity of $T_j - 1$ that it hands over to bank k. Note that we assume that the interbank loan is of maturity $T_j - 1$ (i.e., spanning the intermediate period 1 and the final period T_j) because it is not this paper's goal to analyze rollover risk, which would occur if the interbank loan (or the bonds issued by bank j) matured before period T_j and it needed to be rolledover until period T_j, when bank j's loan to the firm would be canceled. Regarding the liquid assets A_j, we clarify some further aspects below in this same subsection.

The value of the bonds issued by bank j, B_j, and, equivalently, the amount of the interbank loan that bank j can get from bank k, in this section are determined by two factors: a) the secured segment of the bond issuance given by the collateral or debt capacity of the assets of bank j (here we follow, among others, Adrian and Boyarchenko (2012), Brunnermeier and Pedersen (2009), Fostel and Geanakoplos (2014), and Geanakoplos and Fostel (2008)), and b) the unsecured segment of the bond issuance determined by the additional value given by the prospects that bank j may be recapitalized in the final period T_j in case it doesn't have enough liquid funds to pay back the issued bonds in full. Note that when referring to the secured segment of the bond issuance, we are not stating that the secured segment of the bond issuance is necessarily explicitly guaranteed but is certainly implicitly guaranteed by the bank's assets holdings.

Regarding the secured segment of the bond issuance, the debt or collateral capacity of the lending to the firm is $\tau(T_j) \cdot D$, where $\tau(T_j)$ is the debt or collateral capacity ratio, where $0 \leq \tau(T_j) \leq 1$.[12] Specifically, we assume that the debt or collateral capacity ratio of the lending granted by bank j to the firm 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 the firm, and, thus, the riskiness of the bonds issued by bank j. The negative relationship between the debt or 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. Further, the debt or 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, we just assume that $\tau(T_j) = 1 - \gamma \cdot T_j^2 \cdot V(R)$; and thus the value of the secured

[11]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 to our main results.

[12]The debt or collateral capacity ratio is the value of the collateral divided by the fundamental value of the asset (Geanakoplos and Fostel, 2008).

segment of the bond issuance is $B_j^S = (1-\gamma \cdot T_j^2 \cdot V(R)) \cdot D$, which is lower than D. Note that the debt or collateral capacity ratio of the lending to the firm is negatively related to the maturity T_j of the loan to the firm. The longer-term the lending of bank j, chosen or determined in period 0, the lesser the debt or collateral capacity of the lending to the firm in period 1. Note also that the value of the secured part of the bond issuance does not depend on the issuer but on the underlying assets.

Regarding the unsecured segment of the bond issuance, the value is given by the prospects that the bank's *owners* will bail out or recapitalize the bank in case of a partial or total default of the granted lending to the firm in the final period T_j. Note that the bank would only have enough funds to pay back the bonds if the firm pays back the granted lending, but may not have enough funds to pay back the bonds if the firm partially or completely defaults on its loans. Thus, even if bank j is fully willing to pay back the bonds, bondholders can only be certain of being repaid 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.[13] Note also that the bailout or recapitalization may be carried out by the current owners, new owners, and/or the government.[14] Concretely, we assume that the value of the unsecured segment of the bond issuance depends on both the willingness (or the perceived willingness) to recapitalize bank j of the bank's owners (or alternatively, other private agents and/or the government) to put up their own assets to recapitalize the bank in the final period T_j and the recapitalization capacity of the bank owners given by their availability of assets in the final period T_j.[15][16] In terms of our theoretical model, we assume that the value of the unsecured segment of the bond issuance is $B_j^U = \omega_j \cdot C_j$, where ω_j captures the recapitalization willingness of the owner of bank j (or the perceived willingness) 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. Further, we assume that $0 \leq \omega_j \leq 1$, implying that the value of the unsecured segment of the bond issuance adopts values between 0 and a maximum value of C_j, the maximum recapitalization capacity for bank j in the final period T_j.

Taking into account both the secured and unsecured segment of the bond issuance, the value of the bonds that bank j can issue in the intermediate period 1, B_j, is equal to the sum of B_j^S and B_j^U, and given by

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

From equation 1, it is clear that the longer the maturity of the loans to firms, the lower the collateral value of these loans, and the lower the value of the bonds that bank j issues. Thus, we have the following lemma.

[13] Although we do not discuss the exact form of the bailout, besides arguing that the recapitalization of the bank implies the availability of new liquid assets in period T_j to pay back the issued bonds, there are several papers that discuss the best way to carry out a recapitalization, such as Beccalli and Frantz (2016), Brei et al. (2013), and Enoch et al. (2001).

