This paper investigates whether there has been risk sharing between a main bank and borrowing companies in Japan. Horiuchi, et al. (1988) claim that systematic relationships indicating the existence of risk-sharing between them cannot be generally observed. However, contracts conditional on operating profits as in Horiuchi, et al. (1988) may not be feasible because of the moral hazard problem. As Christopher (1982) suggests, indexed contracts are one way to circumvent the moral hazard. Here, an optimal indexed contract involving risk sharing is derived, and is shown to be consistent with the behavior of companies in the Japanese chemical industry.

1. Introduction

The purpose of this paper is to investigate whether there has been risk sharing between a main bank and borrowing companies. As Horiuchi, et al. (1988) have pointed out, previous studies (e.g., Fried and Howitt (1980) and Wakita (1983)) concerning risk sharing between banks and borrowing companies focus on the risk of the market rate of interest, but the risk of operating profits of borrowing companies is not taken into account. An empirical study by Osano and Tsutsui (1985) supports risk sharing in the Japanese bank loan market, but they do not utilize models which involve risks related to the operating profits of borrowing companies. The risk sharing hypothesis implies that the operating profits of borrowing companies positively affect their financial costs. Horiuchi, et al. (1988)'s empirical study shows that this effect is not generally observed for companies in the Japanese chemical industry.

At least for banks, the operating profits of companies are uncertain when the loan rate is determined. Furthermore, borrowing companies know more about their operating profits than banks, but they may have an incentive to understate their operating profits, if interest payment should move so that movements in operating profits are offset in contracts between banks and borrowing companies. This is a moral hazard problem, which limits the range of possible contracts (see, for example, Townsend (1979, p. 265) and Christopher (1982, p. 812)). The empirical evidence provided by Horiuchi, et al. (1988) shows that Japanese main banks have relationships of greater fluidity than has been generally believed. This fact implies that the moral
hazard problem, even in the contract between main banks and borrowing companies, is not negligible. Therefore, the risk sharing considered by Horiuchi, et al. (1988) may not be feasible. The fact that the risk sharing is not observed by Horiuchi, et al. (1988) is reasonable and consistent with our conjecture.1)

One way of circumventing the moral hazard problem is to index the contracted loan rate to changes in market rates, which are observed by both contracting parties and cannot be influenced by one or both of the parties of the contract.2)

A long-term transaction relationship between the contracting parties may protect both parties from opportunistic behavior. Strictly speaking, the transaction specific assets produced by the long-term transaction does this. Otherwise, a bank's customer may abandon the contract and take a spot market transaction when the contracted borrowing rate is higher than the market loan rate. Similarly, a bank may abandon the contract and take a spot market transaction, when the contracted loan rate is lower than the market rate.

It is considered that a long-term transaction relationship or the existence of transaction specific assets provides an incentive to transact under long-term contracts and protects the contracting parties from opportunistic behavior. However, this does not remove the incentive to misrepresent the variables upon which the terms of contracts are made contingent, as in Christopher (1982, section 1).3)

In the theoretical analysis developed in this paper, it is found that covariance between the operating profits of the borrowing companies and the market loan rate, which is an indexed rate of interest, is important in risk sharing based on indexation.

In the empirical analysis, companies are divided into two groups according to the strength of their relationship with a main bank. Companies in the first group have a strong tie with a main bank, and companies in the second group have a weak tie with a main bank or do not even have a

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1) The empirical results of Hirota (1990) support the existence of risk sharing concerning the operating profits of a borrowing company. Although his estimation method basically follows that of Horiuchi, et al. (1988), it is less reliable in that Hirota (1990) uses cross-section data instead of the time series data used by Horiuchi, et al. (1988). This estimation method assumes that all parameters, including the constant term, in the regression equation are the same across all companies. This is a very strong assumption especially since the constant term represents characteristics involving the probability of default of a company. Pooling time-series and cross-section data can be utilized to circumvent the problem of a short sample period.

Cross-section analysis is also not appropriate, because the risk sharing considered here is to stabilize the profits of a borrowing company over time. Furthermore, the monopoly power of main banks should not be ignored in cross-section analysis. This monopoly power may increase the financial costs of borrowing companies. It follows that the degree of dependence on main banks may be positively related to the financial costs of borrowing companies.

Lastly, Hirota (1990) fails to note that there is no reason that financial costs of borrowing companies are negatively related to their current profits, although their financial costs may be negatively related to their past profits.

2) The loan rate determination, without considering bankruptcy, discussed here is related to the determination of $R$ in Williamson (1986). Hence, our analysis does not contradict the analysis of Williamson (1986).

3) Christopher (1982) restricts his attention to the efficiency of indexation, and does not consider risk sharing under indexed contracts, as is done here.
main bank. The former may be presumed to be offered risk sharing by a main bank. The latter may be presumed not to be, because of the possibility of opportunistic behavior.

