THE JOURNAL OF FINANCE • VOL. LV, NO. 3 • JUNE 2000

Multiple versus Single Banking Relationships: Theory and Evidence

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ABSTRACT

A theory of the optimal number of banking relationships is developed and tested using matched bank-firm data. According to the theory, relationship banks may be unable to continue funding profitable projects owing to internal problems and a firm may thus have to refinance from nonrelationship banks. The latter, however, face an adverse selection problem, as they do not know the quality of the project, and may refuse to lend. In these circumstances, multiple banking can reduce the probability of an early liquidation of the project. The empirical evidence supports the predictions of the model.

STUDIES OF THE CORPORATE FINANCIAL STRUCTURE began by focusing on the choice between debt and equity (Harris and Raviv (1991)), and only recently have addressed the choice among alternative forms of debt, such as bank debt, public debt, privately placed debt, and others.[1] From this work a theory of bank-firm relationships has emerged, centered on the idea that banks acquire information about the quality of the firm that is not shared by other financial intermediaries.[2] Much of this theory proceeds on the assumption

* International Monetary Fund, Universita' di Bologna, and Universita' di Sassari and Ente Luigi Einaudi, respectively. We wish to thank Marco Da Rin, Mathias Dewatripont, Giovanni Ferri, Andrea Generale, Andrea Gerali, Giorgio Gobbi, Raghuram Rajan, Andrei Shleifer, Alessandro Sembenelli, and participants in seminars at the Chicago FED, Igier, the University of Brescia, the BIS, and in the 1997 Alicante ASSET meeting; the 1st European Corporate Governance Network Conference; the 1997 CEPR Conference on Information and Learning, Financial Intermediation, and the Macroeconomy; the Center for Financial Studies Conference on Credit Risk Management and Relationship Banking; and the 1998 meetings of the American Finance Association for helpful comments on a previous version of this paper. Valuable suggestions were also received from the editor and from an anonymous referee. This paper is part of a project on "Legal Enforcement and the Structure of Bank-Firm Relations." Financial support was provided by MURST. The Federal Reserve Board has kindly provided us with the public release of the 1988 National Survey of Small Business Finances. The views expressed in the paper are the authors' own, and do not necessarily reflect those of the International Monetary Fund. The data analysis in this work was performed while Luigi Guiso was at the Bank of Italy.

[1] See, among others, Diamond (1991a), Rajan (1992), Berglöf and Von Thadden (1994), Detragiache (1994), and Houston and James (1996).

[2] Sharpe (1990), Diamond (1991a), and Rajan (1992) present theoretical models. Lummer and McConnell (1989) show evidence supporting the idea that banks possess information not shared by other agents. Petersen and Rajan (1994, 1995) and Berger and Udell (1995) study various features of bank-firm relationships using small business data for the United States.

Table I

Number of Bank Relations for Small Businesses in Italy and in the United States

The data refer to firms with 500 or fewer employees. For the United States, they come from the 1988 wave of the National Survey of Small Business Finances. The number of relationships is the number of credit institutions (commercial banks, savings and loans associations, savings banks, credit unions, or mortgage banks) lending to the firm. For Italy, data are from the 1994 Survey of Manufacturing Firms and from the Credit Register. The number of relationships is the number of banks extending credit lines to the firm.

	United States	Italy
Mode	1	3
Median	2	5
75th percentile	2	8
Share of firms with one relationship	44.5%	11.0%

that firms borrow from one bank only, but this does not necessarily conform with the data. Table I reports some simple statistics on the number of bank relationships for samples of small firms in the United States and Italy. Single banking appears to be quite prevalent in the United States, but even there the median number of relationships is two, and 55.5 percent of firms have more than one bank. More striking is the case of Italy, where 89 percent of firms rely on multiple banking, the median number of relationships is five, and the 75th percentile is eight compared to two in the United States.

This paper addresses the questions of why firms, even rather small ones, need more than one bank and, more generally, what explains the cross-sectional variation in the number of banking relationships. A number of considerations suggest that multiple banking should be costly: dealing with more than one bank may involve significant transaction costs. Screening and monitoring costs may be duplicated, or, if banks free ride on the others' efforts, too little screening or monitoring may result. Also, debt renegotiation is likely to be more complex when many creditors are involved. To outweigh these costs, multiple banking must offer substantial benefits to firms or to banks. In the case of large firms, multiple banking may be explained by the desire of banks to diversify firm-specific credit risk. However, as shown in Table I, multiple banking is quite prevalent among small firms, especially in Italy.

One potential explanation for the benefits of multiple banking is suggested by Von Thadden (1994): After it acquires private information about the quality of the borrower, a relationship bank may be able to use this information to extract rents. Ex post rent extraction by the creditor, in turn, may distort entrepreneurial incentives ex ante, and lead to a suboptimal choice of investment projects. In these circumstances, establishing a second relationship can restore competition among lenders and limit ex post rent

extraction.[3] In Von Thadden's model, *two* banking relationships are sufficient for the entrepreneur to capture all the rents, so why firms have *more than two banks* remains unexplained. In the model of Bolton and Scharfstein (1996), increasing the number of creditors complicates debt renegotiation, but the loss of ex post efficiency may be beneficial ex ante, as it limits incentives for strategic default. In equilibrium, firms with high credit quality are better off with two creditors rather than one, and so are firms whose assets are difficult to redeploy. Creditors, however, need not be relationship banks, and results for the case of more than two creditors are not derived.

In this paper, we present a theoretical model in which multiple banking can reduce "liquidity risk" in the sense of Diamond (1991b), namely the risk that a profitable project will have to be prematurely liquidated. By financing the early phases of a project, banks acquire private information about the continuation value of the venture. At the refinancing stage, the firm may need to borrow from nonrelationship banks because unexpected liquidity problems may make relationship banks unable to roll over their initial loans. In doing so, however, the firm faces an adverse selection problem, as noninformed banks will suspect that the project is a lemon.[4] For some parameter values, adverse selection is so severe that the firm is unable to refinance the project outside of the relationship. Under these circumstances, establishing multiple relationships serves to increase the probability that at least one informed bank will be able to refinance the project, thus reducing the likelihood of early liquidation. On the other hand, when adverse selection is mild enough that firms expect to be able to refinance from nonrelationship banks (albeit at a premium), multiple banking offers no benefits to the borrower, and single banking prevails.

The theoretical model has testable empirical implications concerning the determinants of the regime (single versus multiple banking) and concerning the optimal number of relationships for firms in the multiple banking regime. We explore the empirical validity of these implications using a cross section of small and medium-sized Italian manufacturing firms. The Italian data are especially useful because the number of relationships varies considerably across firms; moreover, by merging the data set with firm-level credit register data and with bank balance sheet data, we are able to obtain

[3] An alternative solution would be to resort to nonbank finance (Rajan, (1992)), and the greater availability of nonbank credit in the United States relative to Italy may be one of the factors explaining the greater prevalence of single banking in that country. Small firms, however, have little access to nonbank finance in the United States as well as in Italy. Houston and James (1996) study the firm characteristics associated with different types of debt finance, including multiple versus single banking, for a sample of large, publicly traded U.S. firms. They find that firm size and age are positively correlated with multiple banking, and so is the share of bank debt in total debt. The latter result is consistent with the hypothesis that for large firms multiple banking may perform the same role as nonbank finance.

[4] A similar adverse selection problem arises in Rajan (1992). In that model, no pure strategy equilibrium with refinancing outside of the relationship exists.

detailed information on the characteristics of each firm, on the firm's relationship with banks, and on the attributes of the banks lending to each individual firm. The predictions of the theoretical model suggest a testing strategy based on a two-stage estimation procedure: in the first stage, the choice of regime (single versus multiple banking) is estimated using a probit regression, and in the second stage we estimate the optimal number of relationships for the subsample of firms with more than one relationship taking into account the endogeneity of the regime. In both regressions we extend the set of explanatory variables beyond those suggested by our model to account for factors that could play a role based on intuitive considerations or alternative theories. Our findings are broadly consistent with the predictions of the theoretical model, especially concerning the choice of regime.

The paper is organized as follows. Section I presents the theoretical model and derives its empirical implications. Section II tests the predictions of the model using a sample of matched bank-firm data. Section III concludes.

