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Reciprocity and Network Coordination: Evidence from Japanese Banks*

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Abstract

In this study, we provide the first detailed empirical evidence on the cooperative behavior of individual members of a functioning, real world network. In contrast to experimental evidence from limited settings, our study employs detailed annual data on the volume of loans given to individual firms from each individual bank that lends to them for a period spanning nearly 20 years. Using this detailed data, we are able to exploit substantial cross-sectional variation in the degree of reliance of the banks on the network as a whole and on other individual banks within the network. In addition, we are able to investigate the impact of economic stress on the cooperative behavior of individual network members by comparing the 1980s with the more turbulent 1990s. We find strong evidence that the strength of system-wide reliance on, and thus commitment to, the network, as well as pairwise reliance on other network members, plays an important role in explaining the observed cooperative behavior by Japanese banks.

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In the usual course of economic activity, economic agents become linked in many ways. Many of the linkages create networks where the actions of individual network members have significant effects on the well-being of the other members of the network. Among the most important issues in the analysis of networks are the coordination of the actions of the network members and the sustainability of the network. In particular, an important question concerns the motivation underlying any observed cooperation among network members. How (and to what extent) does cooperation by network members respond to economic incentives?

Empirical research on the source of the motivation for network coordination, however, faces a severe identification problem. For example, observed cross-sectional differences in the nature of network coordination across countries may be as easily attributed to differences in the cultures or social norms across these countries as by differences in their economic environments. Furthermore, empirical tests are hampered by the paucity of micro-level data on the behavior of individual members of functioning networks that allow an analysis of the interactions among network members. We overcome both problems by using micro-level data on the behavior of individual members of a functioning, real world network in a single country.

The key to both the coordination of the actions of the network members and the sustainability of the network itself is a commitment mechanism. As long as parties have potential gains from coordinating through repeated interactions, reciprocity provides an economic commitment mechanism. Reciprocity has two general forms: bilateral reciprocity and system reciprocity. Bilateral reciprocity dictates that a pair of individuals with direct network links will take actions consistent with the cooperative outcome as long as the other party does not defect from the cooperative outcome. System reciprocity is more general, insofar as the reciprocal behavior can come from any network member, rather than requiring a direct link between each pair of network members.

While such a commitment mechanism may be provided by social norms as well as by economic incentives, they have different implications. Under the premise that social norms govern the coordination of the network, to the extent that social norms are slow to change, we should not observe abrupt changes in the tendency of network members to cooperate with each other as economic conditions change. Even if social norms do evolve in response to changes in economic conditions, the premise that social norms govern network coordination implies that all network members should change their behavior similarly.

In contrast, the premise that the economic incentives underlying reciprocity govern the cooperative behavior of network members has some cross-sectional implications. First, with respect to system reciprocity, the greater is the member's reliance on the network, and thus the greater is the member's commitment to the network, the greater is the incentive to cooperate with other network members, both to ensure reciprocation from other members and to enhance the sustainability of the network. Second, given a member's network reliance, the degree of that member's cooperation with another member of the network will be higher the greater are the expected benefits from the bilateral reciprocity by that member. Third, when adverse shocks impact the network, those members that benefit the least from the network, and thus also are least committed to the network, are more likely to reduce their network cooperation, or even to defect from the network. Thus, as individual members of the network or the network itself come under increasing stress, it becomes more important for the members to signal their commitment to the network through their actions in order to ensure continuing reciprocity from other network members.

We exploit a unique dataset of Japanese bank lending behavior that reflects the behavior of individual members of an existing network in order to provide empirical evidence on the determinants of cooperation among network members. In the Japanese main bank system, individual banks lend to overlapping sets of firms. Thus, at a point in time, any given pair of banks may share many borrowers as loan clients, creating a lending network through which the lenders become interdependent.

The degree of this interdependence among the five largest Japanese banks can be seen in Table 1. The table shows both the pairwise commonality and the total commonality of main bank loan clients among the five banks. For each bank, the table shows the share of firms for which the bank serves as the main bank that are also loan clients of one or more of the other four banks. The pairwise entries show that during the 1980s, when the banks are considered as pairs, on average, about 47 percent of each bank's main bank loan customers also borrow from another one of the four banks, rising to 54 percent in the 1990s. When considered as a group, the average share of a main bank's customers that have at least one of the other four banks as a secondary lender rises to 87 percent in the 1980s and 90 percent in the 1990s. This shows the strong linkages among banks within the network, both to individual banks and to the system as a whole, as well as the increased linkages in the more troubled 1990s.

This interdependence of lenders creates externalities, insofar as the extent to which one bank does or does not make credit available to a given firm affects that firm's economic performance, impacting the quality of the outstanding loans made to that firm not only by that bank but also those made by the other network lenders to the firm. Because main banks also serve as secondary lenders to many firms, by focusing on their behavior as secondary lenders, we can exploit the differences in the degree to which a bank relies on, and thus is committed to, the network.

Japan provides an ideal laboratory for the examination of the determinants of coordinated lending within a network for a number of reasons. First, many would argue that social norms play an important role in determining behavior in Japan. Thus, finding evidence that economic incentives still play an important role in driving network cooperation in such an environment would suggest that the results can be generalized to economies in which social norms play a lesser role. Second, Japan has a bank-centered economy with a main bank system that forms a well-defined lending network where banks share many firms as loan clients. Third, the data set we use in this study is particularly appropriate for the study of network coordination, being composed of data for loans to each listed Japanese firm by each of the individual Japanese banks that lend to that firm. Fourth, because individual banks differ in the degree to which their lending occurs as a firm's main bank, banks differ in the degree to which they are committed to the network, and thus in the strength of the economic incentives they face to cooperate in their role as a secondary lender to a firm with that firm's main bank. Furthermore, significant cross-sectional variation in the strength of the bilateral links that are induced by common loan portfolios is present. Such variation helps identify the role of economic incentives, if any, in the coordination of lending. Fifth, the prolonged malaise of the Japanese economy during the 1990s provides an opportunity to investigate the behavior of a network under adverse conditions, since the deterioration in the economic environment from the more prosperous 1980s altered the economic incentives faced by network members. Sixth, a significant proportion of Japanese firms have "keiretsu" affiliations with their largest lender, their main bank. This provides a second network overlaying the basic lending network. A comparison of lending to same-keiretsu firms with that to firms not in the same keiretsu as their main bank can provide evidence on how additional economic (and possibly cultural) incentives impact the degree of cooperation exhibited by secondary lenders to a firm.

Using a detailed panel dataset, we provide strong evidence that economic incentives play an important role in the coordination of lending in Japan during two very different time periods. First, we find that both main bank and secondary bank system reciprocity matter in the 1990s, and that they matter more for keiretsu firm portfolios than for independent firm portfolios. Second, bilateral reciprocity matters for both the 1980s and the 1990s. Third, we find that secondary banks with the greatest commitment to the network substantially increased their cooperation with main banks in the 1990s as the network came under duress. We interpret this result as reflecting the need for the secondary banks with the most dependence on the network to signal to the network that they were still committed to the network.

In the remainder of the paper, Section I contains a background discussion of the coordination of networks and Japanese banking. Section II develops the hypotheses to be tested, discusses our data set, and describes the empirical specification. Section III presents our empirical results. Section IV contains conclusions.

I. Background

Agents repeatedly interact with each other in the course of economic activity. An important part of these interactions takes place anonymously through markets where the actions of agents affect other agents only indirectly through the price mechanism. To the extent that agents are atomistic, in the sense of having a very small effect on the outcome, economic theory predicts that the non-cooperative behavior of agents can result in an outcome that would have obtained under full cooperation. As early as Cournot's (1838) model of duopoly, however, economists have recognized that non-cooperative interactions of agents may not always produce this cooperative outcome when the actions of agents have direct effects on the well-being of others.

While the theoretical work on network design and network formation is quite advanced (for example, Ellison 1993; Jackson and Wolinsky 1996; Bala and Goyal 2000; Ely 2002; Goyal and Vega-Redondo 2005), empirical work on network coordination is limited primarily to the experimental domain (for example, Corbae and Duffy 2004; Heinemann, Nagel and Ockenfels 2004). While experimental studies are important in highlighting the strong and weak points of the theory, by their very nature, they are limited in their ability to predict the outcomes of much more complicated interactions between individual agents that are members of functioning, real world networks. The dearth of empirical studies investigating the important issue of network coordination by individual network members in functioning networks is due to the lack of suitable data on the bilateral and multilateral interactions of individual network members. The few empirical studies that exist concentrate on the mutual insurance systems in developing economies (for example, Fafchamps and Lund 2002; La Ferrara 2003) and, while they may have data on individual network members, they do not have information on pairwise interactions and the data do not cover an extended period of time.

In the context of lending networks, banks may be linked through their bilateral exposures created by the payment system and interbank lending. Such linkages impose potential costs to banks due to the danger of financial contagion (for example, Allen and Gale 2000). Leitner (2005), however, shows that in the spirit of Goyal and Vega-Redondo (2005) and Bala and Goyal (2000), the threat of contagion is precisely the reason behind the formation of the network and is typically an integral part of network design. When the threat of contagion is present, banks that are not subject to adverse shocks have incentives to bail out the banks that were less fortunate in order to prevent the collapse of the entire network.[1] In order to benefit from the scope of mutual insurance provided by the network, banks may be willing to form links, even though such links create the threat of contagion.