First, a loan rate determination equation under an indexed contract for companies is estimated for each group. Secondly, the difference between the two groups is noted as in Fazzari, et al. (1988) and Hoshi, et al. (1991). This approach is better than an approach using the levels not the differences. This is because the estimated coefficients are unbiased estimates of the true difference as long as the biases are the same for the two groups of companies.

It is found that there has been risk sharing between a main bank and borrowing companies having a strong tie with that bank, and there has not been risk sharing between a main bank and borrowing companies which have a weak tie with that bank or do not have any main bank. A significant difference is found between the two groups. That is, a main bank has provided risk sharing for customers who have a strong tie with the bank.

As additional empirical analysis, the equations implied from our model utilizing the effective borrowing rate of interest for companies are estimated. For companies which have a strong tie with a main bank, the empirical results support the risk sharing hypothesis. In contrast, for companies which do not have a strong tie with a main bank, the empirical results do not. However, the difference between the two groups is not significant. This may be because the number of companies studied is small.

The paper is organized as follows. Section 2 explains the theoretical model and derives an optimal indexed contract. In section 3, the estimation method is discussed and in section 4, the data used are described. The estimation results are given in section 5. Section 6 summarizes and discusses the findings of this study.

2. Model

An optimal indexed contract is derived in this section. It is assumed that the market loan rate, the gross profits of a borrowing company and the opportunity cost of bank funds are stochastic variables but the amount of borrowing demanded by a company is non-stochastic and determined according to the project undertaken by the company. For simplicity, it is further assumed that banks are risk-neutral and companies are risk-averse.

Suppose that the degree of absolute risk aversion of a borrowing company $j$, $A_j$, is constant. The expected utility, $E(U_j(Y_j))$, of company $j$ can be approximately represented as follows.

\[ E(U_j(Y_j)) = U_j(E(Y_j) - (1/2) \cdot A_j \cdot \text{Var}(Y_j)), \]

where the operator $E(\ )$ denotes mathematical expectation, $\partial U_j/\partial Y_j > 0$, $\partial^2 U_j/\partial Y_j^2 < 0$, $A_j > 0$, $\text{Var}(Y_j)$ is the variance of $Y_j$, and $Y_j$ is the operating performance of borrowing company $j$, which is designated as ”net profit.” The net profit of a borrowing company $j$, $Y_j$, is represented as follows.

\[ Y_j = X_j - r_{1j} \cdot L_{1j} - r_{2j} \cdot L_{2j} \]
\[ = L_j \cdot ((x_j - (\theta_j \cdot r_{1j} + (1 - \theta_j) \cdot r_{2j}))), \]
\[ = x_j - (\theta_j \cdot r_{1j} + (1 - \theta_j) \cdot r_{2j}) \]

where $X_j$ is gross profit (net profit plus interest payment); $r_{1j}$ is the contracted borrowing rate of interest charged by a main bank; $r_{2j}$ is the weighted average of borrowing rates of interest charged under indexed contracts.
by banks other than a main bank. (The weight is the loan share extended by each bank in the total borrowing from banks other than a main bank); \( L_{1j} \) is the amount of borrowing from a main bank; \( L_{2j} \) is the amount of borrowing from banks other than a main bank; \( L_j \) is the total amount of borrowing from all banks \((L_{1j} + L_{2j} = L_j)\); \( x_j \) is the gross profit per unit of the amount of borrowing, \((X_j/L_j)\), which is designated as the “gross profit ratio”; and \( \theta_j \) is the share of borrowing from a main bank in total borrowing, \((L_{1j}/(L_{1j} + L_{2j}))\). For simplicity, the total amount of borrowing, \( L_j \), is assumed to be fixed and take the value 1.

A bank has two types of customers: customers who have a long-term transaction relationship with the bank or have transaction specific assets in place, and customers who do not. The bank of the former customers is called the main bank.

Since banks are assumed to be risk neutral, a main bank maximizes its expected profits subject to the constraint that the expected utility of a borrowing company is equal to or larger than its reservation utility and given the loan size, \( L_j \), which is fixed to be 1, the share of borrowing from a main bank, \( \theta_j \), and the opportunity cost of bank funds, \( i \). It is assumed that the bank can borrow any amount at the interest rate, \( i \). The main bank’s optimization problem is

\[
\text{(3) max } E((r_{1j} - i) - E(f(\theta_j))) \text{, subject to } E(U_j(Y_j)) \geq U_j,
\]

where \( C() \) is the administrative costs associated with the loan; and \( \bar{U}_j \) is the reservation utility of borrowing company \( j \).