I. The Theoretical Model

A. The Basic Setup

Consider a risk-neutral firm (or entrepreneur) that has no financial resources and wants to implement a project. The project starts at date 0 with investment cost I_0. It yields a return (cash flow) K at date 2 with probability p, and a zero return with the complementary probability, $1 - p$. At an intermediate date (date 1) the project needs a second allotment of funds, I_1, in order to be completed. If the cost I_1 is not paid, then the project must be liquidated at date 1, yielding a liquidation value of zero. The values I_0, I_1, and K are publicly known at date 0; that of p is not known by market participants, but it is common knowledge that it is the realization of a random variable with distribution $F(p)$, density $f(p)$, and support $[p_l, 1]$, with $p_l > 0$. At date 1 the realization of p is observed by the entrepreneur and by outside investors who financed the first stage of the project, but not by other parties. This assumption captures the idea that banks establishing a relationship with a firm acquire information that is not available to other banks. To avoid dealing with strategic interaction among banks at the monitoring stage, it will be assumed that information is acquired at no cost.[5] To keep the analysis simple, we consider only situations in which continuing the investment project at $t = 1$ is more efficient than liquidating it with probability one:

[5] If information were acquired through costly monitoring, and each bank could observe the lending terms offered by other banks, multiple banking would dilute the incentives of each single bank to monitor, and too little monitoring would take place in equilibrium. As a result, inside information would become less precise, mitigating the adverse selection problem and making refinancing outside of the relationship easier. To the extent that it results in less information acquisition, multiple banking may be similar to nonmonitored sources of external finance.

ASSUMPTION 1: $p_1K - I_1 \geq 0$.

Because the entrepreneur has no internal financial resources, he must obtain the amounts necessary for investment from outside investors. The latter consist of a large number of ex ante identical, perfectly competitive, risk-neutral banks, whose opportunity cost of funds is zero at both dates. Each bank incurs a fixed cost c for processing the loan, so multiple banking relationships increase transaction costs. Because we think of our model as especially suited for small and medium-sized firms, we neglect the possibility of nonbank external financing. Furthermore, we consider only one-period loan contracts.[6] Thus, to undertake the investment project the entrepreneur must borrow the amount I_0 at $t = 0$, and at $t = 1$ he must repay the initial loan and invest an additional I_1.

Imperfect loan enforcement is another key feature of the model, as it provides one of the frictions needed for multiple banking relationships to be beneficial. Because loan recovery through legal action is costly, banks can extract only a fraction $v < 1$ of the value of the firm from the borrower. Thus, at the final date, $t = 2$, creditors will receive a payment of no more than vK even if the contractual payment due exceeds that amount.[7] If loan enforcement is more difficult when there are many creditors, then the parameter v may increase with the number of relationships. To keep things simple, however, we will ignore this possible effect.

A second friction that plays a key role in the model is that banks may not be able to refinance a firm even if they believe that the project is profitable. This may occur when banks must reduce the size of their loan portfolios as the result of an unexpected loss of liquidity due to a flight of deposits. Alternatively, a bank's loan portfolio may become too risky relative to regulatory requirements or to the bank's own standards, and some risky projects must be dropped from the portfolio. We will refer to such circumstances as a "liquidity crisis" for the bank, and to a bank that does not experience such a crisis as an "active" bank. Liquidity crises occur with probability $\varepsilon > 0$ and are independent events across banks.[8] Thus, if a firm borrows from n banks at $t = 0$, the probability that at least one of those banks is active at $t = 1$ is $1 - \varepsilon^n$. Hence, increasing the number of banking relationships at $t = 0$ reduces the probability that all relationship banks will experience a crisis at the refinancing stage, $t = 1$.

[6] On the implications of introducing two-period loan contracts, see Section I.F below.

[7] This could be the equilibrium of a prebankruptcy debt renegotiation game in which creditors enforce their claims through the threat of bankruptcy and bankruptcy has deadweight costs. Another interpretation of the parameter v is that it reflects the control rents of the entrepreneur: The continuation value of the firm may depend on its current owner remaining at the helm, so the threat of expropriation through legal action following a default has limited effectiveness.

[8] The results hold if liquidity shocks are less than perfectly positively correlated across banks.

The number of banks participating in the first round of lending is common knowledge, but the occurrence of a liquidity crisis at any of the banks is not observable to other banks.[9] These assumptions imply that, if at $t = 1$ the firm attempts to refinance from a nonrelationship bank, other banks do not know if it is because all relationship banks are experiencing a liquidity crisis or because the project is bad (the realization of p is low).

B. The Refinancing Decision at $t = 1$

At the intermediate date $t = 1$, the firm must borrow to repay the first-period loan and to finance the second round of investment. Let D denote the (yet to be determined) interest and principal payment due on the first-period loan. At $t = 1$, borrowing from more than one bank is always suboptimal, as it increases transaction costs and has no possible benefits, so in equilibrium the firm refinances from one bank only, and transaction costs in equilibrium are always c. To economize on notation, I_1 denotes the amount of additional investment including the transaction cost c, so the amount that the firm must borrow at $t = 1$ is $D + I_1$. The firm can refinance from informed or uninformed banks. If the former option is chosen and if more than one informed bank is active, Bertrand competition ensures that the firm captures all the rents. If, on the other hand, only one informed bank is active, the firm and the bank are in a situation of bilateral monopoly, and the rent allocation is determined through bargaining. To simplify the analysis, however, we will assume that in equilibrium the borrower will capture all the rents even if only one informed bank is active at this stage. Accordingly, if R^i denotes the interest factor charged by an informed bank in equilibrium, the expected zero profit condition for informed banks is the following:

$$p \min[R^i(D + I_1), vK] - (D + I_1) = 0. \tag{1}$$

(Recall that because of imperfect enforcement, banks are unable to extract a repayment of more than vK from the firm.) It follows from equation (1) that if $p < (D + I_1)/vK$, then informed banks are not willing to refinance the project. On the other hand, if $p \geq (D + I_1)/vk$ then informed banks refinance the firm at the break-even interest factor $R^i = 1/p$. The term $vK/(D + I_1)$ is the maximum enforceable interest factor, and will be denoted by R^*. Consider now the strategy of an uninformed bank. If it offers an interest factor R, then the firm will take the loan in two circumstances: when no informed bank is active, an event with probability ε^n, or when at

[9] The assumption that banks know the number of creditors lending to a particular firm is quite realistic: in countries such as Italy or France this information is available at no cost through public credit registers. In countries such as the United States, where public credit registers do not exist, private credit bureaus provide the information at a small cost. Also, liquidity problems at other banks may be difficult to detect because banks may want to hide their problems from potential competitors and from depositors and borrowers.

least one informed bank is active and the interest rate offered by the uninformed bank is more favorable, namely if $R < R^i = 1/p$. The second event has probability $(1 - \varepsilon^n)F(1/R)$. Accordingly, the probability that a loan from an uniformed bank carrying an interest factor R is accepted is

$$\varepsilon^n + (1 - \varepsilon^n)F(1/R), \tag{2}$$

and the expected probability of success of the investment project conditional on refinancing from an uninformed lender is

$$E^u(p|R) = \frac{\varepsilon^n E(p) + (1 - \varepsilon^n)\int_{p_t}^{1/R} pf(p)\,dp}{\varepsilon^n + (1 - \varepsilon^n)F(1/R)}, \tag{3}$$

where $E(p)$ denotes the unconditional expected value of p. Since this expression exceeds $E(p)$, refinancing from uninformed banks reveals unfavorable information about the quality of the project. The break-even interest factor for uninformed lenders is

$$R^u = \frac{1}{E^u(p|R^u)}. \tag{4}$$

If R^u falls short of the highest enforceable interest factor R^*, then uninformed banks are willing to refinance the project at the intermediate date, and vice versa. Lemma 1 shows that a necessary and sufficient condition for uninformed bank refinancing is that expected profits be nonnegative at the maximum enforceable interest rate, namely that

$$R^*(D + I_1)E^u(p|R^*) - (D + I_1) > 0. \tag{5}$$

LEMMA 1: *Condition (5) is a necessary and sufficient condition for uninformed lenders to refinance the project at* $t = 1$.