Because Japan is a bank-centered economy and is characterized by a main bank system, it provides an ideal laboratory for investigating how, and how well, an existing network functions, as well as the extent to which economic incentives contribute to sustaining the cooperative behavior of network members. In the main bank system, a firm's main bank has a particularly close relationship with the firm that typically includes cross-shareholding and board of directors relationships, as well as a lending relationship. However, this relationship also comes with certain responsibilities for the main bank. For example, the main bank is expected to serve as the delegated monitor of the firm for secondary banks that also lend to the firm (for example, Kaplan and Minton 1994; Sheard 1994) and to take a leading role in restructuring the firm should it experience financial difficulties, for example, by requiring changes in management and/or altering the board of directors (Kang and Shivdasani 1995; Morck and Nakamura 1999).

Thus, a Japanese bank has a special responsibility for those firms for which it serves as the main bank arising from some combination of social obligation and economic incentives. However, banks that serve as a main bank to some firms also serve as secondary lenders to many other firms, in which case the motivations and responsibilities underlying their lending behavior likely differ, at least in degree, from those in their role as a main bank. Because banks lend to large numbers of firms and a given firm typically borrows from a number of lenders, these banks form a network. The interdependencies among the lenders arises from the fact that a given bank's willingness to lend to a given firm, especially a troubled firm, affects the firm's performance, and thus the ability of the firm to make timely interest payments and repayments of principal to other lenders. Furthermore, the economic incentive of a secondary lender to a firm to cooperate with the firm's main bank (and the other secondary lenders) in providing loans to a firm is related to the degree to which the secondary lender relies on other network banks to cooperate with it in its role as the main bank to other firms. In other words, the larger a bank's role as a main bank, the greater its potential reliance on other network lenders in their role as secondary lenders to its main bank firms. Thus, in its role as a secondary lender to a firm, the greater the reliance on other banks in the network, the more likely the bank will cooperate with the firm's main bank in the hope that other network banks will reciprocate when its own main bank firms need additional loans.

We use cross-sectional differences in a bank's dependence on, and thus commitment to, the lending network to investigate the impact of economic incentives on the degree of cooperation of a firm's secondary banks with that firm's main bank. In addition, we exploit the altered economic incentives faced by Japanese banks between the relatively tranquil 1980s and the more turbulent 1990s, which experienced a combination of severe problems at many individual firms and a crisis in the banking system as a whole, to better pinpoint the importance of those incentives for sustaining a network under severe stress.

In particular, Peek and Rosengren (2005) find that during the troubled 1990s, banks misallocated credit as a consequence of the perverse incentives they faced associated with a weak bank supervision system and government pressures to aid unhealthy firms. Their finding that financially troubled banks were more likely to increase loans the weaker was the firm's health and the stronger was the bank's affiliation with the firm suggests that banks were making lending decisions based on criteria other than profit maximization. Indeed, even secondary lenders exhibited such behavior, consistent with bank lending behavior being influenced strongly by their commitment to aid other network members in order to sustain the lending network as it came under severe stress.

While the evergreening of loans to a firm by a bank aided the bank directly by enabling the bank to avoid (or delay) a further increase in its reported nonperforming loans that would occur if the firm declared bankruptcy, it also aided the other members of the lending network by maintaining the fiction that the firm was not severely troubled, allowing those banks also to benefit from the fiction that their loans to the firm were not severely impaired. If the firm were unable to keep its interest payments current, it would be difficult for the other lenders to the firm to avoid downgrading their own loans to the firm. Thus, by cooperating with the firm’s main bank in increasing loans to a troubled firm, the secondary lender was aiding not only the firm’s main bank (bilateral reciprocity), but the lending network more generally (system reciprocity) in the hope that other network members would similarly help them with the troubled borrowers for which they served as a main bank.

An implication of the Peek and Rosengren (2005) study is that the strength of the economic incentives, and thus the degree of network cooperation, may be a function of bank health. For example, the weaker is a secondary bank’s health, the greater is the need for the bank to signal its commitment to the network during the 1990s when individual banks and the network came under severe stress. Similarly, the weaker is the main bank’s health, the more it may need cooperation from secondary banks in aiding its firms with increased loans, and the greater is the value of such help.

However, once it became apparent in the mid 1990s that the Japanese government was willing to allow banks to fail, the incentives for secondary banks to continue cooperating with the weakest of the banks, and thus the ones most likely to fail and not be around to reciprocate later, weakened. Table II provides a comparison of the declining linkages of two of the banks that subsequently failed (or nationalized), Long Term Credit Bank (LTCB) and Nippon Credit Bank (NCB), with two of the weaker of the surviving banks, Dai-Ichi Kangyo Bank (DKB) and Sumitomo Bank. The columns labeled "Main" show the share of the banks's outstanding loans that were to firms for which the bank serves as the firm's main bank. The columns labeled "Secondary" show the share of total secondary loans outstanding to those firms made by the other City Banks, which represent the set of banks with the strongest commitment to the network. The entries show a clear increase in the extent to which both LTCB and NCB increased the share of their loans to their main bank clients during the last half of the 1990s. On the other hand, DKB shows no such increase in self-reliance, while Sumitomo shows a smaller increase. Even more interesting is the fact that the City Banks sharply decreased their cooperation as secondary banks with both LTCB, beginning in 1996, and NCB, beginning in 1998. At the same time, no notable decline is apparent in the "Secondary" columns for either DKB or Sumitomo in the last half of the 1990s. The table thus provides suggestive evidence that secondary bank cooperation declined as it became apparent that a bank might not be around to reciprocate with future cooperation.

II. Hypotheses and Empirical Specification

A. Hypotheses

If economic incentives are the driving force underlying network cooperation among banks in Japan, then differences in the degree of commitment should be important, as should the differences in the economic environment in Japan between the 1980s and 1990s as the network, and the individual banks, came under severe stress. We have five primary hypotheses related to the effects of economic incentives on bank cooperation:

1. The greater is a secondary bank's (system) reliance on the lending network, the greater is its cooperation with the firm's main bank. That is, secondary banks with relatively strong links to the network have more of an incentive to cooperate with a firm's main bank. This effect should be stronger in the 1990s (compared to the 1980s) as the network came under severe stress and the sustainability of the network became a greater concern.

2. The lower is the main bank's (system) reliance on the lending network (indicating that relatively more of its lending is in its role as a secondary bank rather than as a main bank), the more secondary banks will cooperate with that main bank in aiding its firms. This occurs because as part of a secondary bank's commitment to the system, it will tend to provide more help to those main banks that have the potential to serve the network more than they are served by the network in order to keep those banks committed to the network. This effect should be greater in the 1990s when the network was under greater stress.

3. The greater is a secondary bank's bilateral reliance on the firm's main bank, the greater is the secondary bank's cooperation with that main bank. The secondary bank cooperates with the main bank in anticipation of the main bank reciprocating, and the greater is the potential for reciprocal cooperation, the greater the incentive for the secondary bank to cooperate.

4. The greater is a main bank's bilateral reliance on the secondary bank, the greater is the secondary bank's cooperation. This occurs as a result of the greater alignment of the interests of the two banks in the success of the firms in their common portfolio.

5. If the firm is in the same keiretsu as its main bank, a secondary bank has a greater incentive to cooperate with the firm's main bank the greater is the secondary bank's reliance on the network. The argument is that with a same-keiretsu affiliation with the firm, the main bank has a stronger obligation to the firm and thus benefits more from receiving cooperation from the secondary banks. This effect should be greater in the 1990s when the network was under severe stress. Furthermore, the difference between the magnitudes of the effects for the keiretsu portfolios in the 1980s compared to the 1990s should be greater than for the case when no same-keiretsu affiliation is present. In fact, in the 1990s this effect should be greater when the main bank has a same-keiretsu affiliation with the firm than when no keiretsu affiliation is present.

B. General Approach to Inference

In order to focus on the question of the degree to which secondary banks cooperate with main banks, for each main bank-secondary bank ordered pair we form a portfolio of the firms that borrow from both banks in the pair. We exclude from the analysis any pair for which the main bank and the secondary bank are in the same keiretsu, since we want to isolate the lending network links among banks from any influences associated with an additional linkage between banks that are in the same keiretsu network. For each main bank-secondary bank pair, we form two portfolios of firms based on the keiretsu membership of the firms. The firms in the "independent" portfolio are either not in a keiretsu, or, if they are in a keiretsu, they are not in the same keiretsu as either the main bank or the secondary bank. The firms in the "keiretsu" portfolio are in the same keiretsu as the main bank of the pair in question. Note that by construction, the firms in the keiretsu portfolios cannot be in the same keiretsu as the secondary bank, since we have omitted main bank-secondary bank pairs for which the two banks are in the same keiretsu.