When a main bank determines its loan rate, it does not ignore the market loan rate. So, we suppose that the contracted borrowing rate charged by a main bank to borrowing company \( j \), \( r_{1j} \), is indexed to the market loan rate, \( r_M \), under a contract between the main bank and the borrowing company as shown in equation (4).

\[
\text{(4) } r_{1j} = \alpha_{0j} + \alpha_{1j} \cdot (r_M - \bar{r}_M),
\]

where \( \bar{r}_M \) is the mean of the market loan rate, \( E(r_M) \). A main bank determines both \( \alpha_{0j} \) and \( \alpha_{1j} \). Substituting (4) into (2) gives

\[
\text{(5) } Y_j = x_j - (\theta_j \cdot (\alpha_{0j} + \alpha_{1j} \cdot (r_M - \bar{r}_M)) + (1 - \theta_j) \cdot r_M).
\]

The expectation and variance of \( Y_j \) respectively are

\[
\text{(6) } E(Y_j) = E(x_j) - (\theta_j \cdot E(r_{1j}) + (1 - \theta_j) \cdot E(r_{2j})) = E(x_j) - (\theta_j \cdot a_{0j} + (1 - \theta_j) \cdot E(r_{2j}))
\]

\[
\text{(7) } \text{Var}(Y_j) = \text{Var}(x_j - \theta_j \cdot r_{1j} - (1 - \theta_j) \cdot r_{2j}) = \text{Var}(x_j) + \theta_j^2 \cdot a_{1j}^2 \cdot \text{Var}(r_M) + (1 - \theta_j)^2 \cdot \text{Var}(r_{2j}) - 2 \cdot \theta_j \cdot a_{1j} \cdot \text{Cov}(x_j, r_M) - 2 \cdot (1 - \theta_j) \cdot \text{Cov}(x_j, r_{2j}) + 2 \cdot \theta_j \cdot (1 - \theta_j) \cdot a_{1j} \cdot \text{Cov}(r_M, r_{2j}).
\]

4) Equation (4) is used instead of the following equation for simplicity.

\[
r_{1j} = \alpha_{0j} + \alpha_{1j} \cdot r_M
\]

There is no substantial difference between these two equations.

5) When \( \alpha_{1j} = 1 \) and \( r_M \) is the prime rate instead of the market loan rate, equation (4) collapses to the indexation rule in Christopher (1982). The indexation rule considered here is thus more general than that of Christopher (1982) in that in our study a main bank is free to choose the value of \( \alpha_{1j} \).
The Lagrangian for the main bank's problem is

\[ H_j = E\left((r_{Uj} - \theta_j) \cdot C(\theta_j) + \lambda_j \cdot (E(U_j(Y_j)) - \bar{U}_j)\right), \]

where \( \lambda_j \) is a positive constant. The first order conditions are

\[ \frac{\partial H_j}{\partial \alpha_{0j}} = \theta_j + \lambda_j \cdot (-\theta_j) = \theta_j \cdot (1 - \lambda_j) = 0, \]

\[ \frac{\partial H_j}{\partial \alpha_{Uj}} = \lambda_j \cdot \left( -\frac{1}{2} A_j \right) \cdot \partial \text{Var} (Y_j) / \partial \alpha_{Uj} \]

\[ = \lambda_j \cdot \left( -\frac{1}{2} A_j \right) \cdot \left( 2 \cdot \theta_j^2 \alpha_{Uj} \text{Var} (r_M) - 2 \theta_j \cdot \text{Cov} (x_j, r_M) \right) \]

\[ + 2 \theta_j \cdot (1 - \theta_j) \cdot \text{Cov} (r_M, r_{2j}) = 0, \]

and

\[ \frac{\partial H_j}{\partial \lambda_j} = E(U_j(Y_j)) - U_j = 0. \]

Suppose that \( \alpha_{0j}^* \) denotes the \( \alpha_{0j} \) which satisfies (10), then

\[ \alpha_{0j}^* = \frac{(\text{Cov} (x_j, r_M) - (1 - \theta_j) \cdot \text{Cov} (r_M, r_{2j}))}{(\theta_j \cdot \text{Var} (r_M))}. \]

Suppose that \( \alpha_{Uj}^* \) denotes the \( \alpha_{Uj} \) which satisfies (11) under the condition that \( \alpha_{Uj} = \alpha_{Uj}^* \). Substituting \( \alpha_{0j}^* \) and \( \alpha_{Uj}^* \) into (4) gives

\[ r_{Uj} = \alpha_{0j}^* + \frac{1}{\theta_j} \cdot \left( \text{Cov} (x_j, r_M) - (1 - \theta_j) \cdot \text{Cov} (r_M, r_{2j}) \right)/\text{Var} (r_M)) \cdot (r_M - \bar{r}_M). \]

Suppose that the weighted average of the borrowing rates of interest charged by banks other than a main bank for company \( j, r_{2j} \), is equal to the market loan rate, \( r_M \):

\[ r_{2j} = r_M. \]

Substituting (14) into (12) gives the optimal choice of \( \alpha_{Uj} \) as

\[ \alpha_{Uj}^* = (1/\theta_j) \cdot \text{Cov} (x_j, r_M)/\text{Var} (r_M) - (1 - \theta_j). \]

From (1), (6), (7), (11), (12)' and (14), the optimal choice of \( \alpha_{0j} \) is

\[ \alpha_{0j}^* = \frac{1}{\theta_j} \cdot \left( E(x_j) - (1 - \theta_j) \cdot E(r_M) \right) \]

\[ - \frac{1}{2} A_j \cdot \left( \text{Var} (x_j) - (\text{Cov} (x_j, r_M))^2/\text{Var} (r_M)) \right) - \frac{1}{\theta_j} \cdot \bar{U}_j. \]