[14] Here we just assume that there are prospects of a bailout, without analyzing the particular reasons for this bailout. The following papers, among others, discuss different reasons for a bailout: Beccalli and Frantz (2016) and Berger and Bouwman (2013).

[15] We will further discuss the issue of the willingness and financial capacity for a bank recapitalization in subsection 3.2, when we introduce the National Development Bank and the government, which is its owner.

[16] 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 research such as that of Sandleris (2016), that analyzes the willingness and financial capacity of governments to pay their issued debts, most of which are unsecured.

Lemma 1. *The value of the bonds that bank j can issue B_j is decreasing in the maturity of the lending by bank j to the firm T_j.*

In addition, we assume that the bonds pay an 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. As stated above, without affecting our results and conclusions, we assume that bank j issues bonds in the intermediate period 1 that mature in period T_j, implying the bonds that are issued are of maturity $T_j - 1$, so that the per-period interest rate that is charged is $(T_j - 1) \cdot i_B$. Note that bank j could also, for example, issue bonds with maturity 1 and rollover the bonds $T_j - 1$ times to minimize the per-period interest rate that it is charged, which would be i_B. However, as explained above, we assume away this possibility because we are not interested in analyzing the trade-offs between a lower per-period interest rate and the problems that arise when there is rollover risks.[17] Also, given our assumptions, issuing bonds of shorter maturity does not affect the value of the bonds in the intermediate period 1 because that value is given by the maturity of the collateral (i.e., the maturity of the loan to the firm).

Then, in case there is a net outflow of deposits from bank j, and taking into account the 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, which we assume away in this paper as stated above 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 debt or collateral capacity ratio of 1.[18]

In addition, we assume that in the case there is a net inflow of deposits to bank j, the amount of inflows D, the maturity of the direct lending by bank k T_k as well as the liquid asset holdings of bank k A_k are given. Further, 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. We assume that the 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

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

[17] Note also that the results and conclusions of this paper are not affected and/or driven by the fact that while the lending to the firm pays 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.

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

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 the fractions $\frac{(T_j-1)}{T_j}$ and $\frac{(T_k-1)}{T_k}$ are introduced 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 between 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 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 $\frac{\partial U(T_j)}{\partial T_j} = i_L D - \alpha i_B (D - A_j)(1 - \frac{1}{T_j^2}) > 0$ as long as $\frac{i_L}{i_B} > \alpha(1 - \frac{A_j}{D})$ given that $T_j \geq 1$. Actually the requirement $\frac{i_L}{i_B} > \alpha\left(1 - \frac{A_j}{D}\right)$ is very weak and easily satisfied: first, if $i_L \geq i_B$, then the condition is always satisfied; second, when $i_L < i_B$, since $0 < \alpha < 1$, $0 < \frac{A_j}{D} < 1$, it is still fine as long as i_L is not too much smaller than i_B.[19] Hence, 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 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 value of its bonds in the intermediate period 1 are 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 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

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

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

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 debt or collateral capacity ratio of the lending to the firm and a lower value for the secured segment of the bond issuance in the intermediate period 1, B_j^S; thus, the maturity of the lending in the initial period 0 is shortened; 2) from point c) and d) of the proposition,

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

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 value for the unsecured segment of the bond issuance in the intermediate period 1, B_j^U; thus, the maturity of the lending in the period 0 is lengthened; 3) from point e) of the proposition, higher 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.

Finally, note that, as is assumed throughout this paper, bank k is always willing to buy bonds from bank j in the amount B_j, where B_j is given by the secured and unsecured segments of the bond issuance. This assumption implies that in our paper we do not analyze situations of credit or market freezes and refinancing risks, where it would be necessary to have a lender of last resort to lend when other do not want to, or a dealer of last resort to buy assets when others do not want to. In this setup, there is no role for a central bank because it would behave exactly the same as bank k by buying bonds from bank j up to the amount of B_j. If the central bank bought bonds from bank j in a higher amount than B_j, the central bank would be lending to bank j more funds than what bank j can pay back in the final period T, and the central bank would be sustaining an expected loss with certainty. In general, this is not how central banks proceed. Of course, it would be different if in our model we assumed that bank k, for some reason, was willing only to buy bonds from bank j in an amount lower than B_j. In that case, the central bank, could step in to make sure that bank j obtained the correct amount of liquid funds B_j and not less. This situation, however, is out of this paper's scope.

3.2 Model with a NDB

In this subsection, we introduce a national development bank (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 CBs to obtain bank deposits at the CBs to settle the granting of the loans to the firms.[20] Next, we compare the optimal determination of the maturity of loans to the firms for this banking system with a NDB and CBs with the alternative banking system with only CBs, analyzed in subsection 3.1.