Proof: See Appendix A.

The next step is to examine the borrowing decision at $t = 0$.

C. An Equilibrium with Only One Banking Relationship

If condition (5) holds, then the firm expects to be able to refinance the project with probability one at $t = 1$, and the first-period loan is always repaid. In equilibrium, then, the initial loan will carry the safe rate of interest, which is zero, so the amount borrowed at $t = 0$ and the amount to be repaid at $t = 1$ are the same. Furthermore, because the loan must

cover transaction costs as well as the initial investment, this amount is $D = I_0 + nc$. The present discounted value of the firm's expected profits at $t = 0$ is then

$$\pi(n) \equiv E(p)K - (I_0 + nc + I_1)\left(R^u\varepsilon^n E(p) + (1 - \varepsilon^n)\left[R^u \int_{p_l}^{1/R^u} p\, dF(p)\right]\right). \tag{6}$$

Using equations (3) and (4), this expression becomes

$$\pi(n) = E(p)K - (I_0 + I_1 + nc). \tag{7}$$

Thus, if nonrelationship finance at date 1 is available, then there are no benefits to multiple banking: choosing $n > 1$ simply increases transaction costs with no offsetting benefits. This result is stated in Proposition 1.

PROPOSITION 1: *If condition (5) holds for $n = 1$ and for $D = I_0 + c$, so that refinancing from uninformed banks is possible, then in equilibrium the firm borrows from one bank only.*

D. An Equilibrium with Multiple Banking

If at the initial date the firm anticipates not to be able to refinance the project from uninformed creditors, then with probability ε^n the project will have to be liquidated prematurely, and with the complementary probability the project will be refinanced by an informed bank. In Section B it was shown that if $p > 1/R^*$ then an informed, active bank is willing to lend because the break-even interest factor $R^i = 1/p$ falls short of the maximum enforceable interest factor R^*. If $p < 1/R^*$, then refinancing will yield an expected loss whatever the interest rate charged. Lending, however, may still be in the best interest of an informed bank because such a bank is already exposed toward the firm and an early liquidation would lead to the loss of the first-period loan. Thus, creditors who are already exposed must choose the lesser of two evils: refinancing the project ("throwing good money after bad"), which involves disbursing I_1 in exchange for an expected repayment of pvK, or offering no refinancing and losing the initial investment.[10] Clearly, when $pvK > I_1$ (or $p > I_1/vK$), refinancing is in the collective interest of relationship creditors, but when $pvK < I_1$, liquidation is preferable. Although banks compete for the privilege of lending for realizations of p such that new lending is profitable ($p > 1/R^*$), they would be more than happy to let another bank shoulder the burden of refinancing at a loss when

[10] If informed banks know that the firm can access uninformed finance, then they will not extend new loans when $p < 1/R^*$.

$1/R^* < p < I_1/vK$. The game that relationship banks play in these circumstances may have interesting aspects but it is beyond the scope of this paper, so we will simply assume that in such states of the world each creditor contributes to the new loan in equal proportion, and that the indebted firm captures all the rents.[11]

To sum up, when condition (5) fails to hold, the project is refinanced at date 1 if two conditions are satisfied: at least one relationship bank is active and the probability of success of the project is $p \geq I_1/vK$. When these conditions obtain, the expected payoff to creditors who refinance the project is $p[(1/p)(I_1 + D)] - I_1 = D$ if $p > 1/R^*$, and zero otherwise. With these results in hand, let us now turn to the borrowing decision at $t = 0$. If the firm borrows from n creditors, and the loan is shared in equal proportion, the expected zero-profit condition for each bank is

$$(1 - \varepsilon^n)(1 - F(1/R^*))(D/n) - [(I_0/n) + c] = 0; \tag{8}$$

hence,

$$I_0 + cn = (1 - \varepsilon^n)(1 - F(1/R^*))D. \tag{9}$$

The present discounted value of the firm's expected profits at $t = 0$ is then

$$\pi(n) = (1 - \varepsilon^n)\left(\int_{I_1/vK}^{1} (pK - I_1)f(p)\,dp - (1 - F(1/R^*))D\right). \tag{10}$$

Using equation (8) and rearranging,

$$\pi(n) = (1 - \varepsilon^n)\left(\int_{I_1/vK}^{1} (pK - I_1)f(p)\,dp\right) - (I_0 + cn). \tag{11}$$

This expression shows that, if the parameters are such that uninformed banks are unwilling to refinance the project, then increasing the number of initial banking relationships affects expected profits in two ways: it lowers profits because it increases transaction costs, and it increases profits because it makes it more likely that the project will be completed. Maximizing expected profits by choice of n (and neglecting the fact that n must be an integer) yields the result stated in Proposition 2.

[11] Banks are assumed to participate in the bailout even if they are experiencing a liquidity crisis. This may be possible if, for instance, other active banks extend loans to banks with liquidity problems to allow them to assume their share of the burden.

PROPOSITION 2: *If uninformed banks do not refinance at $t = 1$, then the optimal number of banking relationships is*

$$n^* = \frac{\ln c - \ln(-Z \ln \varepsilon)}{\ln \varepsilon} \tag{12}$$

where

$$Z \equiv \int_{I_1/vK}^{1} (pK - 1_1) f(p)\, dp. \tag{13}$$

Thus, the optimal number of relationships is generally greater than one, although it could be one for some values of the parameters.[12]

To summarize, if parameters are such that refinancing from informed banks is possible, then the number of relationships is trivially one, as multiple banking has no benefits. Conversely, if refinancing is not expected from nonrelationship banks, then the optimal number of relationships is n^*. In the next subsection we briefly discuss what would change in the model if long-term loan contracts were allowed.

E. Long-Term Contracts

The results obtained so far rely on the assumption that firms finance the project with two short-term loans. However, it could be argued that firms could insure against the premature liquidation of the project by using long-term debt. To analyze this possibility, suppose that at $t = 0$ the firms borrows I_0 and also negotiates to obtain a second allotment of funds I_1 at the interim date. The repayment on both installments will take place at $t = 2$. What happens now if the bank extending the two-period loan experiences liquidity problems at $t = 1$? One possibility is that it will try to reduce its portfolio of risky loans by selling the loan contract to another bank.[13] If the bank sells the loan to another informed bank, then presumably the loan could be sold at its fair price. But if the prospective buyer is an uninformed bank, the price will reflect the same adverse selection problem that affects refinancing. For some values of the parameters, this problem may be so severe that uninformed banks refuse to purchase the loan. If the cost of keeping the loan while experiencing a liquidity crisis is substantial, then banks (and firms, to whom the cost is passed on) may be better off using multiple banking relationships.

[12] For n^* to be positive it must be $c < -Z \ln \varepsilon$, which we assume to hold.

[13] If long-term debt is callable, then the analysis conducted for short-term debt applies. Interestingly, the general condition for loan contracts suggested to its members by the Italian Bankers Association is that "the bank has faculty to recede, limit, reduce, or suspend the line of credit at any moment, even through verbal communication and even when the loan was extended without an explicit temporal limit."

F. Empirical Implications

With the purpose of deriving testable empirical implications for the theoretical model, in this section we analyze how the size of the single banking region and the optimal number of banking relationships in the multiple banking region depend on the parameters of the model.[14] The single banking region is defined by inequality (5) computed for $n = 1$ and $D = I_0 + c$, so changes in the parameters that increase the left-hand side of the inequality tend to make single banking more likely. Intuitively, the two main factors affecting the size of the left-hand side of inequality (5) are the severity of the adverse selection problem, which affects the size of the "lemons premium" that uninformed banks charge to refinance the firm, and the efficiency of the loan enforcement mechanism, which determines whether high interest rates are enforceable. The efficiency of the loan enforcement mechanism is measured by the parameter v, so the higher v is, the more likely is single banking. The severity of the adverse selection problem, on the other hand, is a decreasing function of ε, the parameter measuring bank fragility, because when ε is high, it is less likely that the firm will seek to refinance from uninformed banks for strategic reasons. Thus, a higher value of ε makes single banking more likely. Furthermore, other things being equal, uninformed banks are more likely to offer refinancing the more profitable is the project. Proposition 3 formalizes this intuition.