Substituting (12)' into (4) gives

\[ r_{Uj} = \alpha_{0j}^* + \frac{1}{\theta_j} \cdot \left( \text{Cov} (x_j, r_M)/\text{Var} (r_M) - (1 - \theta_j) \right)/\text{Var} (r_M)) \cdot (r_M - \bar{r}_M), \]

where \( \alpha_{0j}^* \) is defined in equation (15). The second order condition for this optimization is easily shown to be satisfied. It follows that (13)' gives an optimal indexed contract offered by a main bank. It is assumed that the optimal solution is an interior solution. So, it is possible that the optimal interest rates on borrowing charged by a main bank are negative.

Define the interest payment for a company divided by the amount of outstanding borrowings as \( r^* \). The following equation is obtained by simple manipulation.

\[ r^* = \theta_j \cdot r_{Uj} + (1 - \theta_j) \cdot r_{2j} \]

\[ = \theta_j \cdot r_{Uj} + (1 - \theta_j) \cdot r_M \]

\[ = \theta_j \cdot \alpha_{0j}^* + \text{Cov} (x_j, r_M)/\text{Var} (r_M) - (1 - \theta_j) \cdot (r_M - \bar{r}_M) + (1 - \theta_j) \cdot r_M \]

\[ = (\theta_j \cdot \alpha_{0j}^* + (1 - \theta_j) \cdot \bar{r}_M) + \text{Cov} (x_j, r_M)/\text{Var} (r_M)) \cdot (r_M - \bar{r}_M) \]
From (16),

\begin{align*}
(17) \quad E(r^*_j) &= \theta_j a^*_j + (1 - \theta_j) \cdot \bar{r}_M = \theta_j \cdot E(r_{1j}) + (1 - \theta_j) \cdot E(r_{2j}) \\
\text{and} \\
(18) \quad \text{Var}(r^*_j) &= (\text{Cov}(x_j, r_M))^2/\text{Var}(r_M).
\end{align*}

The second equality in (17) is derived from (4) and (14). Equation (17) implies that the mean of \( r^*_j \) is the weighted average of expected loan rates from banks, where the weight is the loan share extended by each bank.

Equations (16)-(18) have important implications. First, from (16), the movement of the rate of interest on borrowing, \( r^*_j \), is directly related to the covariance between the gross profit ratio of a borrowing company, \( x_j \), and the market loan rate, \( r_M \). From (18), ceteris paribus, the larger the absolute value of the covariance between the gross profit ratio, \( x_j \), and the market loan rate, \( r_M \), is, the larger the variance of the borrowing rate, \( r^*_j \), becomes. If the covariance is zero, the variance of the borrowing rate, \( r^*_j \), is also zero, where the borrowing rate, \( r^*_j \), is constant. Secondly, the second term in the last equality of (16) does not depend on the ratio of outstanding borrowings from a main bank, \( \theta_j \). This means that the movement of the borrowing rate is independent of the ratio of outstanding borrowings from a main bank. This is because a main bank adjusts the movement of its loan rate, \( r_{1j} \), according to the ratio of outstanding lending by the main bank in the total outstanding borrowing of a company, \( \theta_j \), since the coefficient of the term \( \text{Cov}(x_j, r_M)/\text{Var}(r_M) \cdot (r_M - \bar{r}_M) \) is \( 1/\theta_j \) in the loan rate determination equations of a main bank (equations (13) and (13)'). This implication calls into question the results of previous empirical studies (for example, Horiuchi, et al. (1988) and Hirota (1990)) which utilize the ratio of outstanding borrowings from a main bank in investigations of risk sharing between a main bank and a borrowing company. This implication is also consistent with the empirical results given in Horiuchi, et al. (1988) that there is no systematic relationship between the degree of dependence on the main bank and the significance of the coefficient, which is significantly positive if ordinary and net profits are stabilized through the adjustment of financial expenses.

From (7), (12)', and (14)

(19) \quad \text{Var}(Y^*_j) &= \text{Var}(x_j) - (\text{Cov}(x_j, r_M))^2/\text{Var}(r_M) \\
&= \text{Var}(x_j) \cdot (1 - \rho_j^2) \\
&\leq \text{Var}(x_j) \cdot ((1 - \rho_j^2) + (\rho_j - \delta_j)^2) \\
&= \text{Var}(x_j - r_M)

where \( \rho_j \) is the coefficient of correlation between \( x_j \) and \( r_M \); and \( \delta_j = (\text{the standard deviation of } r_M)/(\text{the standard deviation of } x_j) \). The inequality in (19) holds with equality, when \( \rho_j = \delta_j \), where \( a^*_j = 1 \), that is, \( r_{1j} \) is parallel to the market loan rate, \( r_M \). Equation (19) shows that the variance of net profits of a company under the indexed contract derived above is no more than the variance under only spot market transactions. Therefore, a company can reduce the risk of its net profits by taking the indexed contract offered by a main bank. Also, (19)' can be obtained from (19).