Concretely, we assume that CB j invests in NDB bonds in the initial period 0 by creating bank deposits D, which are used to pay the NDB. With these bank deposits, the NDB grants lending D to the firm in the initial period 0 and transfers its deposits D in CB j to the firm's account in CB j. In the intermediate period 1, if there is a net outflow of deposits D from CB j, requiring a net payment D from CB j to CB k, CB j may settle its payments to CB k by selling its NDB bonds rather than get an interbank loan or issuing its own bonds to bank k, as in subsection 3.1, and using its own liquid assets available in the intermediate period 1 A_j. Then, the binding survival constraint in the intermediate period 1 for CB j, analyzed in the last subsection 3.1, is $D \leq B_{NDB} + A_j$.

[20] Note that with the adding of NDB bonds, CBs have two options for investing, they can either lend directly to the firms, as analyzed in the last subsection 3.1, or they can buy NDB bonds. In this paper, however, the setup of the model is such that CBs are completely indifferent between these two options. Thus, we are not analyzing the optimal portfolio choice of CBs in terms of lending directly to the firms and/or holding NDB bonds.

In the intermediate period 1, the value of the NDB bonds, as in subsection 3.1, is given by the secured and unsecured segments of the bond issuance, but also by the NDB's liquid asset holdings. The secured segment of the bond issuance, just as in subsection 3.1, is given by the debt or collateral capacity of the NDB's loan to the firm, which is negatively related to the maturity of this lending to the firm. In addition, the value of the unsecured segment, also as in subsection 3.1, is given by both the willingness (or the perceived willingness) to recapitalize the NDB and the recapitalization capacity of the government (the owner of the NDB) in the final period T_{NDB}. Regarding the liquid asset holdings of the NDB A_{NDB}, these serve as a collateral to the bond issuance of the NDB, meaning that these liquid assets will be used by the NDB to pay back part of the NDB bonds once they mature. Note that whereas CBs use their liquid assets to directly settle payments with other CBs, a NDB that does not participate in the payment system, as assumed in this paper, uses its liquid assets as collateral for its bond issuance.[21] Thus, the value of the NDB bonds in the intermediate period 1, B_{NDB}, is

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

From equation 4, it is clear that the longer the maturity of the loans to firms, the lower the collateral value of these loans, and the lower the value of the bonds that the NDB issues. Thus, we have the following lemma.

Lemma 2. *The value of the bonds that the NDB can issue B_{NDB} is decreasing in the maturity of the lending by the NDB to the firm T_{NDB}.*

In the initial period 0, when the NDB issues its NDB bonds and has to decide the maturity of its loans to the firm, the NDB must take into account the value of the NDB bonds in the intermediate period 1 from equation 4 and the payment or survival constraint of CB 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 CB j directly, as it is CB j that creates bank deposits to finance the NDB in the initial period 0, it is still the case that CB j faces liquidity risks when buying NDB bonds because bank deposits may be withdrawn in the intermediate period 1 from CB j to CB k, as analyzed in subsection 3.1. 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 value of the NDB bonds in the intermediate period 1 is high enough for CB j to be able to use them, in conjunction with its liquid assets A_j, to settle net payment of D with CB 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.[22] Then, the maximum maturity of the lending to the firm by the NDB in the initial period 0, T_{NDB}^*, is

[21] Alternatively, the NDB can use its liquid assets to obtain bank deposits from CB j in the initial period 0. CB j would use those liquid assets in case of needing to make a payment to CB k in the intermediate period 1. This alternative has results equivalent to the case analyzed in this paper.

[22] 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 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 valuation of the NDB bonds. This case is not studied in this paper.

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

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 than for the case of the CB T^*_j from proposition 1.*

Note, however, that in equation 5 we not only have the liquid assets of the NDB, A_{NDB}, but also the liquid assets of the CB, A_j. As should be clear from the discussion so far, both liquid assets appear in equation 5 because A_{NDB} is used as collateral for the bond issuance, increasing the value of the NDB bonds in the intermediate period 1, and A_j would be used by CB j to settle its payment with CB k in the intermediate period 1. In addition, another difference is given by the recapitalization capacity of its owner, C, and the willingness (or perceived willingness) to recapitalize the bank by its owner, ω. The difference is that for the case of the CB j it is given by its private owners and for the case of the NDB it is given by the government or the state, which is the NDB's owner.