PROPOSITION 3: *The equilibrium with single banking described in Proposition 1 obtains when the probability of a liquidity crisis for banks is high, when the loan enforcement mechanism is highly efficient, and when the investment project is very profitable.*

Proof: See Appendix A.

Thus, firms that borrow from banks with a low probability of liquidity crisis, that operate in an environment with inefficient loan enforcement, and whose projects are not very profitable are more likely to be in the multiple banking region. In this region, an increase in n increases the firm's expected profits because it increases the probability that at least one informed bank is active ($1 - \varepsilon^n$). The larger ε is, the larger the effect of an increase in n on such probability, and the larger the optimal number of relationships. Furthermore, the likelihood of being refinanced depends also on whether the realization of p is large enough that informed, active banks are willing to lend ($p > I_1/vK$). More efficient loan enforcement makes this more likely, thereby increasing the benefits of expanding the number of relationships. Thus, the optimal number of relationships is increasing in v.

[14] Comparative statics with respect to the transaction cost parameter c are not discussed because in the empirical section we have no direct proxy for this parameter.

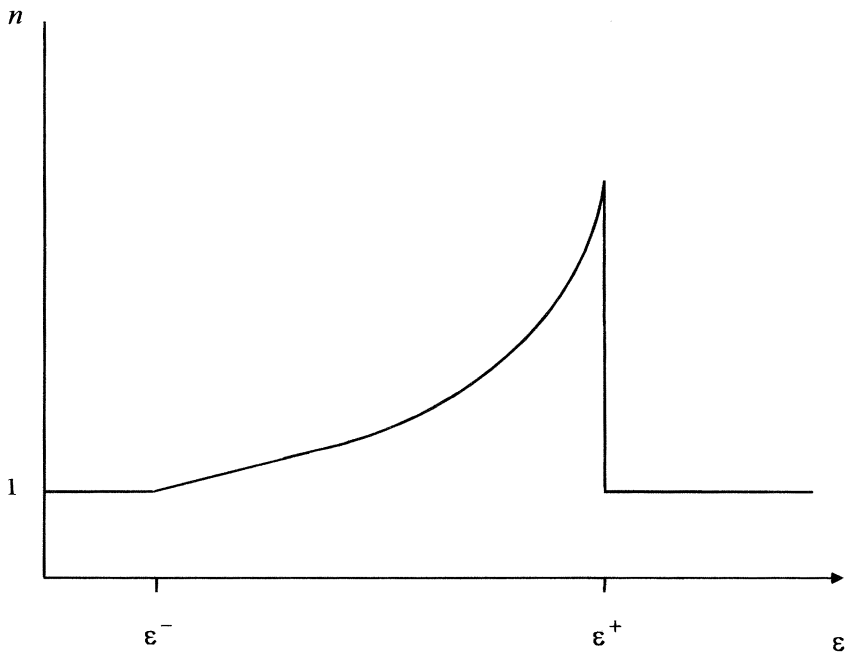

Figure 1. The optimal number of banking relationships. The figure shows the optimal number of relations (n) as a function of the value of ε, the probability of a liquidity crisis. ε^- and ε^+ are the thresholds for ε that define the multiple banking area. From $\varepsilon^- < \varepsilon < \varepsilon^+$ firms choose to borrow from multiple banks; for very low values of ε ($\varepsilon < \varepsilon^-$) or very high ($\varepsilon > \varepsilon^-$) a regime of single banking prevails.

Finally, the more profitable the project, the larger the loss from premature liquidation, and the more beneficial is multiple banking. These results are derived in the following proposition.

PROPOSITION 4: *In the multiple banking region, the optimal number of relationships is increasing in the efficiency of the loan enforcement mechanism and in the profitability of the second stage of the investment project. For realistic values of the parameters, it is also increasing in the probability of a liquidity crisis for banks.*

Proof: See Appendix A.

Propositions 3 and 4 imply a nonmonotonicity in the relationship between the optimal number of banks and the three parameters: large values of the parameters tend to decrease the likelihood that a firm will be in the multiple banking region, but, conditional on being in the multiple banking region, large values of the parameters should be associated with a larger number of banks. Figure 1 illustrates the relationship between the optimal

number of relationships and the fragility parameter ε. In the figure, ε^+ is the value of ε for which condition (5) holds with equality. Thus, for $\varepsilon > \varepsilon^+$ the firm is in the single banking region, and the optimal number of relationships is one. For $\varepsilon < \varepsilon^+$ the firm is in the multiple banking region, and n^* is increasing in ε. For very low values of ε ($\varepsilon < \varepsilon^-$) the benefits of multiple banking are so low that choosing $n = 1$ is optimal even if the firm is in the multiple banking region. Similar figures could be drawn for the other parameters.

To gain a better understanding of how the number of relationships changes with the parameters of the model, we carried out some simulations using alternative values for the parameters. The results are reported in Table II for low and high transaction costs. The single banking outcome is denoted by "*S*" and it occurs for values of the fragility parameter falling in the region defined by inequality (5). When multiple banking prevails, the number of banks increases with the fragility parameter ε, as expected. When transaction costs are low and banks are relatively fragile (Panel A, last column), the optimal number of relationships can be as high as 10. The simulations indicate that changes in the enforcement parameter v have little effect on n^* in the multiple banking region. For instance, as shown in Panel B, increasing v from 0.50 to 0.90 while keeping $\varepsilon = 0.20$, $K = 3$, $I_0 = I_1 = 0.33$, leaves the number of relationships unchanged at three. Similar results apply to changes in the profitability parameters (a change in profitability is obtained by changing the investment requirement while keeping K constant). On the other hand, the value of ε^+, which marks the boundary between the single and the multiple banking region, is very sensitive to both v and to the profitability of the project. In the next to last column of Panel A one can observe how a switch in regime occurs when v is increased from 0.6 to 0.8. Similarly, in the second row a switch from multiple to single banking occurs when ε is increased from 0.3 to 0.5. To summarize, the simulations show that enforcement and profitability should have a strong impact on whether the firm has one or many relationships, but a small effect on the number of relationships for firms in the multiple banking regime. Bank fragility, on the other hand, should matter both for the choice of regime and for the number of relationships.

II. Testing the Theory

The theoretical model developed in the previous section suggests several firm and bank characteristics that should affect the number of banking relationships. In this section, we test the predictions of the model for a cross section of Italian firms. There are three reasons for relying on Italian data. First, among Italian firms there is considerable variation in the number of relationships, which can be as large as 30, even among relatively small businesses. Second, the efficiency of the judicial system varies significantly across regions and this allows us to use a natural proxy for the parameter v, namely the share of loans recovered through the judicial system following default.

Table II

Regions of Multiple Banking and Optimal Number of Relations for Various Parameter Values

The table reports the optimal number of relationships for various values of the parameters of the theoretical model. The single banking outcome is denoted by S. Also reported are the values of the parameter ε (denoted by ε^- and ε^+) marking the boundaries of the region in which the optimal number of relationships is greater than one. ε is the probability that a bank is hit by a liquidity shock. The parameter v is the maximum fraction of the cash flow that creditors can extract from the firm. c is the cost of setting up a relationship. I_0 and I_1 measure the investment costs of the project, and K is cash flow from the project if it succeeds. Given K, higher values of I_0 and/or I_1 imply a lower profitability of the project. All simulations assume that the probability of success of the project p is distributed uniformly in the interval (0.1, 1).