(19)' \quad \text{Var}(Y^*_j) &= \text{Var}(x_j) \cdot (1 - \rho_j^2) \leq \text{Var}(x_j)

The inequality in (19)' holds with equality when \( \rho_j = 0 \). Equation (19)' shows that the variance of the net profits of a company under the indexed contract is no more than the variance of the
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gross profits of a company. Therefore, a main bank which offers the indexed contract takes not only the risk of movements in bank funds cost but also part of the risk in gross profits of a borrowing company in place of the borrowing company. This implies that a main bank provides customers with insurance or risk-sharing through the indexed contract.

In this paper, variable loan rates are used to transfer risks associated with the borrowing company’s earnings to main banks. This setting provides a sharp contrast to the conventional view that variable loan rates are used to stabilize bank profits. This implies that loan rate determination rule given a main bank relationship is very different from the one given an ordinary relationship between banks and borrowers.

3. Estimation Method

In the preceding section, it is found that the covariance between the gross profits of borrowing companies and the market loan rate, which is an indexed rate of interest, is important in risk sharing based on indexation. This implication of the model will now be tested.

As a device for estimation, it is assumed that the gross profit ratio of a company $j$ is positively and linearly related to its operating profit per unit of the amount of borrowing.

$$x_j = b_{0j} + b_{1j} \cdot OP_j + e_j,$$

where $b_{1j} > 0$, $OP_j$ is the operating profits per unit of the amount of borrowing, and $e_j$ is an error. Since $x_j$ includes profits or revenues other than operating profits (for example, non-operating revenues) or expenses, $x_j$ is generally not equal to $OP_j$. The coefficient $b_{1j}$ is expected to be positive but it may be less than one if the non-operating profits counterbalance to a degree the movement of the operating profits. This counterbalance by non-operating profits is also mentioned in Horiuchi, et al. (1988). By simple manipulation, the following equation can be obtained.

$$Cov (x_j, r_M) = b_{1j} \cdot Cov (OP_j, r_M) + Cov (e_j, r_M)$$

Substituting this equation into (16) gives

$$r^*_j = \delta_{0j} + (\delta_{1j} + \delta_{2j}) \cdot Cov (OP_j, r_M)/\text{Var} (r_M) \cdot r_M - \bar{r}_M$$

where $\delta_{0j} \equiv \theta \cdot \delta^*_j + (1 - \theta) \cdot \bar{r}_M$, $\delta_{1j} \equiv Cov (e_j, r_M)/\text{Var} (r_M)$, and $\delta_{2j} \equiv b_{1j} > 0$.

The borrowing rate of interest should be related to the market loan rate, even if there is no risk sharing. However, the movement of the borrowing rate, which is adjusted according to the covariance between the gross profits of the borrowing company and the market loan rate, should not be observed if there is no risk sharing. Therefore, the null hypothesis of no risk sharing between a main bank and borrowing companies, which will be denoted by $H_0$, is $H_0: \delta_{2j} = 0$.

Since the variable $Cov (OP_j, r_M)/\text{Var} (r_M)$ is time invariant, (22) cannot be estimated using time-series data on each company. In addition, since the constant terms $\delta_{0j}(j = 1, 2, \ldots, p)$ are unknown and differ across companies, they cannot be estimated using cross-section data. Therefore, a pooling of time-series and cross-section data is used. Here the following assumptions are necessary.

$$\delta_{ij} = \delta_i, \text{ for all } j,$$

6) The estimation period is too short to utilize moving covariances.

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and

(24) \( \delta_{ij} = \delta_2 \), for all \( j \).

Then, the regression model considered is

(25) \( r_{jt}^* = \delta_{0j} + (\delta_1 + \delta_2 \cdot \text{Cov}(OP_j, r_M)/\text{Var}(r_M)) \cdot (r_{Mt} - \bar{r}_M) + u_{jt} \)

\( j = 1, 2, \ldots, p, \ t = 1, 2, \ldots, m \)

where \( \delta_{0j} \), \( \delta_1 \), and \( \delta_2 \) are unknown coefficients, \( u_{jt} \) is an independent disturbance term, the subscript \( j \) represents company, and the subscript \( t \) represents time. The null hypothesis of no risk sharing simplifies to \( H_0^*: \delta_2 = 0 \).

A random effects model is used, so that the variables are transformed as follows.