Once these portfolios are formed, we calculate the following two variables to measure the degree of cooperation between the main bank (i) and the secondary bank (j) associated with each portfolio. The first variable, $COOP_{ijt}$, is calculated as the proportion of firms that obtained increased loans from both the main bank and the secondary bank during year t; that is, the secondary bank cooperated with the main bank in increasing loans to the firm.[2] The second variable, $NCOOP_{ijt}$, is calculated as the proportion of firms that obtained increased loans from the main bank, but not from the secondary bank; that is, the secondary bank did not cooperate with the main bank in increasing loans to the firm. We focus on increases in loans rather than including decreases or no change in loans because increasing loans to a firm requires active decision making by the lender. On the other hand, no change in loans outstanding to the firm or a decrease in loans can occur passively as a result of no loan decisions being made during the period or as loans amortize. While these outcomes also can occur from active decisions by lenders to reject a loan application or not renew maturing loans, using the available data, one cannot distinguish unambiguously whether either of these results was a consequence of active or passive behavior on the part of the bank.

In addition to these probabilities, we are also interested in the probability that the secondary bank increases its loans to a firm in a given portfolio conditional on the main bank having done so. This conditional probability can be interpreted as the probability that the secondary bank cooperates with the main bank in increasing loans to the firm, and is calculated as $\dfrac{COOP_{ijt}}{COOP_{ijt} + NCOOP_{ijt}}$. Note that the denominator is simply the total proportion of firms in the portfolio that received additional loans from the main bank of the ordered pair during the period.

We choose a reduced-form approach instead of directly modeling the conditional probability of cooperation for several reasons. First, the observed frequency of the main bank increasing loans to the firms in a portfolio is zero in some portfolios, causing the empirical counterpart of the conditional probability to be ill-defined. Second, even when this is not the case, the precision of the empirical measure of the conditional probability is low.

We specify reduced-form models for the expectations of $COOP_{ijt}$ and $NCOOP_{ijt}$ conditional on a set of regressors. Once these models are estimated, we can make statements about the effects of the regressors on the conditional probability using the standard formula for the conditional probability. For this purpose, we estimate fractional logit models (Papke and Wooldridge 1996), since our two dependent variables are restricted to lie between zero and one, inclusive. While the signs of the estimated coefficients of the logit model indicate the direction of the effects, inferences about the economic magnitude of the effects are not as straightforward. In order to conduct inference about the economic significance of the effects, we calculate the derivative of the estimated conditional probability with respect to the regressors of interest for each observation in our data set, and then average those derivatives. It is tedious, but otherwise easy, to obtain the standard errors for these "average marginal effects."

C. Data and Specification

We use a rich panel data set to examine Japanese bank lending patterns in order to determine the extent to which secondary bank lenders to a firm cooperate with the firm's main bank. By using Japanese firm-level data, we are able to link individual Japanese firms to their individual lenders. For our tests, we use annual data for 1982 through 1999. We include all firms included in the Pacific-Basin Capital Market Databases (PACAP), which includes all first- and second-section firms that are traded on the Tokyo stock exchange. The PACAP database includes the balance sheet and income statements of firms based on their fiscal year-end reports.[3] The data for loans outstanding to individual firms from each lender are obtained from the Nikkei Needs Bank Loan database, with loan reporting based on the firm's fiscal year. We identify each firm's main bank as the bank with the largest volume of loans outstanding to the firm in the prior year.[4] Keiretsu membership is obtained from <u>Industrial Groupings in Japan: The Anatomy of the Keiretsu.</u>

The unit of observation in our empirical work is a main bank-secondary bank pair. For this purpose, we first create a main bank list for each year in our data set. In a given year, any bank that serves as the main bank for at least 15 firms is included in the main bank list. Once the main bank list is formed for a given year, we form ordered pairs consisting of a main bank and a secondary bank. In each year and for each main bank, we form an ordered pair with each remaining bank in the data set, whether or not that secondary bank is on the main bank list for that year. Clearly, some ordered pairs will contain a secondary bank that is also serving as a main bank for other firms.

Once the observations are defined as main bank-secondary bank ordered pairs, we form two portfolios for each pair of banks. The first, the "independent" portfolio, contains all the firms with positive loans outstanding from both banks of the pair in the prior year that are either not in a keiretsu, or, if they are, are not in the same keiretsu as either the main bank or the secondary bank of the pair. Note that by construction, the first member of the pair serves as the main bank for each of the firms in the portfolio; hence, the second member serves as a secondary lender to each of the firms in the portfolio. The "keiretsu" portfolio is constructed in the same fashion, except that we require all the firms in the portfolio to be in the same keiretsu as the main bank.

One potential problem with some of the constructed portfolios is that they contain a very small number of firms. The precision of our dependent variables, calculated as empirical frequencies, will be low for such portfolios. Thus, we restrict our analysis to only those portfolios with at least 10 firms. For a given portfolio, the value of COOP is calculated as the proportion of the firms in the portfolio that had increased loans from *both* the main bank and the secondary bank during period t, and the value of NCOOP is calculated as the proportion of the firms in the portfolio that had increased loans from the main bank *but not* from the secondary bank during period t.

In order to control for the persistence in bank cooperation, we need to define measures for prior cooperation for each pair of banks. We choose *not* to use lagged values of COOP and NCOOP, since the composition of the firms in the portfolios are not necessarily identical from year to year. Instead, for a given portfolio, we define LCOOP as the proportion of firms that are in the portfolio in both period t and period t-1 that had increased loans from both the main bank and the secondary bank from period t-2 to period t-1. The variable LNCOOP is defined analogously.

Our measure of system reciprocity, SYSREC, is defined as the volume of loans outstanding by bank i in its role as a main bank at the end of the prior year, divided by the total volume of loans by bank i at the end of the prior year:

$$SYSREC_{it} = \frac{\sum_{k \in F_{it}^{M}} L_{kit-1}}{\sum_{k \in F} L_{kit-1}}, \tag{1}$$

where F is the set of all firms in the data set, and for any bank i, F_{it}^{M} denotes the set of firms that had outstanding loans from that bank, and for which that bank served as the firm's main bank. SYSRECMB is defined as the SYSREC value for the main bank in an ordered pair, and SYSRECSB is defined as the SYSREC value for the secondary bank in an ordered pair.

To construct our two measures of bilateral reciprocity, BIRECMB and BIRECSB, we use information for all of the firms for which both banks of the ordered pair (i,j) had positive loans outstanding in the prior year. Then our measure of main bank bilateral reciprocity that reflects main bank i's (relative) reliance on secondary bank j is given by:

$$BIRECMB_{ijt} = \frac{\sum_{k \in F_{it}^{M}} L_{kj,t-1}}{\sum_{k \in F_{it}^{M}} \sum_{n \neq i} L_{kn,t-1}}, \tag{2}$$

where L_{kj} represents loans to firm k from bank j. Similarly, our measure of secondary bank bilateral reciprocity that reflects secondary bank j's (relative) reliance on main bank i of the ordered bank pair is given by:

$$BIRECSB_{ijt} = \frac{\sum_{k \in F_{jt}^{M}} L_{ki,t-1}}{\sum_{k \in F_{jt}^{M}} \sum_{n \neq j} L_{kn,t-1}}, \tag{3}$$

BIRECSB is defined to be zero if the secondary bank does not serve as a main bank to any firm in that year; that is, if the set F_{jt}^{M} is empty.

Finally, we need a measure for the "health" of each bank. In order to construct a uniform measure across time periods, we chose the relative market-to-book value ratio, since many other measures of health that are based on a bank's balance sheet data, such as bank capital-to-assets ratios, nonperforming loan ratios and reported profits, are not reliable, especially in the 1990s when widespread bank regulator forbearance occurred. The relative measure of bank health, HEALTH, is calculated as

$$HEALTH_{it} = \frac{M_{i,t-1} - \overline{M}_{t-1}}{s_{t-1}}, \tag{4}$$

where $M_{i,t-1}$ is the ratio of the market value of equity to the book value of equity for bank i, winsorized at the first and ninety-ninth percentiles, $\overline{M}_{t-1}$ is the cross-sectional average of $M_{i,t-1}$ across all banks in our sample, and s_{t-1} is the cross-sectional standard deviation of $M_{i,t-1}$. Note that a bank of "average" health would have a value for HEALTH of zero. HEALTHMB is the value of HEALTH for the main bank in the ordered bank pair, while HEALTHSB is the value of HEALTH for the secondary bank in the ordered bank pair.

The baseline specification for the expected value of COOP, conditional on the set of regressors, is:

$$E\left(COOP_{ijt} \middle| X_{ijt}\right) = F\left(Z_{ijt}\right) \text{, where} \tag{5}$$

$$Z_{ijt} = \alpha_t + \theta_i + \mu_j + \beta_1 SYSRECMB_t + \beta_2 SYSRECSB_t + \beta_3 BIRECMB_{ijt} + \beta_4 BIRECSB_{ijt} +$$

$$\beta_5 HEALTHMB_t + \beta_6 HEALTHSB_t + \beta_7 LCOOP_{ijt} + \beta_8 LNCOOP_{ijt}, \tag{6}$$

where α_t is the set of year fixed effects, θ_i is the set of main bank fixed effects, μ_j is the set of secondary bank fixed effects, and $F\left(Z_{ijt}\right) = \frac{e^{Z_{ijt}}}{1 + e^{Z_{ijt}}}$ is the CDF of the standard logistic distribution. Our general specification involves a set of interaction terms using our measures of bank health:

$$Z_{ijt} = \alpha_t + \theta_i + \mu_j + SYSRECMB_t \times \left(\beta_{0sm} + \beta_{1sm} HEALTHMB_t + \beta_{2sm} HEALTHSB_t\right) +$$

$$SYSRECSB_t \times \left(\beta_{0ss} + \beta_{1ss} HEALTHMB_t + \beta_{2ss} HEALTHSB_t\right) +$$

$$BIRECMB_{ijt} \times (\beta_{0bm} + \beta_{1bm} HEALTHMB_t + \beta_{2bm} HEALTHSB_t) +$$

$$BIRECSB_{ijt} \times (\beta_{0bs} + \beta_{1bs} HEALTHMB_t + \beta_{2bs} HEALTHSB_t) +$$

$$\beta_{1o} HEALTHMB_t + \beta_{2o} HEALTHSB_t + \beta_{3o} LCOOP_{ijt} + \beta_{4o} LNCOOP_{ijt}\,. \qquad (7)$$

The specification of the expected value of NCOOP conditional on the same set of regressors is done in a similar fashion. Table III contains the sample means of the dependent variables and each of the independent variables.