Parameter Values		Boundaries of the Multiple Banking Region		Optimal Number of Relations for Different Values of the Probability of a Liquidity Shock (ε)		
Profitability	Enforcement	Lower Bound (ε^-)	Upper Bound (ε^+)	$\varepsilon = 0.2$	$\varepsilon = 0.3$	$\varepsilon = 0.5$
Panel A: Low Cost of Setting Up a Relationship $c = 1/1000$						
Low profitability	$v = 0.5$	0.013	0.51	5	6	10
($K = 3$, $I_0 = I_1 = 0.2$)	$v = 0.6$	0.013	0.34	5	6	S
	$v = 0.8$	0.013	0.17	S	S	S
	$v = 0.9$	0.013	0.11	S	S	S
High profitability	$v = 0.5$	0.016	1.00	5	6	10
($K = 3$; $I_0 = I_1 = 0.33$)	$v = 0.6$	0.016	1.00	5	6	10
	$v = 0.8$	0.018	0.54	5	6	10
	$v = 0.9$	0.018	0.43	5	6	S
Panel B: High Cost of Setting Up a Relationship $c = 1/100$						
Low profitability	$v = 0.5$	0.013	0.53	3	4	6
($K = 3$, $I_0 = I_1 = 0.2$)	$v = 0.6$	0.013	0.36	3	4	S
	$v = 0.8$	0.013	0.18	S	S	S
	$v = 0.9$	0.013	0.13	S	S	S
High profitability	$v = 0.5$	0.054	1.00	3	4	6
($K = 3$; $I_0 = I_1 = 0.33$)	$v = 0.6$	0.054	1.00	3	4	6
	$v = 0.8$	0.055	0.56	3	4	6
	$v = 0.9$	0.055	0.43	3	4	S

Finally, we have obtained data that allow us to identify all the banks lending to each firm in the sample, a crucial feature to construct measures of shocks to bank liquidity.

A. Data Sources and Description

To construct the sample, we rely on three different data sources, which are described in detail in Appendix B. The first is the 1994 wave of the Survey of Manufacturing Firms (SMF) conducted by Mediocredito Centrale (an investment bank) on a random sample of more than 4,000 small and medium-sized manufacturing firms. The SMF reports various characteristics of the firms, but has no information on the firms' sources of funding or on bank-firm relationships. To obtain this information, we merged the SMF with data from the Credit Register (CR) database. The CR database reports, for each firm and loan category, the amount of credit granted by each relationship bank together with the amount utilized. The merged data set covers 1,849 firms and contains a full description of each firm and its indebtedness with all the banks in the system. It is our reference sample. A firm is considered to have a relationship with a bank if it borrows from the bank under at least one of the six loan categories reported in the data base.[15]

The third and final step was to obtain information on the characteristics of the banks lending to each individual firm. This was achieved by merging the data set with the Bank Balance Sheet database (BB), which reports for each bank in the system and for various years (at a quarterly frequency) information on balance sheet items and other bank characteristics.

B. The Testing Strategy

According to the theoretical model, firms can be in one of two regimes depending on parameter values: in the first regime, they expect to be able to access nonrelationship banks to refinance investment. Firms in this regime always find it optimal to borrow from one bank only, as multiple banking has costs but no benefits. In the second regime, loans from nonrelationship banks are not available at the refinancing stage, and more relationships reduce the probability of premature liquidation of the investment project.

These features of the theoretical model suggest a two-stage empirical test: in a first stage, the implications of the model concerning the choice of regime are tested, and in the second stage the number of relationships is estimated conditional on the firm being in the multiple banking regime. The first-stage estimation is performed using a probit model, in which the independent variable is a dummy equal to one for firms with only one relationship

[15] The loan categories are: commercial paper discounted by the bank, lines of credit, export loans, collateralized loans, medium-term loans, and long-term loans. All firms in our sample have at least one credit line; 1,393 discount commercial paper and 146 financial paper. Export loans are used by 998 firms; few firms have medium-term and long-term loans and collateralized loans.

and zero for firms with multiple relations. The explanatory variables are proxies for firm and bank characteristics that impinge on the size of the single-banking region as stated in Proposition 3 above.

To make the empirical specification richer, we also include variables capturing aspects suggested by alternative theories or likely to be important in practice. The second-stage regression estimates the number of banking relationships in the multiple banking region. Though the number of relationships is a discrete variable, for simplicity we treat it as a continuous variable, and use an OLS estimator. Since the number of relations has a large range of variation (from two to more than 30) this should not constitute a source of significant bias. To correct for selection bias, we insert the Mills ratio computed from the first-stage probit estimate in the OLS regression.

C. The Explanatory Variables

As a proxy for the enforcement parameter v we use the average share of credit recovered through the judicial system by banks operating in the same region as the firm. This share has considerable geographical variation due to differences in the efficiency of the judicial system.[16] The parameter v may also be affected by firm characteristics that are associated with larger entrepreneurial control rents, and therefore strengthen the bargaining power of management/shareholders relative to creditors in workout negotiations. Proxies for control rents included in the regression are the share of the firm owned by the largest shareholder and the correlation between the firms' output and the output of firms belonging to the same industry (see Appendix B for details on the construction of all the variables). The higher this correlation, the more difficult it should be for creditors to sell off the assets of a liquidated firm, and the larger should be the entrepreneurial rents (Shleifer and Vishny (1992)).

Additional proxies for entrepreneurial control rents are various measures of research and development and innovation intensity.[17] A negative correlation between the extent of entrepreneurial control rents and the probability of single banking also supports the hypothesis that multiple banking serves to reduce rent appropriation by banks (Von Thadden (1994)).

The other explanatory variables suggested by the model are the profitability of the investment project (proxied by the profit-to-sales ratio) and bank fragility, namely the propensity of banks to experience liquidity problems that force them to cut back their loan portfolios. To capture bank fragility, we rely on two indicators. The first is a proxy for idiosyncratic liquidity shocks to each bank based on observed changes in the ratio of liquid funds

[16] For instance, the average length of time to repossess collateral is about three years in Valle d'Aosta, a Northern region, and about seven years in the Southern region of Sicily (Generale and Gobbi (1996)). Creditors must use the courts of the region where the firm is located to recover defaulted loans.

[17] Alternatively, R&D intensity may be associated with single banking if information leakages to competitors are more likely with multiple lenders (Yosha (1995)).

to assets (see Appendix B for details). The second proxy is a weighted average of the ratio of nonperforming loans to assets of each creditor bank. In this case, the hypothesis is that banks with a higher share of nonperforming loans are more prone to liquidity shocks.

Because many features of the economy in Italy exhibit sharp differences across regions, we introduce dummy variables for firms operating in Northern Italy and in Central Italy. In all the regressions we control for the size of the firm measured by the number of employees. Firm size is expected to affect the number of relationship for three reasons. First, large firms may have to rely on multiple banking to allow banks to diversify firm-specific credit risk. Second, firm "complexity" is likely to increase with size, and more complex firms may find it necessary to rely on several banks (e.g., because they need to serve plants located in different regions). Finally, if the cost of setting up a new relationship is in part fixed, then larger firms with larger borrowing requirements should be more inclined to rely on multiple banking.

Other explanatory variables included are the leverage of the firm, its age, and a dummy variable for group membership. Leverage may increase the probability of multiple banking, because—other things being equal—the probability of default is higher for more leveraged firms, and the adverse selection problem should be more severe. Also, higher leverage may mean lower unit costs of establishing a relationship. Firms belonging to a group may be better able to obtain financing from other members of the group when nonrelationship banks are unwilling to refinance, so we expect group membership to be associated with more reliance on single banking and with a smaller number of relationships. Older firms, to the extent that they are better known, may face less severe adverse selection problems when seeking nonrelationship finance, so they may be less likely to use multiple banking as well. Also, if building banking relationships takes time, in the multiple banking region age may be positively correlated with the number of relationships.

Finally, we introduce as an additional control the average size of the banks lending to each firm. Bank size may be related to bank fragility; as shown by Buchinsky and Yosha (1995), smaller banks are more likely to be exposed to liquidity shocks. Bank size should then have a negative effect on the probability of borrowing from a single bank and on the number of relationships in the multiple banking regime. Table III summarizes the explanatory variables included both in the probit and in the OLS regression and their expected sign.

D. Results

Table IV shows the results of the probit regression for the probability of single banking in column (1). The average share of loans recovered after default, proxying the parameter v, has a positive and significant coefficient as predicted by the model. Its effect is also economically relevant; raising the share of loans recovered from its minimum value of about 40 percent to

Table III

Explanatory Variables and Their Expected Sign

The table lists the explanatory variables used in the regressions and the expected signs of their coefficients according to the theoretical model. The notation (or zero) indicates that the variable has a negligible impact on the dependent variable according to simulation results. The share of defaulted loans recovered is the average share recovered through legal procedures by the banks operating in the firm's province. Liquidity shocks are defined as the average variability of the innovations to a measure of liquidity for the pool of banks lending to the firm. Nonperforming loans are scaled by loanable funds. Profitability is gross profits divided by sales. Leverage is the ratio of total bank debt to sales. Firm size is the number of employees. Firm age is the number of years since the firm was founded. For each firm the size of lending banks is the average value of loanable funds of its relationship banks. The comovement indicator is a measure of correlation of sales among firms in the same industry using a 44 industrial sector classification. See Appendix B for more detailed information on the construction of the variables.