(26) \( z_{kjt} = Z_{kjt} - c \cdot \bar{Z}_{kj}, \ j = 1, 2, \ldots, p, \ t = 1, 2, \ldots, m, \)

where

\[
\begin{align*}
Z_{kjt} &= r_{jt}^* \quad \text{if} \quad k = 1, \\
Z_{kjt} &= r_{Mt} - \bar{r}_M \quad \text{if} \quad k = 2, \\
Z_{kjt} &= (\text{Cov}(OP_j, r_M)/\text{Var}(r_M)) \cdot (r_{Mt} - \bar{r}_M) \quad \text{if} \quad k = 3,
\end{align*}
\]

and

\[
\bar{Z}_{kj} = \frac{1}{m} \sum_{t=1}^{m} Z_{kjt}, \quad j = 1, 2, \ldots, p, \ k = 1, 2, 3.
\]

Since the parameter \( c \) is constrained to be in the \([0, 1]\) interval, its value is determined by a grid search over this interval. Using these transformed data, ordinary least squares is applied to (25) as the value of \( c \) is increased from 0 to 1 in step of 0.01 The likelihood was found to be maximized at the value of \( c \) which is equal to 1. Therefore, the parameter \( c \) is set equal to 1, where the random effects model and the fixed effects model coincide.7) For the purpose of comparison, the following two equations were also estimated.

(27) \( r_{jt}^* = \delta_{0j} + \delta_1 \cdot (r_{Mt} - \bar{r}_M) + u_{jt}, \ j = 1, 2, \ldots, p, \ t = 1, 2, \ldots, m \)

(28) \( r_{jt}^* = \delta_{0j} + \delta_2 \cdot (\text{Cov}(OP_j, r_M)/\text{Var}(r_M)) \cdot (r_{Mt} - \bar{r}_M) + u_{jt} \)

\( j = 1, 2, \ldots, p, \ t = 1, 2, \ldots, m \)

Next, the same approach adopted by Fazzari, et al. (1988) and Hoshi, et al. (1991) is used. That is, companies are divided into two groups, and the difference between the groups is investigated. This approach may be useful even if the estimated coefficients are biased (see Hoshi, et al. (1991, p. 43)).

In addition to the variables used in the previous regressions, two additional terms are added: (1) \( (r_{Mt} - \bar{r}_M) \cdot D_j \), where \( D_j \) is a dummy variable, taking the value 1 if company \( j \) has a strong tie with a main bank, otherwise it takes the value 0; and (2) \( (\text{Cov}(OP_j, r_M)/\text{Var}(r_M)) \cdot (r_{Mt} - \bar{r}_M) \cdot D_j \). Therefore the estimated equation is:

(29) \( r_{jt}^* = \delta_{0j} + \delta_{11} \cdot (r_{Mt} - \bar{r}_M) + \delta_{12} \cdot D_j \cdot (r_{Mt} - \bar{r}_M) \\
+ \delta_{21} \cdot (\text{Cov}(OP_j, r_M)/\text{Var}(r_M)) \cdot (r_{Mt} - \bar{r}_M) \\
+ \delta_{22} \cdot D_j \cdot (\text{Cov}(OP_j, r_M)/\text{Var}(r_M)) \cdot (r_{Mt} - \bar{r}_M) + u_{jt} \)

\( j = 1, 2, \ldots, p, \ t = 1, 2, \ldots, m \).

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The risk sharing hypothesis predicts that $\delta_{22}$ is positive, and that $\delta_{21}$ is not significant. Furthermore, the following constraint

\[(30) \quad \delta_{12} = \delta_{22} = 0\]

is tested using an $F$-test. This hypothesis implies that there is no difference in the movement of the borrowing rate between companies which have a strong tie with a main bank and those which do not.

4. Data

The empirical investigation is based on panel data for companies in the Japanese chemical industry. The focus on the chemical industry enables an easy comparison with previous studies. The sample is a subset of companies in the Japanese chemical industry that have been continuously listed on the Tokyo, Osaka or Nagoya Stock Exchanges between the fiscal years 1979 and 1988. The data was extracted from data tapes provided by the Japan Development Bank.

The companies in the sample were separated into two groups: A, those which have a strong tie with a main bank, and B, those which do not have a strong tie with a main bank. The classification was made using information from the *Keiretsu no Kenkyû* edited by the Economic Research Association (Keizai Chōsa Kyōkai). Therefore, the companies used here are those appearing in both the data tapes provided by the Japan Development Bank and *Keiretsu no Kenkyû*.

Companies which have only one financial affiliation for the estimation period are referred to as companies which have a strong tie with a main bank (Group A). All other companies are referred to as companies which do not have a strong tie with a main bank (Group B). Companies in Group B are more heteroscedastic than companies in Group A, since they may change their main bank or may have a non-financial affiliation. However, few companies have a non-financial affiliation or do not have financial affiliation at all, so that separate models cannot be estimated for them alone.

Annual data for the fiscal years 1979–1988 is used. Our selection rules\(^8\) leave a sample of 90 companies. The number of Group A is 65, and that of Group B is 25.\(^9\)

Variables are defined as follows:

- $r_{jt}^\ast = (\text{interest payment and discount charge})/(\text{the amount of outstanding borrowings and outstanding discounted note receivable})$, retrieved from the Japan Development Bank tape,
- $OP_{jt}$ = operating profits of company $j$ at time $t$, retrieved from the Japan Development Bank tape, and
- $r_{Mt}$ = the average contracted interest rates on loans and discounts, retrieved from the *Economic Statistics Annual* produced by the Bank of Japan.