III. Results

The estimation results are discussed in two subsections. Subsection A contains the discussion of the results from the estimation of the baseline specification given in equation (6), while subsection B contains the discussion of the results for the full specification given in equation (7). For each fractional logit model estimated, we present the coefficient estimates as well as their t-statistics, with estimated coefficients that are significant at the 5 percent level or better shown in boldface. This allows inference on the sign of the effect of the independent variables. However, as in the standard logit models, the estimated parameters in the fractional logit model are identified only up to scale. In any case, we are not interested in the magnitudes of these coefficients. Our interest lies in the derivatives of the probability that a secondary bank increases loans to a firm conditional on the main bank having done so. In the rest of the study, we will refer to this as the probability of cooperating with the main bank. In each regression table, we will present the fractional logit estimates, as well as the average marginal derivative (AMD) of the conditional probability of cooperating with the main bank with respect to each independent variable.

The probability of cooperation is defined as the probability that the secondary bank increases loans conditional on the main bank having done so. Letting X_{ijt} denote the stacked set of regressors, and β_o denote the stacked set of parameters for the COOP and NCOOP equations:

$$E\left(COOP_{ijt} \mid X_{ijt}, COOP_{ijt} + NCOOP_{ijt}\right) = G\left(X_{ijt}, \beta_o\right) \equiv \frac{E\left(COOP_{ijt} \mid X_{ijt}\right)}{E\left(COOP_{ijt} \mid X_{ijt}\right) + E\left(NCOOP_{ijt} \mid X_{ijt}\right)}. \quad (8)$$

Then, the "average marginal derivative" for the kth regressor is calculated as

$$\hat{\delta}_k \equiv \frac{1}{n} \sum_{ijt} \frac{\partial \hat{G}\left(X_{ijt}, \hat{\beta}\right)}{\partial X_{ijt}^k}, \quad (9)$$

where $\hat{G}\left(X_{ijt}, \hat{\beta}\right)$ is the estimated conditional probability. The Appendix contains the derivation of, and expressions for, the AMDs and their standard errors.

A. Baseline Specification

The estimation results for the baseline specification are presented in Tables IV and V for the independent firm portfolios and for the portfolios of firms that have keiretsu affiliations with their main banks (referred to as keiretsu firms), respectively. In each table, the first three columns report the results for the 1982-1990 period, denoted "early period" hereafter, and the last three columns report the results for the 1991-1999 period, denoted "later period" hereafter. Asymptotic t-statistics for the estimated coefficients and for the calculated AMDs for the conditional probability of cooperation are reported below the point estimates in parentheses. Each estimated model includes main bank fixed effects, secondary bank fixed effects and a set of annual dummy variables. For brevity, coefficient estimates for these fixed effects are not reported. In Section A.1, we discuss in detail the results for the independent firm portfolios, while in Section A.2 we briefly discuss the results for the keiretsu firm portfolios.

A.1 Independent Firm Portfolios

The first set of independent variables in Table IV is related to the degree to which the main bank and the secondary bank are committed to the network, as measured by the share of the loans they make in their capacity as a main bank. These variables are intended to capture the effects of system reciprocity on the coordination of lending. In the early period, both main bank (SYSRECMB) and secondary bank (SYSRECSB) system reciprocity have AMDs for the probability of cooperation with a sign opposite that predicted, although neither has a statistically significant impact on the coordination of lending. However, this does not necessarily mean that system reciprocity does not impact the coordination of lending. Remember that our specifications include individual dummy variables for each main bank and for each secondary bank (the main bank and secondary bank fixed effects). To the extent that the banks with high network dependence are the same ones that also cooperate the most, a separate, identifiable effect of system reciprocity may not be observed. Especially during the relatively stable early period, the absence of a statistically significant effect should not be surprising, since a stable equilibrium would necessarily entail such a correlation.

During the more turbulent later period, however, changes in the economic environment generate a scope for distinguishing the effects of system reciprocity, if any. In fact, we find that during this later period when the lending network came under severe stress, both main bank system reciprocity and secondary bank system reciprocity have AMDs for the probability of cooperation with the predicted sign that indicate statistically significant impacts on the coordination of lending. Furthermore, all four of the associated individual fractional logit estimated coefficients are now of the predicted sign. That is, in the COOP equation the probability that both the main bank and the secondary bank increase loans to an independent firm is higher the greater is the network dependence of the secondary bank and the lower is the network dependence of the main bank, while in the NCOOP equation the probability that the secondary bank does not increase loans to an independent firm when the main bank does is lower the larger is the network dependence of the secondary bank and the smaller is the network dependence of the main bank.

The next set of independent variables shown in Table IV contains our measures of bilateral reciprocity. In both the early and the later periods, BIRECMB has a positive and statistically significant effect on the coordination of lending, with the effect being smaller in the 1990s. As expected, the COOP equation shows that the higher the main bank bilateral reciprocity, the higher is the probability that the secondary bank will cooperate with the main bank in increasing loans to an independent firm. The NCOOP equation shows that the probability that a secondary bank does not cooperate with the main bank in increasing loans decreases with increasing main bank bilateral reciprocity. The effect of BIRECSB is positive, as expected, but is statistically significant only for the 1990s.

The next two sets of independent variables in Table IV are included as control variables. For bank health, only the AMD for HEALTHSB in the early period is statistically significant. While that effect is negative, it is of such a small magnitude that it is unlikely to be economically significant. Both of the measures related to the persistence of coordination have statistically significant effects of the predicted sign in each subperiod, indicating that the coordination of lending to the independent firms is quite persistent.

A.2 Keiretsu Firm Portfolios

Table V indicates that the effects of system and bilateral reciprocity differ somewhat for the portfolios of keiretsu firms relative to those for independent firms, especially during the 1990s. While main bank system reciprocity has similar effects to those for the independent portfolios, the magnitude of the effect of secondary bank system reciprocity is more than double that for the independent firm portfolios in the later period, consistent with our prediction that secondary bank system reciprocity should be a stronger driver of the coordination of lending for the keiretsu firms during the troubled 1990s. As the health of firms and banks deteriorated in the 1990s, it became more important for banks to obtain cooperation from other network banks in increasing loans to their troubled same-keiretsu firms. Thus, in their role as a secondary lender, they had a stronger need to signal their commitment to the network by cooperating with the main banks when the main bank had a keiretsu affiliation with the firm.

The second difference between the results for the keiretsu and independent portfolios is for the effect of bilateral reciprocity. While the estimated effect of BIRECMB remains statistically significant for each subperiod, it is now the case that the magnitude of the effect is larger rather than smaller in the 1990s compared to the 1980s. The other difference is that BIRECSB no longer has a statistically significant effect in the 1990s.

B. Full Specification

In this subsection, we discuss the estimation results for the full specification. As in the previous subsection, we present the estimates of the fractional logit model, as well as the AMDs for the conditional probability of cooperation. However, since the full model has many interaction terms, teasing out the effects of individual variables may be cumbersome. Therefore, we discuss the economic significance of the results in a simplified manner by making use of the estimated AMDs in calculating the effects of the independent variables under several bank health scenarios. In what follows, Section B.1 contains the discussion of the results for the independent firm portfolios, while Section B.2 contains the discussion of the results for the keiretsu firms.

B.1 Independent Firm Portfolios

Table VI contains the results of the estimation of the fractional logit model in equation (7) for the sample of firms that do not have a keiretsu affiliation with their main banks. As before, the first three columns contain the results for the early period, while the last three columns contain the results for the later period.

In order to assess the effect of the health of the main bank and the secondary bank on the sensitivity of coordinated lending to system and bilateral reciprocity, we calculate the average marginal derivatives of the probability of cooperation under four different scenarios based on the values of one and minus one for HEALTHMB and HEALTHSB. Recall that a value of one corresponds to the bank's health being one standard deviation above the mean for all banks in our sample, while a value of minus one corresponds to one standard deviation below the mean.

Table VII presents the results for this exercise. Panel A reports the descriptive statistics for the conditional probabilities for each subperiod in order to provide a benchmark for interpreting the economic significance of differences in the conditional probabilities. Panel B presents the AMDs both unscaled and scaled by the interquartile range of the variables. Panel C presents the scaled AMDs for variations in bank health. The reported entry in each cell represents the average marginal derivative of the probability of cooperation with respect to the variable in the column heading.