Explanatory Variable	Probability of Single Banking	Number of Relationships in the Multiple Banking Region
Share of defaulted loan recovered	+	− (or zero)
Liquidity shocks	+	+
Nonperforming loans	+	+
Profitability	+	+
Firm size	−	+
Firm leverage	−	+
Firm age	+	+
Group membership	+	?
Average size of lending banks	−	−
Patents	−	+ (or zero)
R&D	−	+ (or zero)
Product innovation	−	+ (or zero)
Process innovation	−	+ (or zero)
Product and process innovation	−	+ (or zero)
Share of first owner	−	+ (or zero)
Industry comovement	−	+ (or zero)

85 percent[18] would increase the probability of single banking by nine percentage points. This is a remarkable effect, given that the unconditional probability of single banking is 10 percent. The variables measuring bank fragility have the expected signs and are statistically significant (although the ratio of nonperforming loans is significant only at the 10 percent confidence level), but the size of the effect is small: increasing the two variables by two standard deviations would increase the probability of single banking by only 1.4 and 1.3 percentage points, respectively. This is consistent with the simulation results in Table II. Profitability also increases the probability

[18] This figure is close to the recovery rate for structured loans in the United States (Asarnow and Edwards (1995)).

of single banking, as predicted by the theoretical model. Thus, the three variables suggested by the model seem to play a relevant role in determining whether a firm relies on single or on multiple banking.

For variables not explicitly modeled, the table shows that firm size has a negative and significant impact, confirming that larger firms are less likely to use single banking, and so does leverage, as expected. Also, it appears that firms borrowing from large banks are—ceteris paribus—less likely to rely on single banking than firms borrowing from small banks. This result is consistent with the view that bank size is a proxy for bank liquidity. Firm age, the group membership dummy, and the variables capturing entrepreneurial control rents are not statistically significant. Finally, of the five indicators of firm's attitude to innovate, all but one have a negative effect on the probability of single banking, as expected. All of the coefficients, however, have relatively high standard errors. As a robustness check, the probit regression was reestimated omitting all the variables that were not statistically significant in the previous specification; the size of the coefficient of the remaining explanatory variables and the significance levels remain virtually unchanged.

Table IV, column (3), reports the estimation results of the second-stage regression, in which the determinants of the number of relationships for firms with more than two banks are estimated. To avoid relying on the nonlinearity of the probit estimates to reach identification of the second-stage parameter, we assume that all the variables related to R&D and innovation adoption, though they affect the choice of regime, do not affect the number of relationships in the second stage. This restriction is justified by the simulation results in Table II, which show that proxies for v, though they affect the choice of regime, do not affect the number of relations in the multiple banking regime.[19] To correct for the selection bias, we insert as a regressor the Mill's ratio computed from the first-stage probit. The proxy for loan recovery is not significant and has the wrong sign; however, because the simulation results show that the number of relationships in the multiple banking regime is not sensitive to changes in this parameter, this result should not be taken as evidence against the theoretical model. In contrast, both variables capturing bank fragility are significant and have positive coefficients as predicted by the model. The average size of the lending banks has a negative and significant effect, and this finding, together with the negative coefficient of bank size in the probit equation, supports the interpretation of this variable as a proxy for bank liquidity. Firm profitability has the predicted positive sign but is not statistically significant. Finally, the number of relationships tends to increase with firm size and leverage, but the group membership dummy and the variables capturing entrepreneurial

[19] An alternative procedure to reach identification of the second-stage parameters would be to exclude the loan recovery variable v. Since this variable is not significant in the second-stage regression (see below), following this route would not change the results.

Table IV

Determinants of the Choice between Single and Multiple Banking and of the Optimal Number of Banking Relationships in the Multiple Banking Region

The table reports regression coefficients and associated t-statistics. The first two regressions estimate the probability that the firm borrows from only one bank using a probit model. In the last two regressions the dependent variable is the number of relationships for firms using more than one bank. The regressions are estimated using OLS corrected for selectivity bias using the Mill's ratio computed from the first-stage probit. The Mill's ratios of regressions (3) and (4) are computed from the probit regressions (1) and (2) respectively. The share of defaulted loans recovered is the average share recovered through legal procedures by the banks operating in the firm's province. Liquidity shocks are measured by the average variability of the innovations to a measure of liquidity for the pool of banks lending to the firm. Nonperforming loans are scaled by loanable funds. Profitability is gross profits divided by sales. Leverage is the ratio of beginning-of-period total bank debt to sales. Firm size is the number of employees. Firm age is the number of years since the firm was founded. The comovement indicator is a measure of correlation of sales among firms in the same industry using a 44 industrial sector classification. See Appendix B for more detailed information on the construction of the variables. The (0,1) notation means that the variable is a dummy equal to one if the firm has the specified characteristic. All regressions include two regional dummies for the firm location.

	Probability of Single Banking		Optimal Number of Relationships in the Multiple Banking Region	
Explanatory Variable	(1)	(2)	(3)	(4)
Share of defaulted loans recovered	0.016	0.018	−0.001	−0.015
	(2.175)	(2.454)	(−0.068)	(−0.971)
Liquidity shocks	0.504		2.141	2.510
	(2.333)		(2.081)	(2.479)
(Liquidity shocks)^2|$Q > 10$		−3.841		
		(−5.629)		
(Liquidity shocks)^2|$Q \leq 10$		1.657		
		(6.634)		
Nonperforming loans	5.589		26.016	9.759
	(1.750)		(2.476)	(1.346)
(Nonperforming loans)^2|$Q \leq 10$		−17.465		
		(−0.822)		
(Nonperforming loans)^2|$Q > 10$		15.558		
		(0.741)		
Profitability	2.164	1.757	0.834	0.053
	(3.196)	(2.608)	(1.009)	(0.067)
Firm size	−0.187	−0.135	0.961	1.133
	(−3.221)	(−2.241)	(7.276)	(9.581)
Firm leverage	−1.708	−1.576	3.968	4.739
	(−6.421)	(−5.805)	(6.228)	(8.792)
Firm age	0.002	0.002	0.0215	0.0189
	(0.902)	(0.831)	(4.479)	(4.026)
Group membership (0,1)	−0.017	−0.019	0.070	0.093
	(−0.163)	(−0.175)	(0.325)	(0.436)
Average size of lending banks	−0.248	−0.188	−0.336	−0.121
	(−6.400)	(−4.700)	(−2.039)	(−0.949)

Table IV—*Continued*

Explanatory Variable	Probability of Single Banking (1)	(2)	Optimal Number of Relationships in the Multiple Banking Region (3)	(4)
Patents (0,1)	−0.212	−0.212		
	(−1.197)	(−1.197)		
R&D (0,1)	−0.147	−0.137		
	(−1.300)	(−0.748)		
Product innovation (0,1)	−0.0429	−0.0039		
	(−0.278)	(−0.243)		
Process innovation (0,1)	−0.165	−0.162		
	(−1.313)	(−1.237)		
Product and process innovation (0,1)	0.117	0.109		
	(0.970)	(0.880)		
Share of first owner	−0.116	0.002	0.005	0.003
	(−1.210)	(1.431)	(1.370)	(0.973)
Industry comovement	−0.163	0.879	2.312	2.306
	(−0.910)	(1.368)	(1.712)	(1.737)
Constant	0.963	2.507	2.486	−0.640
	(1.371)	(2.759)	(1.125)	(−0.351)
Mill's ratio			−10.446	−7.506
			(−7.289)	(−10.01)
Number of observations	1,754	1,760	1,557	1,563

control rents are not significant. Overall, the results of the estimation are remarkably supportive of the predictions of the model, although the significance of variables such as firm size, leverage, and age suggests that there are factors other than those considered by our theory that are empirically relevant.