Regarding the liquid assets and comparing 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 loans provided to firms directly by the CBs. Note, however, that this is not an advantage per se of the banking systems with a NDB and CBs over the alternative banking system with only CBs, analyzed in the last section 3, but the consequence of their being more liquid assets in the system. If the liquid assets of the NDB A_{NDB} would be given to the CBs, maybe in the form of a recapitalization of the CBs by the government, we would be in a situation where $T^*_{NDB} = T^*_j$.

Regarding the recapitalization capacity of its owner, C, and the willingness (or perceived willingness) to recapitalize the bank by its owner, ω, if these are higher for the owner of the NDB, the government or state, than for the owners of CBs, private bank owners, 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. This higher recapitalization capacity and the willingness (or perceived willingness) to recapitalize the NDB by its owner, the government, in comparison with the private owners of CBs imply a real advantage of a banking systems with a NDB and CBs over the alternative banking system with only privately-owned CBs, analyzed in subsection 3.1.

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

To clarify the above results, in figure 6 we compare the value of the bonds issued by the NDB, B_{NDB}, from equation 4, with the value of the bonds issued by CB j, B_j, from equation 1, taking as independent variable the maturity of the lending to the firm. For the NDB, we assume that it has no liquid assets ($A_{NDB} = 0$) to concentrate on understanding how the higher recapitalization capacity and the willingness (or perceived willingness) to recapitalize the NDB by its owner ends up influencing the results. As discussed above, if the NDB has positive liquid

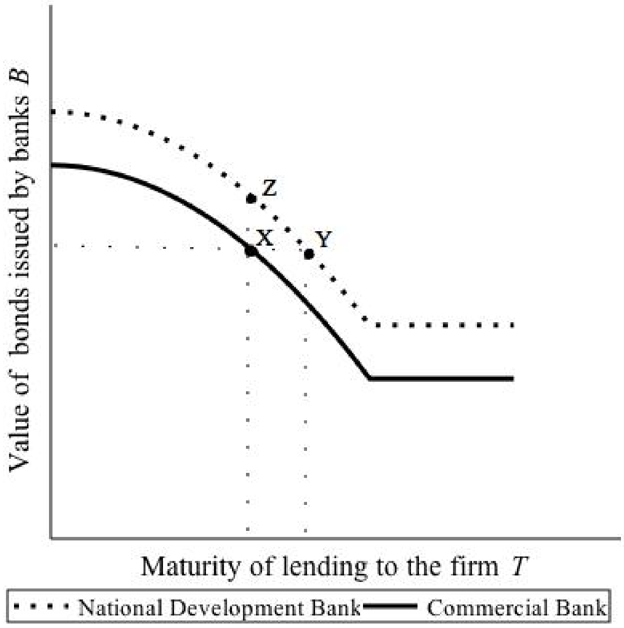

Figure 6: The Value of Bonds Issued by Banks and the Maturity of the Lending to the Firm

assets ($A_{NDB} > 0$), the NDB bonds will have a higher value than the bonds issued by CBs, but this higher value is just the consequence of there being more liquid assets in the banking system and is no strict advantage of the banking system with a NDB and CBs over the system with CBs only. Rather, the assumptions that $C_{NDB} > C_j$ and $\omega_{NDB} > \omega_j$ imply that CB bonds that are guaranteed by loans to the firm of a certain maturity have the same value as bonds issued by the NDB that are guaranteed by loans to the firm with a higher maturity. This result is this paper's key explanation for the maturity-lengthening role of NDBs. Clearly, in figure 6, whereas point X, which represents the case of the CB, implies the same bond 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. Note also that, given a certain maturity of the lending to the firms by either the CB or the NDB, the value of the bonds issued by the NDB is greater than the value of the bonds issued by the CB. This result is depicted in figure 6 by comparing point X (CB) and point Z (NDB). Furthermore, this result implies that, given a certain maturity of the lending to the firms, CBs are better able to cope with liquidity risks when holding NDB bonds rather than issuing their own bonds. Thus, given a fixed maturity of the lending to the firms, CBs will always prefer to buy NDB bonds rather than lending directly to the firms. Note, finally, that for both the NDB and the CB, initially there is a negative relationship between the value of the bonds and the maturity of the lending to the firm, but at high levels of the maturity of the lending to the firm the relationship is horizontal. This horizontal relationship is given at high levels for the maturity of the lending to the firm, where the secured segment of the bond issuance is zero and all the value of the bonds is given by the unsecured segment of the bond issuance (i.e., the value given by willingness (or the perceived willingness) to recapitalize the bank and the recapitalization capacity of the owner of the bank).