Panel A shows that secondary bank cooperation with main banks declined from the early period to the later period, even as the network came under increased stress. Panel B shows that in the early period, SYSRECSB has a sign opposite that predicted, although the effect is not statistically significant, while both BIRECMB and BIRECSB have the predicted positive effects that are statistically significant. In the latter period, all four effects are of the predicted signs and are statistically significant. Furthermore, the change from the early to the late subperiods for both

SYSRECMB and SYSRECSB are in the predicted direction. The effects of both BIRECMB and BIRECSB are smaller in the 1990s compared to the 1980s. In terms of economic significance, comparing the AMDs scaled by the interquartile range of Panel B with the means and interquartile ranges in Panel A, it is apparent that many of the effects are meaningful. For example, the scaled AMDs of SYSRECMB and SYSRECSB in the later period are each over 15 percent of the mean of the conditional probability and about one-half of the interquartile range of the conditional probability. Similarly, the scaled AMD for BIRECMB in the early period is 18 percent of the mean of the conditional probability and three-quarters of the interquartile range of the conditional probability.

With respect to the sensitivity of the effects to bank health, Table VI shows that only three interaction effects in the early period and one in the later period have statistically significant effects. Still, for completeness, Panel C of Table VII shows the sensitivity of the AMDs for each of the explanatory variables. Among the significant effects for the early period, Panel C shows that the SYSRECSB effect increases the conditional probability of cooperation with better secondary bank health, the BIRECMB effect declines with better secondary bank health, and the BIRECSB effect declines with better main bank health. For the later period, the BIRECSB effect increases with better secondary bank health, perhaps because healthier secondary banks are more able to cooperate by increasing loans.

B.2 Keiretsu Firm Portfolios

In this subsection, we perform for the keiretsu firm portfolios the same exercise as in Table VII. The estimates of the fractional logit model used for this exercise are presented in Table VIII. The sensitivity results are presented in Table IX. For brevity, we highlight only the important differences from the prior discussion.

Compared to the results for the independent firm portfolios, in the 1990s the AMDs of the conditional probabilities of cooperation for SYSRECSB is stronger, while those for SYSRECMB, BIRECMB and BIRECSB are weaker. Consequently, the economic significance tends to be diminished, except for SYSRECSB, which has a scaled AMD that is over 40 percent of the mean conditional probability shown in Panel A and exceeds the interquartile range of the conditional probability. With respect to the sensitivity to bank health, for the keiretsu firm portfolios, the only bank health interaction variable that is statistically significant for the 1980s in Table VIII is that for main bank health interacted with SYSRECMB. For the 1990s, we now have four rather than only two statistically significant interaction effects. For this latter period, better main bank health weakens the negative effect of SYSRECMB, while better secondary bank health increases both BIREC effects and mitigates the impact of SYSRECSB.

IV. Conclusions

Our study fills an important gap in the empirical network literature by testing the implications of economic theories of cooperation in networks using micro-level data on individual network members. Compared to the extant empirical literature, which is mostly experimental in nature, our study exploits rich sources of cross-sectional and time series variation from an operating network. The richness of our data set also allows us to investigate cooperation between individual members of the network.

Our empirical results provide strong support for predictions of economic theory about the cooperation of network members. We find that system reciprocity plays a dominant role in determining cooperation within the network. Our most important finding is that when the network as a whole comes under economic stress in the 1990s, system reciprocity plays an even more important role in determining cooperation. While bilateral links play an important role in determining the degree of cooperation, their role is somewhat diminished in the 1990s.

Appendix: Derivation of Average Marginal Derivatives

For each data point in our sample, the conditional expectations of the dependent variables, COOP and NCOOP, are given by (dropping the observation subscripts in order to reduce notational clutter):

$$P_1 \equiv E[COOP|X] = \frac{\exp(X'\beta_1)}{1+\exp(X'\beta_1)} \tag{A.1}$$

$$P_2 \equiv E[NCOOP|X] = \frac{\exp(X'\beta_2)}{1+\exp(X'\beta_2)} \tag{A.2}$$

Define the probability of cooperation using (A.1) and (A.2) as

$$\tilde{P} \equiv \frac{P_1}{P_1 + P_2} \tag{A.3}$$

The sample averages of the marginal effects with respect to the kth explanatory variable are given by

$$\hat{\delta}_{1,k} \equiv \frac{1}{n}\sum_{ijt}\frac{\partial P_1}{\partial X_k}\ ,\ \hat{\delta}_{2,k} \equiv \frac{1}{n}\sum_{ijt}\frac{\partial P_2}{\partial X_k}\ ,\ \tilde{\delta}_k \equiv \frac{1}{n}\sum_{ijt}\frac{\partial \tilde{P}}{\partial X_k} \tag{A.4}$$

The covariance matrix of the estimated AMD's can be estimated using a first-order Taylor expansion around the vector of true parameter values:

$$\mathrm{cov}(\hat{\delta}_{1,k}, \hat{\delta}_{1,m}) \equiv \left[\frac{1}{n}\sum_{ijt}\frac{\partial^2 P_1}{\partial X_k \partial \beta_1}\right]' \mathrm{cov}(\hat{\beta}_1) \left[\frac{1}{n}\sum_{ijt}\frac{\partial^2 P_1}{\partial X_m \partial \beta_1}\right] \tag{A.5}$$

$$\mathrm{cov}(\hat{\delta}_{2,k}, \hat{\delta}_{2,m}) \equiv \left[\frac{1}{n}\sum_{ijt}\frac{\partial^2 P_2}{\partial X_k \partial \beta_2}\right]' \mathrm{cov}(\hat{\beta}_1) \left[\frac{1}{n}\sum_{ijt}\frac{\partial^2 P_{21}}{\partial X_m \partial \beta_{21}}\right] \tag{A.6}$$

$$\mathrm{cov}(\tilde{\delta}_k, \tilde{\delta}_m) \equiv \left[\frac{1}{n}\sum_{ijt}\frac{\partial^2 \tilde{P}}{\partial X_k \partial \beta}\right]' \mathrm{cov}(\hat{\beta}) \left[\frac{1}{n}\sum_{ijt}\frac{\partial^2 \tilde{P}}{\partial X_m \partial \beta}\right] \tag{A.7}$$

where $\beta \equiv [\beta_1' \quad \beta_2']'$, and $\hat{\beta} \equiv [\hat{\beta}_1' \quad \hat{\beta}_2']'$ are the stacked vector of parameters and their estimates, and $\mathrm{cov}(\hat{\beta})$ is the estimated covariance matrix of the parameter estimates. The expressions for various partial derivatives in (A.4)-(A.7) are relatively easy to obtain for our model:

$$\frac{\partial P_1}{\partial X_k} = P_1(1 - P_1)\beta_{1,k} \tag{A.8}$$

$$\frac{\partial P_2}{\partial X_k} = P_2(1 - P_2)\beta_{2,k} \tag{A.9}$$

$$\frac{\partial \tilde{P}}{\partial X_k} = \tilde{P}(1 - \tilde{P})\left[(1 - P_1)\beta_{1,k} - (1 - P_2)\beta_{2,k}\right] \tag{A.10}$$

$$\frac{\partial^2 P_1}{\partial X_k \partial \beta_{1,m}} = (1 - 2P_1)P_1(1 - P_1)\beta_{1,k}X_m + 1[k = m]\,P_1(1 - P_1) \tag{A.11}$$

$$\frac{\partial^2 P_2}{\partial X_k \partial \beta_{2,m}} = (1 - 2P_2)P_2(1 - P_2)\beta_{2,k}X_m + 1[k = m]P_2(1 - P_2) \tag{A.12}$$

$$\begin{aligned}\frac{\partial^2 \tilde{P}}{\partial X_k \partial \beta_{1,m}} = {} & (1 - 2\tilde{P})\tilde{P}(1 - \tilde{P})X_m\left[(1 - P_1)\beta_{1,k} - (1 - P_2)\beta_{2,k}\right] + \\ & \tilde{P}(1 - \tilde{P})\left[1(k = m)(1 - P_1) - P_1(1 - P_1)\beta_{1,k}X_m\right]\end{aligned} \tag{A.13}$$

$$\begin{aligned}\frac{\partial^2 \tilde{P}}{\partial X_k \partial \beta_{2,m}} = {} & -(1 - 2\tilde{P})\tilde{P}(1 - \tilde{P})X_m\left[(1 - P_1)\beta_{1,k} - (1 - P_2)\beta_{2,k}\right] - \\ & \tilde{P}(1 - \tilde{P})\left[1(k = m)(1 - P_2) - P_2(1 - P_2)\beta_{2,k}X_m\right]\end{aligned} \tag{A.14}$$

where 1(.) is an indicator function that takes the value of one if the expression in the parentheses is true, and zero otherwise.

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Table I
Degree of Reliance of Main Banks on Secondary Banks

The entries in the table represent averages of annual data for each subperiod. The first two columns are calculated by first calculating for each of the five banks the share of their main bank loan clients that are common loan clients with each of the other four banks for each year. These numbers are then averaged across the four secondary lenders and across the individual years in the subperiod. The numbers in the final two columns are calculated for each year as the share of each bank's main bank loan clients that are also a loan client of at least one of the other four banks. The annual shares are then averaged to obtain the subperiod averages.