E. Extensions

The above estimates have one potential drawback: According to the theoretical model, all firms in the single-banking region of the parameter space (i.e., firms fulfilling condition (5)) have one relationship. However, there may also be firms belonging to the multiple banking region who choose to borrow from one bank only because the benefits from multiple banking are very low relative to the costs (see Section I.F). The approach described so far assumes that all firms with only one relationship in the sample belong to the former category, and to the extent that this assumption is not correct, the probit regression may be misspecified. Take for example the parameter ε, capturing bank fragility. The smaller is ε, the less likely the firm is to be in the single banking region (Proposition 3); however, if ε is very small, then the firm could be in the multiple banking region *and* have chosen $n^* = 1$. The

same is true for the parameter v. In the case of v, however, the simulations in Table II indicate that firms in the multiple banking region choose $n^* = 1$ only for implausibly low values of v, so that in this case the misspecification problem can safely be ignored.

To take into account potential nonmonotonicities with respect to bank fragility in the choice of regime, we estimate an alternative specification of the probit equation where ε is replaced by two truncated variables. The first is equal to the square of ε if ε is less than or equal to its 10th percentile (our empirical threshold for ε^-); otherwise it is equal to the 10th percentile. The second truncated variable is equal to the square of ε if ε is greater than its 10th percentile, and equal to the 10th percentile otherwise. To support the prediction of the theoretical model that the relation between the probability of single banking and liquidity shocks has an inverse U-shape (decreasing for low values of ε and increasing for relatively high values) we should find a negative coefficient for the first truncated variable and a positive coefficient for the second truncated variable. The results of the probit estimation are reported in the column (2) of Table IV, and those of the corresponding second-stage regression are in the last column. Inserting the nonlinear terms in ε has little effect on the coefficients of the other variables in the probit, and nothing of substance changes in the second-stage regression.

The presence of the nonmonotonicities suggested by the theory is supported by the coefficient estimates when the liquidity shock is used as a proxy for ε: the coefficient of the first truncated variable is negative, that of the second is positive, and both are statistically significant. When the share of nonperforming loans is used as a proxy for liquidity shocks, the sign of the coefficients are as predicted but the standard errors are large.[20]

F. Evidence from Cross-Country Comparison

In the introduction, we reported data on bank-firm relationships in Italy and the United States, indicating that, although both U.S. and Italian firms make use of multiple banking, single banking tends to be much more prevalent in the United States. This evidence raises the question of whether the number of relationships depends not only on firm-level characteristics, but also on features of the financial system or the economy that may be different across countries. To properly address this question would require considerable data gathering efforts and is well beyond the scope of this paper. Nonetheless, we have been able to obtain data on the number of bank relationships and on the efficiency of the loan recovery mechanism for 11 European countries (including Italy). The data on the number of relationships come from a survey of corporate treasurers and cash managers of 1,129 firms in 20 European countries. This data set is analyzed in a recent study by Ongena and

[20] Results (not reported) are similar if we capture nonmonotonicities in the probit regression by inserting quadratic terms in addition to the linear terms for the liquidity shocks proxies.

Smith (1998).[21] Unfortunately, the number of observations per country tends to be small (e.g., there are only 25 French firms and 13 Polish firms), and it is unclear to what extent the sample is representative of the population. Thus, the evidence presented in this section should be regarded as tentative.

To measure the efficiency of loan recovery, we use data on collateral recovery costs and on time to recovery for mortgage loans from the European Mortgage Lenders Association. These figures are available for 11 countries. We find a negative correlation between the inefficiency of loan recovery and the incidence of single banking, as predicted by our model, with correlation coefficients of -0.67 when collateral recovery cost is used as a proxy of v and -0.46 percent when the time to recovery is used.

III. Concluding Remarks

Much of the theory of banking relationships implicitly assumes that firms have only one bank, but empirical evidence shows that this is not always the case. In particular, in a sample of small and medium-sized Italian firms we find that multiple banking is extremely widespread. To explore why firms may find it necessary to establish multiple relationships with banks, we have developed a theoretical model where multiple banking ensures a more stable supply of credit, and reduces the risk of premature liquidation of the investment project. The intuition is quite straightforward: If there is a positive probability that the relationship will be terminated because of reasons internal to the bank (e.g., liquidity problems), the firm may expect to have to resort to nonrelationship finance at some time in the future. But in accessing this source of credit, the firm faces an adverse selection problem, as outsiders have less information than relationship lenders and suspect that the firm may be a bad risk. When the adverse selection problem is so severe that noninformed finance is unavailable, then it may pay off to establish more than one relationship from the start.

The theoretical model predicts that firms whose banks are less fragile or whose creditors find it more difficult to enforce loan repayment should be more likely to resort to multiple banking. Conditional on adopting multiple banking, however, bank fragility should be associated with a larger number of relationships. The expected profitability of the project has effects similar to bank fragility. We test whether these predictions receive empirical support using firm level data for a sample of Italian small and medium-sized

[21] Ongena and Smith (1998) perform a number of interesting tests on this data set. For instance, they test whether the cross-country variation in the number of relationship is explained by such variables as the concentration of the banking industry, the development of equity and bond markets, the efficiency of the judicial system, the degree of protection of creditor rights, and the fragility of the banking system. Introduction of the latter three variables was inspired by the theory presented in this paper. However, the authors do not follow the two-stage estimation procedure required by our theoretical model; thus it is not clear that their findings can be related to the predictions of our model.

businesses. This data set contains detailed information on bank-firm relationships and the characteristics of the banks lending to each firm. The empirical results lend support to the theory, especially concerning the determinants of the choice between single and multiple banking.

We also offer some evidence from a cross section of European countries showing that the efficiency of the loan enforcement mechanism tends to be negatively correlated with the share of firms using a single banking relationship, as predicted by our theory. A comprehensive empirical analysis of the factors explaining the configuration of bank-firm ties across countries remains a topic for future research.

Appendix A. Proofs

Proof of Lemma 1: To prove that condition (5) is sufficient, notice that expected profits of uninformed lenders are negative for $R = 1$, and that they are a continuous function of R for $R \geq 1/p_l$. Thus, if the inequality holds there must be a value of R for which uninformed banks break even. To prove necessity, it is sufficient to show that expected profits are increasing in R; actually, all that is needed is that expected profits be increasing when nonnegative since negative expected profits for $R = 1$ and for $R = R^*$ would imply negative expected profits for all $R \in [1, R^*]$. To this end, rewrite equation (3) as

$$\frac{a(R)}{b(R)} - 1 = 0 \tag{A1}$$

where

$$a(R) = R\left[\varepsilon^n E(p) + (1 - \varepsilon^n)\int_{p_l}^{(1/R)} pf(p)\,dp\right]$$

and

$$b(R) = \varepsilon^n + (1 - \varepsilon^n)F(1/R).$$

Since $b(R) > 0$, the left-hand side of equation (A1) is increasing if and only if

$$a'(R) - b'(R)\left[\frac{a(R)}{b(R)}\right] > 0. \tag{A2}$$

Since

$$a'(R) = \varepsilon^n E(p) + (1 - \varepsilon^n)\int_{P_1}^{(1/R)} pf(p)\,dp - (1 - \varepsilon^n)f(1/R)(1/R)^2$$

and

$$b'(R) = -(1 - \varepsilon^n)f(1/R)(1/R)^2,$$

inequality (A2) can be rewritten as

$$\varepsilon^n E(p) + (1 - \varepsilon^n)\int_{p_l}^{(1/R)} pf(p)\,dp - (1 - \varepsilon^n)f(1/R)(1/R)^2\left[1 - \frac{a(R)}{b(R)}\right] > 0. \tag{A3}$$

But when expected profits are nonnegative, $a(R)/b(R) \geq 1$, thus the condition above must hold.