The justification for the higher recapitalization capacity of the owner of the NDB, the government, in comparison to the owners of the private CBs, 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 owners of the CBs. 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 not only hinges on the *size* of the government in comparison with the private bank owners, in terms of owning liquid assets, but fundamentally on the *ability to raise taxes* given by the legal power of the state. In addition, but related to the taxation argument, the government may find it easier and cheaper than private bank owners to access to additional capital by borrowing from national and/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 in comparison with the willingness of the private bank owners to recapitalize their CBs.[23] 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 only lose their own capital in the failing banks, the government may, among other consequences, have to increase unemployment benefits, obtain lower tax revenues, lose elections because of voters' dissatisfaction, and/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., 2019). Moreover, this higher 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 and/or bondholders but 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. Thus, this will undermine the value of private bank bonds, given the probable incurred 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 banks is always higher. Note also that, although out of this paper's scope, if for some reason agents have difficulty to correctly evaluate 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.

[23]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.

Finally, note that if the government issues its own bonds to CBs and these bonds have a higher 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 than the case analyzed above may be achieved. In this case, it may be better if the government issues its bonds to CBs and uses those bank deposits to recapitalize the NDB so that that the NDB can, in turn, lend to the firms. Note, however, that 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 are more valuable 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 price of NDB bonds.

4 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 borrowers. As will be clarified below, the monitoring skills, which determine the monitoring quality of the banks, will affect the valuation of the bonds issued by these banks, and thus, will affect the maturity of the lending to firms by these 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 a 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 affect 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 on lend to or buy bonds from the active bank, will assess indirectly the true variance of the investment project by using the estimation of the active bank and taking into account this bank's monitoring quality, which we assume is known by all.[24] Therefore, when a certain bank j determines and states 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 greater values for q_j corresponds with lower monitoring quality. Thus, the lower the monitoring quality of bank j (i.e., the greater the value of q_j), the larger is the true variance inferred by the other banks. Note that in the last section we analyzed the case in which bank j is perfect at monitoring ($q_j = 1$) and, thus, the

[24] These assumptions may be justified by asymmetric information and/or imperfect information arguments.

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 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 higher monitoring quality will also be able to issue bonds with higher value. The reason is that the other banks perceive that the secured segment of the bond issuance, $B_j^S(q_j) = (1 - \gamma \cdot T_j^2 \cdot V(R) \cdot q_j) \cdot D$, 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.*

These results imply that, given a certain value for the bonds issued by the banks, banks with higher monitoring quality will be able to lend to firms with longer maturity than banks with lower monitoring quality. Similarly, given a certain level for the maturity of the lending to the firms, the value of the bonds issued by banks with higher monitoring quality is higher than the value of the bonds issued by banks with lower monitoring quality. In figure 7 we depict these results by comparing the value of the bonds issued by a bank with high monitoring quality with the value of the bonds issued by a bank with low monitoring quality, taking as independent variable the maturity of the lending to the firm.

We now turn back to the comparison of last subsection 3.2 between a banking system where it is the NDB that grants the loans to the firms financed by CBs that buy the NDB bonds with a banking system where it is the CBs that directly grant the loans to the firms. The new assumption 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 CBs, meaning that $q_{CB} < q_{NDB}$, this reduces the NDB's advantage over CBs in terms of the lengthening of the maturity of lending to firms. Recall that in subsection 3.2, we assumed that the NDB had an advantage over CBs 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 to the CBs, the NDB may grant loans of lower maturity than those of the CBs, even when $C_{NDB} > C_{CB}$ and $\omega_{NDB} > \omega_{CB}$.*

Figure 8 depicts what is expressed in corollary 2 and highlights two sub-regions where the results are different. In sub-region Z, although low monitoring quality puts the NDB at a disadvantage, the NDB still benefits from the higher value of the recapitalization willingness