Main Bank	Pairwise		Total	
	1982-1990	1991-1999	1982-1990	1991-1999
IBJ	0.45	0.55	0.80	0.87
DKB	0.47	0.55	0.87	0.92
Sakura	0.48	0.53	0.86	0.90
BOTM	0.44	0.50	0.86	0.88
Sumitomo	0.49	0.55	0.94	0.92
Average	0.47	0.54	0.87	0.90

Table II
Abandoning Failing Banks

The columns labeled "Main" show the share of the bank's total outstanding loans that were to firms for which the bank serves as the firm's main bank. The columns labeled "Secondary" show the share of total secondary loans outstanding to those firms made by the other City Banks.

	Failing Banks				Surviving Banks			
	LTCB		NCB		DKB		Sumitomo	
Year	Main	Secondary	Main	Secondary	Main	Secondary	Main	Secondary
1982	0.23	0.54	0.24	0.58	0.22	0.60	0.21	0.54
1983	0.23	0.54	0.26	0.59	0.22	0.60	0.21	0.53
1984	0.22	0.55	0.28	0.54	0.21	0.61	0.21	0.52
1985	0.22	0.54	0.27	0.54	0.22	0.61	0.21	0.53
1986	0.28	0.56	0.28	0.51	0.21	0.60	0.22	0.53
1987	0.26	0.56	0.27	0.47	0.21	0.60	0.23	0.52
1988	0.22	0.58	0.26	0.45	0.18	0.58	0.23	0.51
1989	0.27	0.56	0.25	0.48	0.18	0.59	0.25	0.54
1990	0.23	0.64	0.25	0.42	0.18	0.60	0.25	0.52
1991	0.21	0.60	0.24	0.46	0.18	0.59	0.25	0.51
1992	0.23	0.63	0.25	0.55	0.20	0.64	0.25	0.55
1993	0.26	0.63	0.25	0.60	0.20	0.65	0.23	0.61
1994	0.33	0.64	0.26	0.62	0.21	0.65	0.23	0.58
1995	0.30	0.66	0.29	0.64	0.22	0.64	0.24	0.59
1996	0.36	0.52	0.29	0.64	0.22	0.63	0.26	0.58
1997	0.33	0.51	0.28	0.65	0.22	0.64	0.26	0.59
1998	0.34	0.46	0.30	0.46	0.22	0.64	0.26	0.59
1999	0.29	0.38	0.31	0.44	0.23	0.64	0.26	0.56

TABLE III
Sample Means of Independent Variables

	Independent Sample		Keiretsu Sample	
	82-90	91-99	82-90	91-99
COOP	0.245	0.213	0.236	0.181
NCOOP	0.200	0.233	0.230	0.257
SYSRECMB	0.216	0.259	0.333	0.330
SYSRECSB	0.117	0.128	0.107	0.115
BIRECMB	0.039	0.041	0.032	0.033
BIRECSB	0.047	0.050	0.044	0.044
HEALTHMB	0.869	0.612	0.561	0.682
HEALTHSB	0.139	0.123	0.074	0.076
LCOOP	0.281	0.235	0.272	0.193
LNCOOP	0.243	0.285	0.263	0.298

TABLE IV
Fractional Logit Estimates and AMDs of the Probability of Cooperation
Baseline Specification: Independent Firm Portfolios

The unit of observation is a bank pair consisting of a main bank and a secondary bank that do not have a keiretsu affiliation. For a given pair, we form portfolios of firms such that each firm in the portfolio has positive loans outstanding from both the main bank and the secondary bank, and the firms do not have a keiretsu affiliation with the main bank. Any main bank-secondary bank pair that does not share at least 10 clients is omitted from the analysis. COOP is the proportion of firms in the portfolio whose loans from both the main bank and the secondary bank have increased. NCOOP is the proportion of firms in the portfolio whose loans from the main bank increased but whose loans from the secondary bank did not increase. SYSRECMB is our measure of system reciprocity for the main bank. SYSRECSB is our measure of system reciprocity for the secondary bank. BIRECMB is the first of our measures of directional bilateral reciprocity, and is interpreted as the degree of reliance by the main bank on the secondary bank. BIRECSB is our second measure of directional bilateral reciprocity, and is interpreted as the degree of reliance by the secondary bank on the main bank. LCOOP is the proportion of firms in the portfolio whose loans from both the main bank and the secondary bank have increased in the prior year. LNCOOP is the proportion of firms in the portfolio whose loans from the main bank have increased but whose loans from the secondary bank did not increase. HEALTHMB and HEALTHSB are based on the market-to-book ratio of the main bank and the secondary bank, respectively, in the prior year, and are measured as the number of standard deviations away from the mean for all banks in that year. Each regression includes a set of dummy variables for each year, for each main bank, and for each secondary bank. AMD is obtained by using the fractional logit estimates of both the COOP and NCOOP equations, and is calculated as the sample average of the derivatives of the probability that the secondary bank increases loans conditional on the main bank having done so. Estimated coefficients that are significant at the 5 percent level or better are shown in boldface.

	1982-1990			1991-1999		
	COOP	NCOOP	AMD	COOP	NCOOP	AMD
SYSRECMB	0.0298	0.0165	0.0094	**-0.1489**	0.1295	**-0.3093**
	(0.23)	(0.15)	(0.04)	(2.20)	(1.95)	(2.31)
SYSRECSB	-0.1020	-0.0096	-0.0903	**0.1863**	**-0.2352**	**0.4674**
	(0.79)	(0.08)	(0.37)	(2.38)	(2.99)	(2.97)
BIRECMB	**0.7619**	**-0.8051**	**1.7591**	**0.5433**	**-0.5129**	**1.1733**
	(5.37)	(5.92)	(6.32)	(4.80)	(4.03)	(5.00)
BIRECSB	-0.0162	-0.0136	0.0006	**0.2019**	**-0.1313**	**0.3710**
	(0.22)	(0.21)	(0.00)	(3.37)	(2.42)	(3.24)
HEALTHMB	-0.0069	0.0006	-0.0076	0.0025	0.0015	0.0012
	(1.51)	(0.13)	(0.85)	(0.80)	(0.47)	(0.20)
HEALTHSB	**-0.0126**	0.0062	**-0.0202**	0.0044	-0.0009	0.0060
	(2.37)	(1.32)	(2.08)	(1.42)	(0.29)	(0.92)
LCOOP	**0.3398**	**0.1582**	**0.1444**	**0.3008**	**0.1132**	**0.2140**
	(13.26)	(6.95)	(3.28)	(11.76)	(4.67)	(4.55)
LNCOOP	**0.3961**	**0.4864**	**-0.2053**	**0.2935**	**0.5380**	**-0.2602**
	(13.91)	(15.52)	(4.24)	(12.89)	(21.73)	(6.75)
Log L	-906.14	-806.01		-950.72	-959.98	
R-Squared	0.485	0.476		0.424	0.556	
Mean of Dependent Variable	0.247	0.198		0.216	0.226	
No. of Observations	1,681	1,681		1,878	1,878	

TABLE V
Fractional Logit Estimates and AMDs of the Probability of Cooperation
Baseline Specification: Keiretsu Firm Portfolios

The unit of observation is a bank pair consisting of a main bank and a secondary bank that do not have a keiretsu affiliation. For a given pair, we form portfolios of firms such that each firm in the portfolio has positive loans outstanding from both the main bank and the secondary bank, and the firms have a keiretsu affiliation with the main bank. Any main bank-secondary bank pair that does not share at least 10 clients is omitted from the analysis. COOP is the proportion of firms in the portfolio whose loans from both the main bank and the secondary bank have increased. NCOOP is the proportion of firms in the portfolio whose loans from the main bank increased but whose loans from the secondary bank did not increase. SYSRECMB is our measure of system reciprocity for the main bank. SYSRECSB is our measure of system reciprocity for the secondary bank. BIRECMB is the first of our measures of directional bilateral reciprocity, and is interpreted as the degree of reliance by the main bank on the secondary bank. BIRECSB is our second measure of directional bilateral reciprocity, and is interpreted as the degree of reliance by the secondary bank on the main bank. LCOOP is the proportion of firms in the portfolio whose loans from both the main bank and the secondary bank have increased in the prior year. LNCOOP is the proportion of firms in the portfolio whose loans from the main bank have increased but whose loans from the secondary bank did not increase. HEALTHMB and HEALTHSB are based on the market-to-book ratio of the main bank and the secondary bank, respectively, in the prior year, and are measured as the number of standard deviations away from the mean for all banks in that year. Each regression includes a set of dummy variables for each year, for each main bank, and for each secondary bank. AMD is obtained by using the fractional logit estimates of both the COOP and NCOOP equations, and is calculated as the sample average of the derivatives of the probability that the secondary bank increases loans conditional on the main bank having done so. Estimated coefficients that are significant at the 5 percent level or better are shown in boldface.