Proof of Proposition 3: The region of single banking is defined by inequality (5) calculated for $n = 1$ and $D = I_0 + c$. Let $T(\varepsilon, v, K, I_0, I_1)$ be the left-hand side of inequality (5). To prove the proposition, we will show that the function T is increasing in its first three arguments and decreasing in the last two arguments (an increase in K for constant investment levels corresponds to an increase in the profitability of the project, and so does a decline in I_0 or I_1 for constant K). To this end, define $q = (I_0 + I_1 + c)/vK$. Then

$$\left.\frac{\partial T}{\partial \varepsilon}\right|_{n=1} = (1/q)\left[E(p) - \int_{p_l}^{q} pf(p)\,dp\right] - 1 + F(q). \tag{A4}$$

Hence,

$$\left.\frac{\partial T}{\partial \varepsilon}\right|_{n=1} = \int_q^1 \left(\frac{p}{q} - 1\right) f(p)\,dp, \tag{A5}$$

which is always positive. To prove that T is increasing in v and in the profitability of the project, it is sufficient to prove that T is decreasing in q. To see this, notice first that v, K, I_0, and I_1 enter T only through q, and that T is decreasing in v and K and increasing in I_0 and I_1. The derivative of T with respect to q is

$$\left.\frac{\partial T}{\partial q}\right|_{n=1} = (1/q^2)\left(q^2(1 - \varepsilon)f(q) - \left[\varepsilon Ep + (1 - \varepsilon)\int_{p_l}^{q} pf(p)\,dp\right]\right) - f(q)(1 - \varepsilon); \tag{A6}$$

hence,

$$\left.\frac{\partial T}{\partial q}\right|_{n=1} = -(1/q^2)\left(\varepsilon Ep + (1-\varepsilon)\int_{p_l}^{q} pf(q)\,dp\right). \tag{A7}$$

This expression is always negative.

Proof of Proposition 4: First, we will prove that n^* is increasing in the probability of a liquidity crisis, ε, at least for reasonable values of the parameters. Define $x = -\ln \varepsilon > 0$. Then, from equation (12)

$$n^* = \frac{-\ln c + \ln(Zx)}{x}, \tag{A8}$$

so that n^* is increasing in ε if and only if it is decreasing in x. Differentiating with respect to x,

$$\frac{\partial n^*}{\partial x} = \frac{1 - [\ln(Zx) - \ln c]}{x^2}. \tag{A9}$$

Rearranging, for n^* to be increasing in ε it must be

$$\ln Z > \ln c + 1 - \ln \varepsilon. \tag{A10}$$

This is a mild condition on the expected profitability of the second stage of the project. For instance, if transaction costs are as high as five percent and the probability of a liquidity crisis is as high as 30 percent, the condition is satisfied if the expected return is 11.3 percent. If transaction costs are one percent and ε is still 30 percent, the threshold value of Z falls to 2.3 percent. Lower values for the probability of a liquidity crisis would further reduce the lower bound on Z. Thus, for realistic values of the parameters the optimal number of relationships n^* is increasing in ε. As for the effects of v on n^*, note that

$$\frac{\partial n^*}{\partial v} = \left(-\frac{1}{Z \ln \varepsilon}\right)\left(\frac{\partial Z}{\partial v}\right) = \left(-\frac{1}{Z \ln \varepsilon}\right)\left(\frac{(I_1)^2}{(v)^2 K}\right)\left(\frac{1-v}{v}\right) f\left(\frac{I_1}{vK}\right), \tag{A11}$$

which is always positive. Finally, the equation above also shows that an increase in Z, the expected continuation value of the project, increases n^*.

Appendix B

A. Data Sources

Three main sources have been used in the empirical analysis: the 1994 Survey of Manufacturing Firms (SMF), the Credit Register information (CR), and the Banks Balance Sheet database (BB). The SMF is conducted every

three years on a sample of small and medium-sized manufacturing firms with at least 10 employees. The sample contains 4,431 firms. The information collected includes employment and its composition, investment effected and types of investments, R&D activities, location, ownership structure, industrial sector, year of foundation, capacity utilization, total sales, export sales and a number of balance sheet items for the survey year and the two previous years. For firms with fewer than 500 employees, the sample is stratified by gross product per employee in order to ensure representativeness. Also, detailed information on mergers, acquisitions, and breakups is available. For a subset of the firms in the sample, credit register information is available, making it possible to supplement the information in the SMF with data on bank-firm relations.

The CR information is extracted from the public Credit Register which is administered by the Bank of Italy; it pools information on the loans extended by Italian banks. Banks must report to the credit register the amounts granted and effectively utilized for all loans in excess of a minimum threshold which, at the relevant time for this paper, was 80 million lire (about $46,000). This information is reported separately for six types of loans (financial and commercial paper, foreign credit operations, credit lines, collateralized loans, medium- and long-term loans, and personal guarantees).

Finally, the BB data set retrieves information on the banks lending to each individual firm from a database of the population of Italian banks. This database contains both balance sheet variables and non-balance sheet bank characteristics, such as the number of branches, year of foundation, location of headquarters, number of employees, and bank ownership.

B. Explanatory Variables

Firm size: Logarithm of the number of firm employees in 1992. Source: SMF.

Firm leverage: Ratio of total sales in 1994 to beginning-of-period total bank debt (value of utilized bank loans). Source: SMF (sales) and CR (bank debt).

Share of defaulted loans recovered: Average share of defaulted loans that is recovered in the province where the firm is located. The figures come from a 1994 survey of loan recovery procedures carried out by the Bank of Italy on a sample of 269 banks (see Generale and Gobbi (1996)) for a description).

Nonperforming loans: Average share of nonperforming loans on loanable funds across relationship banks. The indicator is constructed as follows: for each bank in the population (about 850) and for each quarter between 1987 and 1994 the ratio between defaulted loans and loanable funds is computed; the ratio is then averaged across quarters to obtain a measure of the incidence of defaults for each bank. For each firm in the sample we then compute the average value of this indicator, using as weights the share of total bank loans contributed by each bank. Source: BB and CR.

Liquidity shocks: Using the BB database, for each bank in the population and each quarter from 1987 to 1995 the ratio between liquidity and loanable funds is computed. Liquidity is defined as *liq* = *free reserves* + 0.05 *required reserves* + *government bonds* + *net position in the interbank market*. We take five percent of the required reserves since this is the share that can be mobilized to face liquidity needs; for each bank i at time t the following variable is defined:

$$dliq(i,t) = [\log(liq(i,t)/mliq(i)]/se(i),$$

where $ml(i)$ is the mean across time of $\log(liq(i,t))$ and $se(i)$ is its standard error. This procedure accounts for bank fixed effects and for the possible presence of outliers. To eliminate the aggregate component of the liquidity shocks, we regress $dliq(i,t)$ on a set of time dummies, one for each quarter; the regression residual is taken as a measure of idiosyncratic liquidity shocks. For each bank, the standard error of this residual is then computed to obtain a measure of fragility. Finally, for each *firm*, we compute the average value of the standard error of the idiosyncratic liquidity shocks among the pool of its relationship banks, using as weights the share of loans extended.

Average bank size: The logarithm of the average size of each firm's relationship banks in terms of loanable funds, using as weights the shares of the total loan extended to the firm by each bank in the pool. Source: BB and CR.

Firm age: Computed as 1992 minus the year of foundation. Source: SMF.

Group membership: Dummy variable: equal to one if the firm belongs to a group, equal to zero otherwise. Source: SMF.

Industry comovement: The correlation among the sales of the firm and those of other firms in the same industry constructed by Guiso and Parigi (1999). The source of the data is a balanced panel of 5,054 Italian industrial firms from 1983 to 1995. To construct the indicator, the authors classify firms into 44 industrial sectors. For each sector, they regress the standardized rate of growth of firms sales (in deviation from its mean) on a set of year dummies, as measures of aggregate shocks. Sectors where aggregate shocks are more important (and thus where firm sales tend to co-vary closely) have a higher R^2 for this regression relative to sectors where idiosyncratic disturbances are dominant. These R^2 are then assigned to 1994 SMF firms on the basis of their industry code.

Share of first owner: Share of firm equity in the hands of largest shareholder. Source: SMF.

Indicators of R&D and adoption of innovations: The patents indicator is a dummy variable that is equal to one if the firm has either sold or purchased a patent; the R&D indicator is a dummy that is equal to one if the firm has invested in R&D in the three years covered by the SMF

(1992 to 1994); finally the three dummies for the adoption of innovations take the value one if during the period 1992 to 1994 the firm has innovated its products, production processes, or both.

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