No. 994

Regional Disparities of the Japanese Banking Performance

by

Tatsuyoshi Miyakoshi and Yoshihiko Tsukuda

June 2002

Regional Disparities of the Japanese Banking Performance *

Tatsuyoshi Miyakoshi
University of Tsukuba, Institute of Policy and Planning Sciences,
Tsukuba, Ibaraki, 305-8573, JAPAN.
and
Yoshihiko Tsukuda
Tohoku University, Graduate School of Economics,
Kawauchi, Aoba-ku, Sendai, 980-8576, JAPAN.

June 23, 2002

JEL Classification Numbers: C23, D24, G21.

Keywords: Japanese banking performance, regional disparity, cause of disparity

---

* We would thank Hajime Hori, Osamu Kamoike, Yoshiro Tsutsui, Yasuo Maeda, Masatoshi Yamada, Katsmi Matsuura for their helpful comments at several seminars. The research by the first author was supported by a grant-in-aid from the Zengin Foundation for Studies on Economics and Finance in 1999 and a grant-in-aid 13630104 from the Ministry of Education, Science and Culture of Japan.
Correspondence should be to Tatsuyoshi Miyakoshi: Institute of Policy and Planning Sciences University of Tsukuba,Tsukuba, Ibaraki 305-8573, JAPAN
E-mail:miyakosi@sk.tsukuba.ac.jp, Phone:81-298-53-5168, Fax:81-298-55-3849

Abstract

The paper analyzes the regional structure of the Japanese banking industry in the fiscal year 1998 in order to determine whether disparity among the regions in the technical inefficiency for production exists using a stochastic frontier model. We find that there actually exists the disparity. The paper then investigates what factors cause the disparity. We choose two factors for possible causes: the first one is knowledge disparity for manipulating the banking technology and the second one is competitiveness disparity for motivating avoiding waste. These factors significantly affect the levels of the mean parameter of the normal distribution that is truncated at zero.

I. Introduction

The purpose of the paper is to investigate the regional structure of the Japanese banking performance. Hara (1994) and Muramoto(1995) claimed that there exists the regional disparity in banking performance over Japan, the disparity causes an differential economic growth among regions and consequently distinctive economic prosperity. Their claim has an important policy implication for the financial authority. If the regional disparity exists, the financial policies uniformly over the regions are not appropriate. But, they provided no empirical evidence for their claim.

Amos and Wingender(1993), Samolyk(1994) and Jayaratne and Stran (1996) found some evidences that local banking condition helps to explain the regional income growth for the USA. However, there seem to be no empirical studies about the regional disparities for the Japanese banking performance. This lack of empirical studies is partially attributed to the fact that the regional banks in Japan were not obliged to disclose non-performing loans until the fiscal year 1997 even if they accumulated a large amount of bad loans.

We apply a stochastic frontier production model for the Japanese banking industry in order to measure the banking performance. Since the epoch making study by Aigner, Lovell and Schmidt (1977), the stochastic frontier approach has been greatly developed. The stochastic frontier model presumes the existence of technical inefficiencies of production for individual firms. Kumbhakar, Ghosh and McGuckin (1991) and Reifschneider and Stevenson (1991) proposed a stochastic frontier model in which the inefficiency effects are expressed as an explicit function of firm specific variables. Battese and Coelli (1995) extended their model to that with panel data. Recently Battese, Heshmati and Hjalmarsson (2000) applied Battese and Coelli (1995) type of specification for the Swedish banking industry.

Although the model of Battese and Coelli (1995) has been applied for many empirical works, it implicitly lays an important postulate that the inefficiency effect (the mean parameter μ_i in the equation (2)) is positively related to the expectation of the technical inefficiency for production. Tsukuda and Miyakoshi (2002) analytically confirm the postulate by Battese and Coelli. The finding of Tsukuda and Miyakoshi (2002) is important because it gives a theoretical justification for the use of model specification by Battese and Coelli (1995).

The paper analyzes the regional structure of the Japanese banking industry in the fiscal year 1998 in order to determine whether disparity among the regions in the technical inefficiency for production exists using a stochastic frontier model, and will find that there actually exists the disparity. The paper then investigates what factors cause the disparity. We choose two factors for possible causes: the first one is knowledge that manipulates the banking technology and the second one is competitiveness that motivates the banks to avoid waste. These factors significantly affect the levels of the mean parameter. However, these two variables are not completely satisfactory to explain the disparity of technical inefficiency among the regions. We need further research for determining the causes of regional disparity.