	1982-1990			1991-1999		
	COOP	NCOOP	AMD	COOP	NCOOP	AMD
SYSRECMB	-0.0366	-0.0814	0.0496	**-0.1799**	0.1010	**-0.3288**
	(0.24)	(0.59)	(0.18)	(2.43)	(1.41)	(2.21)
SYSRECSB	-0.0408	0.0246	-0.0694	**0.4485**	**-0.4991**	**1.0584**
	(0.25)	(0.18)	(0.25)	(4.17)	(5.13)	(5.07)
BIRECMB	**0.6401**	-0.3400	**1.0386**	**0.9373**	**-0.5057**	**1.6932**
	(2.81)	(1.50)	(2.38)	(4.29)	(2.17)	(3.79)
BIRECSB	-0.0536	0.0866	-0.1498	0.0613	0.1361	0.2102
	(0.68)	(1.27)	(1.05)	(0.79)	(1.85)	(1.33)
HEALTHMB	-0.0007	-0.0045	0.0041	-0.0081	0.0035	-0.0138
	(0.08)	(0.55)	(0.24)	(1.72)	(0.80)	(1.50)
HEALTHSB	-0.0017	-0.0093	0.0082	0.0062	-0.0028	0.0106
	(0.28)	(1.60)	(0.72)	(1.78)	(0.72)	(1.43)
LCOOP	**0.1931**	**0.1504**	0.0400	**0.2859**	**0.2397**	**0.1362**
	(6.12)	(5.72)	(0.72)	(8.68)	(7.89)	(2.38)
LNCOOP	**0.2092**	**0.5265**	**-0.3495**	**0.3171**	**0.6272**	**-0.1978**
	(6.97)	(18.32)	(6.96)	(10.20)	(21.88)	(4.12)
Log L	-674.16	-667.75		-631.43	-742.27	
R-Squared	0.494	0.470		0.467	0.563	
Mean of Dependent Variable	0.238	0.228		0.185	0.252	
No. of Observations	1,283	1,283		1,376	1,376	

TABLE VI
Fractional Logit Estimates and AMDs of the Probability of Cooperation
Full Specification: Independent Firm Portfolios

The unit of observation is a bank pair consisting of a main bank and a secondary bank that do not have a keiretsu affiliation. For a given pair, we form portfolios of firms such that each firm in the portfolio has positive loans outstanding from both the main bank and the secondary bank, and the firms do not have a keiretsu affiliation with the main bank. Any main bank-secondary bank pair that does not share at least 10 clients is omitted from the analysis. COOP is the proportion of firms in the portfolio whose loans from both the main bank and the secondary bank have increased. NCOOP is the proportion of firms in the portfolio whose loans from the main bank increased but whose loans from the secondary bank did not increase. SYSRECMB is our measure of system reciprocity for the main bank. SYSRECSB is our measure of system reciprocity for the secondary bank. BIRECMB is the first of our measures of directional bilateral reciprocity, and is interpreted as the degree of reliance by the main bank on the secondary bank. BIRECSB is our second measure of directional bilateral reciprocity, and is interpreted as the degree of reliance by the secondary bank on the main bank. LCOOP is the proportion of firms in the portfolio whose loans from both the main bank and the secondary bank have increased in the prior year. LNCOOP is the proportion of firms in the portfolio whose loans from the main bank have increased but whose loans from the secondary bank did not increase. HEALTHMB and HEALTHSB are based on the market-to-book ratio of the main bank and the secondary bank, respectively, in the prior year, and are measured as the number of standard deviations away from the mean for all banks in that year. Each regression includes a set of dummy variables for each year, for each main bank, and for each secondary bank. AMD is obtained by using the fractional logit estimates of both the COOP and NCOOP equations, and is calculated as the sample average of the derivatives of the probability that the secondary bank increases loans conditional on the main bank having done so. Estimated coefficients that are significant at the 5 percent level or better are shown in boldface.

	1982-1990			1991-1999		
	COOP	NCOOP	AMD	COOP	NCOOP	AMD
SYSRECMB	-0.1427	0.0172	-0.1642	**-0.1685**	0.0929	**-0.2912**
	(1.08)	(0.15)	(0.67)	(2.34)	(1.26)	(2.00)
SYSRECMB x HEALTHMB	**0.1497**	0.0485	0.0899	**0.0451**	0.0335	0.0140
	(3.88)	(1.11)	(1.14)	(1.99)	(1.33)	(0.29)
SYSRECMB x HEALTHSB	0.0271	-0.0384	0.0747	0.0018	0.0178	-0.0174
	(1.20)	(1.93)	(1.81)	(0.12)	(1.20)	(0.57)
SYSRECSB	-0.1482	-0.0006	-0.1477	**0.2004**	**-0.2303**	**0.4775**
	(1.14)	(0.00)	(0.60)	(2.39)	(2.76)	(2.83)
SYSRECSB x HEALTHMB	0.0325	-0.0048	0.0385	-0.0115	-0.0019	-0.0108
	(1.44)	(0.21)	(0.85)	(1.12)	(0.17)	(0.50)
SYSRECSB x HEALTHSB	**0.0866**	-0.0705	**0.1740**	**-0.0418**	0.0295	-0.0793
	(2.08)	(1.94)	(2.25)	(2.11)	(1.42)	(1.93)
BIRECMB	**1.2017**	**-1.1406**	**2.6146**	**0.5394**	**-0.4505**	**1.0996**
	(4.17)	(3.95)	(4.33)	(3.73)	(2.91)	(3.74)
BIRECMB x HEALTHMB	-0.0429	0.0512	-0.1063	-0.0520	-0.0665	0.0145
	(0.31)	(0.38)	(0.38)	(0.80)	(1.05)	(0.11)
BIRECMB x HEALTHSB	**-0.4311**	**0.3028**	**-0.8063**	-0.0325	0.0076	-0.0449
	(2.57)	(1.98)	(2.46)	(0.40)	(0.08)	(0.26)
BIRECSB	**0.3192**	**-0.2364**	**0.6121**	**0.2154**	**-0.2264**	**0.4902**
	(2.10)	(2.17)	(2.38)	(2.88)	(3.19)	(3.43)
BIRECSB x HEALTHMB	**-0.2395**	**0.1592**	**-0.4368**	0.0005	0.0534	-0.0579
	(2.37)	(2.48)	(2.60)	(0.01)	(1.34)	(0.68)
BIRECSB x HEALTHSB	-0.0876	0.0612	-0.1634	**0.1445**	**-0.1227**	**0.2968**
	(1.16)	(1.05)	(1.23)	(2.41)	(2.19)	(2.57)
HEALTHMB	**-0.0480**	-0.0271	-0.0145	-0.0094	-0.0119	0.0025

	(2.95)	(1.44)	(0.43)	(0.92)	(1.04)	(0.11)
HEALTHSB	-0.0127	0.0145	-0.0306	0.0079	-0.0072	0.0168
	(0.87)	(1.15)	(1.14)	(0.98)	(0.94)	(1.06)
LCOOP	**0.3283**	**0.1615**	**0.1290**	**0.2959**	**0.1128**	**0.2088**
	(12.98)	(7.10)	(2.94)	(11.56)	(4.67)	(4.46)
LNCOOP	**0.3880**	**0.4836**	**-0.2097**	**0.2853**	**0.5371**	**-0.2681**
	(13.84)	(15.34)	(4.32)	(12.61)	(21.79)	(0.97)
Log L	-905.32	-805.62		-950.27	-959.67	
R-Squared	0.495	0.482		0.430	0.560	
Mean of Dependent Variable	0.247	0.198		0.216	0.226	
No. of Observations	1,681	1,681		1,878	1,878	

TABLE VII
Average Marginal Derivatives of Conditional Probability: Independent Firm Portfolios

Calculations in this table are based on the AMDs in Table VI. Panel A contains descriptive sample statistics for the conditional probability that can be used to compare the magnitudes of the estimated effects. The first row in Panel B reports the average derivatives with respect to each variable in the column headings when HEALTHMB=HEALTHSB=0, i.e., both the main bank and the secondary bank are of average health. The entries in the second row of Panel B are obtained by multiplying the entries in the first row with the interquartile range of the variables given by the column headings using their respective subsamples. Hence, the entries in the second row of Panel B represent the effects of increasing the variable from the first quartile to the third quartile. Panel C contains the scaled average marginal derivatives under the scenarios given by the row captions.

Panel A: Descriptive Statistics for Conditional Probability

	1982-1990	1991-1999
Sample Mean	0.5549	0.4942
Sample Median	0.5547	0.4989
Lower Quartile	0.4880	0.4186
Upper Quartile	0.6213	0.5762
Interquartile Range	0.1333	0.1576

Panel B: Average Marginal Derivatives

	1982-1990				1991-1999			
	SYSRECMB	SYSRECSB	BIRECMB	BIRECSB	SYSRECMB	SYSRECSB	BIRECMB	BIRECSB
Unscaled	-0.164	-0.148	2.615	0.612	-0.291	0.478	1.100	0.490
Scaled by the Interquartile Range	-0.048	-0.020	0.102	0.025	-0.087	0.075	0.043	0.023

Panel C: Scaled Average Marginal Derivatives by Bank Health

	1982-1990				1991-1999			
	SYSRECMB	SYSRECSB	BIRECMB	BIRECSB	SYSRECMB	SYSRECSB	BIRECMB	BIRECSB
HEALTHMB=-1, HEALTHSB=-1	-0.097	-0.050	0.137	0.049	-0.086	0.089	0.044	0.012
HEALTHMB=-1, HEALTHSB= 1	-0.053	-0.002	0.074	0.036	-0.097	0.064	0.041	0.039
HEALTHMB= 1, HEALTHSB=-1	-0.044	-0.039	0.129	0.014	-0.078	0.086	0.045	0.006
HEALTHMB= 1, HEALTHSB= 1	0.000	0.009	0.066	0.000	-0.088	0.061	0.042	0.034