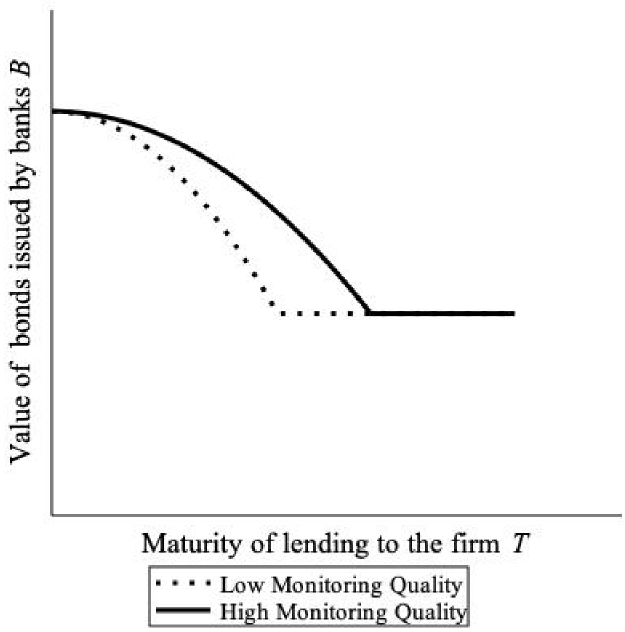

Figure 7: Monitoring Quality, the Value of Bonds, and the Maturity of Lending

and capacity, and, thus can still grant loans of longer maturity in comparison with CBs, given a certain value for the issued bonds. However, in sub-region X, the CBs will provide loans of longer maturity than the NDB, given a certain value for the issued bonds, because in this sub-region the disadvantage of the NDB from the lower monitoring quality is greater than the advantage of the higher recapitalization willingness and capacity.

Regarding the possible justification for assuming that the monitoring quality of state-owned banks is lower than that of private-owned banks, it could be related to poor governance, as argued by LaPorta et al. (2002) and Dinc (2005).[25] The poor governance would negatively affect monitoring skills, such as the evaluation of projects, screening of borrowers, and/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 non-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 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.

A conclusion from this analysis is that the quality of monitoring by banks is an important

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

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 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 evaluation of projects, screening of borrowers, and collection of repayments, and thus achieve high monitoring quality.

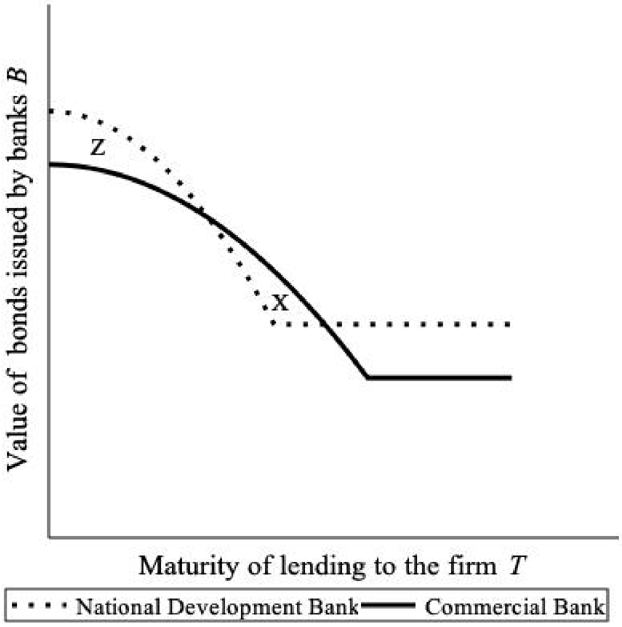

Figure 8: NDB with Low Monitoring Quality, the Value of Bonds and the Maturity of the Lending to the Firm

5 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. As will be clarified below, the market liquidity of the bonds issued by banks determines the 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 CBs, we add a new channel through which the NDB may have an additional advantage over CBs. Note also that through this channel, we are also presenting an advantage that the NDB may have over state-owned CBs. In the last two sections, we assumed that the NDB was the only state-owned bank and that all the CBs were privately owned. If we had assumed instead the existence of state-owned CBs, and if these state-owned CBs had the same characteristics as the NDB, in terms of recapitalization capacity and willingness, and monitoring quality, then there would not be any advantage to having a NDB when the banking system also has state-owned CBs. However, with this new assumption about the market liquidity of bonds, we provide an argument for the existence of a NDB, even when there are state-owned CBs 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 will also be traded at a discount in the secondary market after having been issued (Bao et al., 2011; Vayanos and Wang, 2013). Thus, we assume that there is a negative relationship between the market liquidity of bonds and the value of those bonds in the intermediate period 1.[26] Specifically, we assume that the value of the bonds issued by bank j in the intermediate period 1 is a fraction δ_j of the value of the secured and unsecured segment of the bond issuance, where δ_j captures the reduction in the value of the bonds of bank j resulting from the level of market liquidity of the bonds of bank j and $0 \leq \delta_j \leq 1$. Note that $\delta_j = 1$ means perfect market liquidity and $\delta_j = 0$ means perfect market illiquidity. Thus, the value of bonds by bank j with market liquidity δ_j in the intermediate period 1, $B_j(\delta_j)$, is

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

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

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

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 value for the bonds issued by the banks, the bank with the bonds with 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 value of the bonds issued by the banks with bonds with higher market liquidity is higher than the value of the bonds issued by the banks with bonds with lower market liquidity. In figure 9 we depict these results by comparing the value of the bonds issued by a bank with bonds with high market liquidity with the value of the bonds issued by a bank with bonds with low market liquidity, taking as independent variable the maturity of the lending to the firm.