5. Estimation Results

In this section, the estimation results are presented. Tables 1-a and 1-b show the estimation

\(^8\) That there are no missing values and the amount of outstanding borrowings is positive for estimation period is included in the rules.

\(^9\) Two companies for which the calculated borrowing rate of interest exceeds 100% in any fiscal year are omitted from companies in Group B. The borrowing rates of interest of companies other than these two have a reasonable range.
results based on equations (25), (27) and (28) for companies in Group A and Group B, respectively. These tables yield the results we expected. For Group A, $\delta_2$ is positive and significant at the 1 per cent level. For Group B, $\delta_2$ is not significant at the 60 per cent level. There is no important difference in these three regressions in each table indicating that the results obtained are robust to some extent. From the above results, for Group A, the covariance between operating profits of borrowing companies and the market loan rate is a significant explanatory variable.

Table 1-a  Companies which Have a Strong Tie with a Main Bank

<table>
<thead>
<tr>
<th></th>
<th>$\delta_1$</th>
<th>$\delta_2$</th>
<th>S.E.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1.161*</td>
<td>0.0485*</td>
<td>2.13</td>
<td>0.280</td>
</tr>
<tr>
<td></td>
<td>(13.709)</td>
<td>(12.091)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1-b  Companies which do not Have a Strong Tie with a Main Bank

<table>
<thead>
<tr>
<th></th>
<th>$\delta_1$</th>
<th>$\delta_2$</th>
<th>S.E.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.783*</td>
<td>0.00081</td>
<td>2.01</td>
<td>0.132</td>
</tr>
<tr>
<td></td>
<td>(6.202)</td>
<td>(0.4079)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$\delta_1$</th>
<th>$\delta_2$</th>
<th>S.E.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.76984*</td>
<td></td>
<td>2.01</td>
<td>0.135</td>
</tr>
<tr>
<td></td>
<td>(6.3240)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1-c  All Companies

<table>
<thead>
<tr>
<th></th>
<th>$\delta_{11}$</th>
<th>$\delta_{12}$</th>
<th>$\delta_{21}$</th>
<th>$\delta_{22}$</th>
<th>S.E.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.7833*</td>
<td>0.3777°</td>
<td>0.00081</td>
<td>0.0477*</td>
<td>2.10</td>
<td>0.246</td>
</tr>
<tr>
<td></td>
<td>(5.9391)</td>
<td>(2.4210)</td>
<td>(0.3906)</td>
<td>(10.678)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$\delta_{11}$</th>
<th>$\delta_{12}$</th>
<th>$\delta_{21}$</th>
<th>$\delta_{22}$</th>
<th>S.E.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>0.9545*</td>
<td>-0.04626</td>
<td>0.01121*</td>
<td></td>
<td>2.23</td>
<td>0.151</td>
</tr>
<tr>
<td></td>
<td>(6.8708)</td>
<td>(-0.28886)</td>
<td>(5.7271)</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$\delta_{11}$</th>
<th>$\delta_{12}$</th>
<th>$\delta_{21}$</th>
<th>$\delta_{22}$</th>
<th>S.E.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>1.0531*</td>
<td></td>
<td>0.001927</td>
<td>0.04496*</td>
<td>2.11</td>
<td>0.242</td>
</tr>
<tr>
<td></td>
<td>(14.903)</td>
<td></td>
<td>(0.94440)</td>
<td>(10.376)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>$\delta_{11}$</th>
<th>$\delta_{12}$</th>
<th>$\delta_{21}$</th>
<th>$\delta_{22}$</th>
<th>S.E.</th>
<th>$R^2$</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>0.92047*</td>
<td></td>
<td></td>
<td>0.011145*</td>
<td>2.23</td>
<td>0.153</td>
</tr>
<tr>
<td></td>
<td>(12.527)</td>
<td></td>
<td></td>
<td>(5.7395)</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

S.E. = standard error of the regression.
$R^2$ = adjusted $R$-squared.
$T$-statistics are shown in parentheses.
* = significant at the 1 per cent level.
° = significant at the 5 per cent level.
However, for Group B, the covariance is not. Table 1-c shows the estimation results based on equation (29) for all companies using dummy variables. This table also gives the results we expected in that $\delta_{21}$ is not significant at 60 per cent level, $\delta_{22}$ is positive and significant at 1 per cent level, and the constraint $\delta_{12} = \delta_{22} = 0$ is rejected at the significant level of 1 per cent. That is, the difference between both groups of companies is significant. These results in Table 1-c support the results in Tables 1-a and 1-b.

These estimation results show that companies in Group A are provided with risk sharing, but companies in Group B are not provided with risk sharing.