TABLE VIII
Fractional Logit Estimates and AMDs of the Probability of Cooperation
Full Specification: Keiretsu Firm Portfolios

The unit of observation is a bank pair consisting of a main bank and a secondary bank that do not have a keiretsu affiliation. For a given pair, we form portfolios of firms such that each firm in the portfolio has positive loans outstanding from both the main bank and the secondary bank, and the firms have a keiretsu affiliation with the main bank. Any main bank-secondary bank pair that does not share at least 10 clients is omitted from the analysis. COOP is the proportion of firms in the portfolio whose loans from both the main bank and the secondary bank have increased. NCOOP is the proportion of firms in the portfolio whose loans from the main bank increased but whose loans from the secondary bank did not increase. SYSRECMB is our measure of system reciprocity for the main bank. SYSRECSB is our measure of system reciprocity for the secondary bank. BIRECMB is the first of our measures of directional bilateral reciprocity, and is interpreted as the degree of reliance by the main bank on the secondary bank. BIRECSB is our second measure of directional bilateral reciprocity, and is interpreted as the degree of reliance by the secondary bank on the main bank. LCOOP is the proportion of firms in the portfolio whose loans from both the main bank and the secondary bank have increased in the prior year. LNCOOP is the proportion of firms in the portfolio whose loans from the main bank have increased but whose loans from the secondary bank did not increase. HEALTHMB and HEALTHSB are based on the market-to-book ratio of the main bank and the secondary bank, respectively, in the prior year, and are measured as the number of standard deviations away from the mean for all banks in that year. Each regression includes a set of dummy variables for each year, for each main bank, and for each secondary bank. AMD is obtained by using the fractional logit estimates of both the COOP and NCOOP equations, and is calculated as the sample average of the derivatives of the probability that the secondary bank increases loans conditional on the main bank having done so. Estimated coefficients that are significant at the 5 percent level or better are shown in boldface.

	1982-1990			1991-1999		
	COOP	NCOOP	AMD	COOP	NCOOP	AMD
SYSRECMB	-0.3119	0.1546	-0.4934	**-0.2732**	0.1149	**-0.4616**
	(1.47)	(0.84)	(1.28)	(3.08)	(1.40)	(2.67)
SYSRECMB x HEALTHMB	**0.2453**	**-0.2230**	**0.4974**	**0.1199**	-0.0426	**0.1951**
	(2.11)	(2.25)	(2.35)	(2.46)	(0.99)	(2.09)
SYSRECMB x HEALTHSB	-0.0223	0.0388	-0.0652	-0.0312	0.0202	-0.0595
	(0.31)	(0.37)	(0.38)	(1.15)	(0.73)	(1.10)
SYSRECSB	0.0304	-0.0056	0.0378	**0.5518**	**-0.5940**	**1.2815**
	(0.19)	(0.04)	(0.13)	(4.77)	(5.52)	(5.72)
SYSRECSB x HEALTHMB	-0.0397	-0.0038	-0.0375	-0.0330	0.0267	-0.0681
	(1.21)	(0.12)	(0.61)	(1.36)	(1.13)	(1.38)
SYSRECSB x HEALTHSB	-0.0113	-0.0737	0.0677	**-0.0694**	0.0257	**-0.1140**
	(0.23)	(1.62)	(0.77)	(2.72)	(0.96)	(2.16)
BIRECMB	**0.8786**	-0.3658	1.3145	0.5054	-0.0666	0.7134
	(1.97)	(0.86)	(1.56)	(1.77)	(0.23)	(1.23)
BIRECMB x HEALTHMB	-0.1628	0.0631	-0.2385	0.1261	-0.1514	0.3080
	(0.83)	(0.33)	(0.64)	(0.88)	(1.14)	(1.09)
BIRECMB x HEALTHSB	-0.0389	-0.0769	0.0422	0.2321	-0.2481	**0.5373**
	(0.15)	(0.31)	(0.09)	(1.91)	(1.88)	(2.11)
BIRECSB	-0.0515	0.1776	-0.2455	0.0901	-0.1820	0.2912
	(0.30)	(1.34)	(0.84)	(0.64)	(1.47)	(1.07)
BIRECSB x HEALTHMB	-0.0104	-0.0888	0.0850	-0.0108	0.0000	-0.0140
	(0.09)	(0.92)	(0.41)	(0.12)	(0.00)	(0.08)
BIRECSB x HEALTHSB	-0.0209	-0.0385	0.0196	0.1482	**-0.2351**	**0.4171**
	(0.22)	(0.45)	(0.11)	(1.82)	(2.87)	(2.48)
HEALTHMB	-0.0781	**0.0815**	**-0.1697**	**-0.0504**	0.0199	**-0.0839**
	(1.66)	(2.03)	(1.99)	(2.42)	(1.13)	(2.13)

HEALTHSB	0.0129	-0.0082	0.0224	0.0138	0.0055	0.0124
	(0.44)	(0.20)	(0.33)	(1.06)	(0.42)	(0.47)
LCOOP	**0.1902**	**0.1499**	0.0373	**0.2866**	**0.2428**	**0.1339**
	(6.02)	(5.65)	(0.67)	(8.55)	(7.94)	(2.34)
LNCOOP	**0.2071**	**0.5294**	**-0.3544**	**0.3215**	**0.6256**	**-0.1903**
	(6.85)	(18.20)	(7.02)	(10.32)	(21.87)	(4.02)
Log L	-673.89	-667.53		-630.89	-741.97	
R-Squared	0.497	0.474		0.476	0.567	
Mean of Dependent Variable	0.238	0.228		0.185	0.252	
No. of Observations	1,283	1,283		1,376	1,376	

TABLE IX
Average Marginal Derivatives of Conditional Probability:
Keiretsu Firm Portfolios

Calculations in this table are based on the AMDs in Table VIII. Panel A contains descriptive sample statistics for the conditional probability that can be used to compare the magnitudes of the estimated effects. The first row in Panel B reports the average derivatives with respect to each variable in the column headings when HEALTHMB=HEALTHSB=0, i.e., both the main bank and the secondary bank are of average health. The entries in the second row of Panel B are obtained by multiplying the entries in the first row with the interquartile range of the variables given by the column headings using their respective subsamples. Hence, the entries in the second row of Panel B represent the effects of increasing the variable from the first quartile to the third quartile. Panel C contains the scaled average marginal derivatives under the scenarios given by the row captions.

Panel A: Descriptive Statistics for Conditional Probability

	1982-1990	1991-1999
Sample Mean	0.5049	0.4232
Sample Median	0.5087	0.4232
Lower Quartile	0.4286	0.3377
Upper Quartile	0.5846	0.5089
Interquartile Range	0.1560	0.1712

Panel B: Average Marginal Derivatives

	1982-1990				1991-1999			
	SYSRECMB	SYSRECSB	BIRECMB	BIRECSB	SYSRECMB	SYSRECSB	BIRECMB	BIRECSB
Unscaled	-0.493	0.038	1.315	-0.246	-0.462	1.282	0.713	0.291
Scaled by the Interquartile Range	-0.028	0.004	0.048	-0.011	-0.081	0.177	0.029	0.014

Panel C: Scaled Average Marginal Derivatives by Bank Health

	1982-1990				1991-1999			
	SYSRECMB	SYSRECSB	BIRECMB	BIRECSB	SYSRECMB	SYSRECSB	BIRECMB	BIRECSB
HEALTHMB=-1, HEALTHSB=-1	-0.052	0.001	0.055	-0.015	-0.105	0.202	-0.005	-0.005
HEALTHMB=-1, HEALTHSB= 1	-0.059	0.016	0.059	-0.014	-0.126	0.170	0.037	0.034
HEALTHMB= 1, HEALTHSB=-1	0.004	-0.007	0.038	-0.008	-0.036	0.183	0.019	-0.007
HEALTHMB= 1, HEALTHSB= 1	-0.003	0.007	0.041	-0.006	-0.057	0.152	0.061	0.033

Endnotes

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[1] Thus, even in the absence of government pressure, Japanese banks themselves may have had an incentive to participate in the "convoy system," whereby healthier banks aided weaker banks, during the troubled 1990s.

[2] This measure of cooperation potentially understates the degree of cooperation of secondary banks with main banks. For example, a secondary bank could also aid a main bank by increasing loans to a firm when the firm's main bank is unable to do so due to the main bank's poor health. In unreported results, we broadened the measure of cooperation to include instances when the secondary bank increased loans to a firm even when the main bank did not do so. We obtained results similar to those reported, in large part due to the fact that this is a relatively rare occurrence, representing only about 7 percent of the total observations.

[3] Because fiscal year-ends are spread across all 12 months in Japan, we must group them into our annual observations. Most Japanese firms have a fiscal year-end in March and relatively few have fiscal year-ends in the middle of the calendar year. Thus, we group firms with fiscal year-ends in January through June of calendar year t and July through December of calendar year t-1 into our year t observations. Furthermore, the partial year observation of a firm that changes its fiscal year-end is not included in the sample.

[4] Ties are broken by keiretsu membership or by considering the past and future lending to the firm. In order to attach some smoothness to the main bank definition, we do not always change the designated main bank when another lender becomes the largest lender to the firm. Specifically, if the loans from the largest lender in a given year do not exceed the loans from the main bank designated in the prior year by at least 10 percent, we do not change the main bank.