We now turn back to the comparison of subsection 3.2 between a banking system where the NDB grants the loans to the firms financed by CBs that buy the NDB bonds with a banking system where the CBs 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

[26] Note that all through this paper we are taking the interest rate or coupon of bonds as fixed and given; and 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 valuation 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 value of bonds and not on the interest rate or coupon of those bonds.

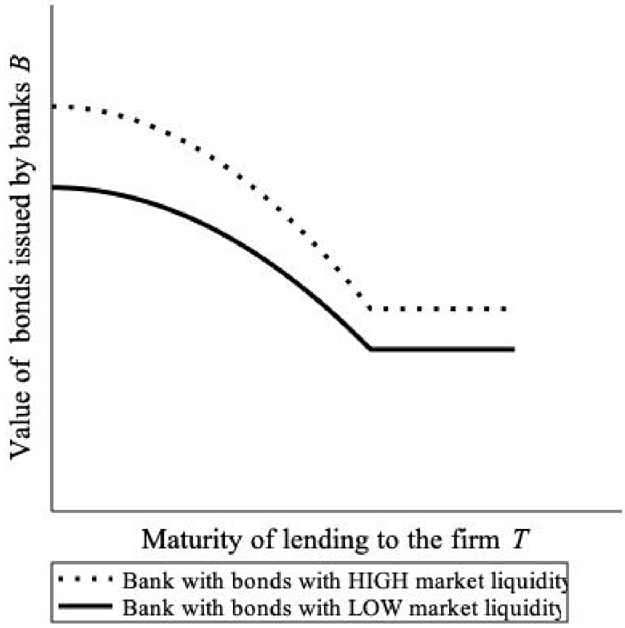

Figure 9: Market Liquidity of Bonds, the Value of Bonds, and Maturity of Lending

we assume that the NDB bonds have a higher market liquidity than the bonds issued by CBs, meaning that $\delta_{NDB} > \delta_{CB}$, then, this increases the advantage of the NDB over CBs 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 CBs analyzed in last section 4.

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

Figure 10 depicts what is expressed in corollary 3 by comparing a situation where the NDB has a lower monitoring quality than CBs, 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 CBs, which gives them an advantage over CBs. In that figure it is clear that a NDB with low monitoring quality, but no advantage over CBs in terms of the market liquidity of its bonds, would not be able to lend longer term than CBs. However, a 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 CBs with high monitoring quality but low market liquidity for their bonds. Evidently, the market liquidity of bonds is an important factor that explains the value of bonds and, thus, influences the maturity of the lending by banks to firms.

Another important proposition that can be made with the introduction of the market liquidity of bonds is to give a rational 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 CBs were all privately owned. If we had allowed for the existence of state-owned CBs, 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,

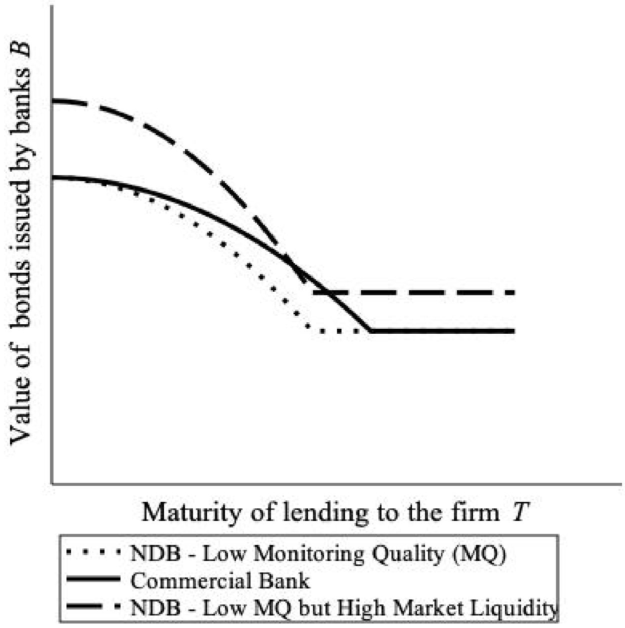

Figure 10: NDB with Low Monitoring Quality, High Market Liquidity of Bonds and the Maturity of the Lending to the Firm