The same empirical analysis is performed utilizing the effective loan rate. The effective loan rate is constructed according to the following equation.

$$\text{the effective loan rate} = \frac{\text{interest payable} - \text{interest receivable}}{\text{total borrowing} - \text{cash and deposit}}$$

where total borrowing is the amount of outstanding borrowings and outstanding discounted note receivable. Cash and deposits are regarded as compensating balances, since data on compensating balances or data for deposits only could not be obtained. Companies whose (total borrowing — cash and deposit) is negative are omitted. As a result, the number of companies in Group A is 37, and the number of companies in Group B is 8. The estimation results are given in Tables 2-a, 2-b, and 2-c. According to Table 2-a, companies in Group A are provided with risk sharing, since $\delta_{2}$ is positive and significant at the 5 per cent level. According to Table 2-b, companies in Group B are not provided with risk sharing, since $\delta_{2}$ is not significant at the 70 per cent level. However, the additional dummy variables are not significant at the 90 per cent level (see Table 2-c). Moreover, the constraint $\delta_{12} = \delta_{22} = 0$ is not rejected by an F-test at the 50 per cent significance level suggesting that the difference between both groups of companies is insignificant. This may be due to the small number of companies analyzed, particularly the number of companies in Group B.

To summarize, using panel data from companies in the Japanese chemical industry, the result is obtained that there has been risk sharing between banks and borrowing companies which have a strong tie with a main bank. Risk sharing between a main bank and borrowing companies which do not have strong tie with a main bank is not observed.

6. Conclusion

This paper investigated whether there has been risk sharing between banks and borrowing companies. Horiuchi, et al. (1988) have reported that systematic relationships indicating the existence of risk-sharing between main banks and major borrowing companies cannot be generally observed. However, it should be noted that it is difficult for a bank to know or observe operating profits when the loan rate is determined. This is because borrowing companies have an incentive to understate them if interest payments are positively related with operating profits in contracts. Therefore, contracts dependent on operating profits are not feasible.

Risk-averse companies demand a contract stabilizing net profits. However, complete contingent contracts are not feasible since there is a moral hazard problem. Therefore, the main bank offers an indexed contract involving risk sharing. The bank can do this, since it has a long-term transaction relationship with the borrowing companies, which protects the contracting parties, to
a degree, from such opportunistic behavior as contracting parties breaking contracts and implementing spot market transaction if spot market transactions are more profitable than contract transactions.

In a world of asymmetric information and transaction costs, the indexation of loan rates may be more feasible and efficient than complete contingent contracts. In this view, an indexed contract was applied to risk sharing between a main bank and borrowing companies rather than a complete

<table>
<thead>
<tr>
<th>Table 2-a</th>
<th>Companies which Have a Strong Tie with a Main Bank (the effective loan rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\delta_1$</td>
</tr>
<tr>
<td>(1)</td>
<td>0.794*</td>
</tr>
<tr>
<td></td>
<td>(3.453)</td>
</tr>
<tr>
<td>(2)</td>
<td>0.661*</td>
</tr>
<tr>
<td></td>
<td>(2.9413)</td>
</tr>
<tr>
<td>(3)</td>
<td>0.00307</td>
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<td></td>
<td>(1.5968)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2-b</th>
<th>Companies which do not Have a Strong Tie with a Main Bank (the effective loan rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\delta_1$</td>
</tr>
<tr>
<td>(1)</td>
<td>0.845*</td>
</tr>
<tr>
<td></td>
<td>(5.601)</td>
</tr>
<tr>
<td>(2)</td>
<td>0.847*</td>
</tr>
<tr>
<td></td>
<td>(5.647)</td>
</tr>
<tr>
<td>(3)</td>
<td>0.00478</td>
</tr>
<tr>
<td></td>
<td>(0.4286)</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Table 2-c</th>
<th>All Companies (the effective loan rate)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\delta_{11}$</td>
</tr>
<tr>
<td>(1)</td>
<td>0.8453</td>
</tr>
<tr>
<td></td>
<td>(1.9154)</td>
</tr>
<tr>
<td>(2)</td>
<td>0.8444</td>
</tr>
<tr>
<td></td>
<td>(1.9167)</td>
</tr>
<tr>
<td>(3)</td>
<td>0.8038*</td>
</tr>
<tr>
<td></td>
<td>(4.222)</td>
</tr>
<tr>
<td>(4)</td>
<td>0.80351*</td>
</tr>
<tr>
<td></td>
<td>(4.2269)</td>
</tr>
</tbody>
</table>

*S.E.* = standard error of the regression.
$R^2$ = adjusted $R$-squared.
$T$-statistics are shown in parentheses.
* = significant at the 1 per cent level.
* = significant at the 5 per cent level.
contingent contract. The loan rate determination rule was determined under an indexed contract and it was shown to be consistent with panel data from companies in the Japanese chemical industry. That is, there has been risk sharing between a main bank and borrowing companies which have a strong tie in Japan or, at least, in the Japanese chemical industry.

In contrast to Horiuchi, et al. (1988), our results support the study of Nakatani (1983) showing that corporate groups have contributed to the stabilization of corporate performance through main banks. However, like Horiuchi, et al. (1988), our study does not support the study of Osano and Tsutsui (1985) indicating that the fluctuation in Japanese loan rate is narrowed by risk-sharing between banks and borrowing companies.

First draft received February 14, 1992; final draft accepted October 13, 1992.

REFERENCES