and the monitoring quality, then the NDB would have no advantage over the state-owned CBs 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 state-owned CBs' bonds, then we still have an argument favoring the existence of NDBs, which finance their lending to firms through issuing bonds to CBs, both privately- and state-owned. In a sense, all these different advantages and disadvantages for the different types of banks allow for and justify a complex banking systems 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 CBs, both state-owned and privately-owned, several arguments related to the market liquidity literature can be put forward. Vayanos and Wang (2012) argue that agents face costs of market participation (e.g., 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 a NDB that finances its lending by issuing NDB bonds that are bought by CBs in the initial period 0. Clearly, all CBs must incur the participation costs for the NDB bonds in the initial period 0 in order to buy them. Therefore, those CBs that face a net deposit inflow in the intermediate period 1, and accept NDB bonds to settle payments with the CBs that face net deposit outflows, are already correctly informed for the trade and do not need to incur, to a large extent, in additional participation costs in the intermediate period 1. In contrast, consider the banking system with only CBs. In this case, CBs are not buying bonds from any CB in the initial period 0, and thus, will not have incentives to incur in any participation costs in the initial period 0. Only in the intermediate period 1, when CBs know if they face a net deposit inflow from other CBs, will they incur the participation costs for the bonds issued by the CBs that face net deposit outflows and need financing. Clearly, NDB bonds have an advantage in terms of lower participation cost over bonds issued by other CBs in the intermediate period 1, and thus we may expect that NDB bonds have a higher market liquidity than bonds issued by CBs.

In addition, and also related to the last argument, Pagano (1989) states that the volume of trade for an asset is an important factor in explaining the market liquidity for that asset. In this sense, while the banking system with a NDB and CBs implies that only one type of bond will be issued, the NDB bonds, the banking system with only CBs implies that many different types of bonds will be issued, one for each CB that issues bonds in the intermediate period 1. 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 in comparison with CBs' bonds. Note, however, that throughout this paper, we have been analyzing pure and extreme examples of banking systems where either all CBs were buying the NDB bonds or no CB was buying NDB bonds and only buying bonds from other CBs. 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 CBs will also have an advantage over small CBs 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 through bond issuance instead of trying to mimic CBs that are in the payment system and are deposit-creators and -takers.

6 Concluding Remarks

In this paper we have studied the theoretical determinations of the maturity of the lending to firms or investors by banks. Our model links the maturity lengthening role of banks with the value of the bonds that banks issue in the interbank market. Our main result is that a banking system with CBs and state-owned NDBs may provide longer-term lending to firms in comparison with a banking system with only private-owned commercial banks (PCBs) because NDB bonds have more value than bonds issued by PCBs, thus allowing banks to better cope with maturity mismatch risks and liquidity problems in case interbank payments are necessary. One reason NDB bonds have more value than the bonds issued by PCBs is that NDBs are owned by the government; hence, there is a higher recapitalization willingness and capacity compared with private bank owners. Another advantage is that NDBs finance themselves through bond issuance rather than deposit-creation and -taking, which increases the market liquidity of their bonds. However, if NDBs have lower monitoring quality than PCBs, this reduces the advantages of NDBs over PCBs in terms of their maturity lengthening role. Note also that because of the NDB bonds' higher market liquidity, NDBs may even have an advantage over state-owned CBs (SCBs), in terms of the maturity of loans to firms, even when SCBs have similar characteristics in terms of the recapitalization capacity and willingness (or perceived willingness) to recapitalize the bank by the government or state, and the monitoring quality. In a sense, all the different advantages and disadvantages of the different types of banks allows for and justifies a 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 relevant for countries that have governments with stronger credibility, finances and net worth, in comparison with countries with governments plagued by credibility concerns, over-indebtedness and excessive fiscal deficits. Also, it is important that NDBs are well-governed and have high monitoring skills and quality and that the investment projects that get lending and financing from NDBs have higher expected financial or productive returns and are less risky. Clearly, badly managed NDBs, which do not keep out narrow private and political vested interests, will probably end up in a fragile financial position with high non-performing loans and low credibility. Note also that we are not arguing that NDBs should not undertake low-return and/or high-risk projects; rather, we are arguing that those projects will inevitably lower the value of NDB bonds and curtail their maturity lengthening role. Further, the maturity lengthening role of NDBs is improved when fostering the market liquidity of their bonds and when NDBs are bigger, in the sense of their relative bond issuance size in the banking system, which improves their bonds 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 CBs that are in the payment system and are deposit-creators and -takers. In addition, the maturity lengthening role of NDBs is more important when they have a proper liquidity management, possess an adequate amount of liquid asset holdings, and are well capitalized. Finally, the advantages of NDBs in comparison with CBs, especially in terms of recapitalization willingness and capacity and bond market liquidity, is what makes them more suitable than CBs 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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