The paper is organized as follows. Section 2 states the model, technical inefficiency for production and a method for statistical inference on the inefficiency. Section 3 explains a categorization of the regions over Japan and the data source. Section 4 presents and discusses the empirical results. Section 5 gives some concluding remarks.

2. The Model and Technical Inefficiency

2.1 The model

In order to investigate the regional structure of the Japanese banking performance, we apply a stochastic frontier production function:

$$Y_{ij} = X_{ij}\beta + \varepsilon_{ij}, \quad \varepsilon_{ij} = V_{ij} - U_{ij} \quad , \tag{1}$$

where Y_{ij} denotes the output in logarithms for the *j-th* bank in the *i-th* region; X_{ij} is a 1×K vector of input variables in logarithms; β is a K×1 vector of coefficients associated with the input variables; N is the number of regions and R_i is the number of banks within the *i-th* region. The V_{ij} s are $iid N(0,\sigma_V^2)$ random errors, and independent from the U_{ij}s. The U_{ij}s are *iid* $|N(\mu_i,\sigma_U^2)|$ random variables associated with technical inefficiency for production, where $|N(\mu_i,\sigma_U^2)|$ denotes the normal distribution with mean μ_i and variance σ_U^2 that is truncated at zero, and

$$\mu_i = Z_i\delta, \qquad i = 1,..,N\ ;\ j = 1,..,R_i\ . \tag{2}$$

The Z_{ij} is a 1×M vector of variables which influence the inefficiency for the banks in the *i-th* region, and δ is an M×1 vector of coefficients.

The model specified in (1) and (2) was developed by Battese and Coelli (1995) for analyzing the panel data. It should be noted that the model of this paper involves no panel data structure because the data within the region are taken from different banks within that region. The model simply represents the production function for the the *j-th* bank in the *i-th* region. We assume that all banks over the different regions have access to the same production technology. In other wards, the β parameters in the equation (1) are the same for all banks. However, the inefficiency effects are permitted to come from truncated normal distributions that might have different means.

The μ_i is a key parameter of our model in the sense that it determines the distribution of inefficiency for the banks in the *i-th* region. The μ_i is constant within the region but possibly varies along with the regions. In the empirical study of Section 4, we apply two kinds of formulation for μ_i, in which Z_i takes either the set of dummy variables for the regions or the set of economic variables.

2.2 Technical Inefficiency

Battese and Coelli (1988, p.389) define the rate of technical efficiency of production for the *i-th* region at the *j-th* individual bank as a ratio of its mean production to the corresponding mean with $U_{ij} = 0$:

$$TE_{ij} \equiv \frac{E(Y_{ij}^* \mid U_{ij}, X_{ij})}{E(Y_{ij}^* \mid U_{ij} = 0, X_{ij})} , \tag{3}$$

where Y_{ij}^* (= $\exp(X_{ij}\ \beta + V_{ij} - U_{ij})$) denotes the value of production in original units. Alternatively, the rate of technical inefficiency is defined by $TIE_{ij} = 1 - TE_{ij}$. The rate of technical inefficiency defined by the equation (3) becomes

$$TIE_{ij} = 1 - \exp(-U_{ij}), \tag{4}$$

which is a random variable taking the values between zero and one. We simply call TIE_{ij} the technical inefficiency for production as well as U_{ij} . There should be no confusion.

We apply this concept of technical inefficiency for production in order to compare the banking performance among the different regions over Japan. Before carrying out empirical study in Section 4, we clarify the characteristics of the technical inefficiency and describe a method of statistical inference about it.

(i) **The distribution of technical inefficiency**

We are able to estimate ε_{ij} (= $V_{ij} - U_{ij}$) as residuals $\hat{\varepsilon}_{ij} = Y_{ij} - X_{ij}\hat{\beta}$ if we can get an estimate $\hat{\beta}$. However, the U_{ij} can not be identified even if the value of ε_{ij} is determined. The sole source for inference on technical inefficiency comes from the distribution of U_{ij} conditional on ε_{ij}. Tsukuda and Miyakoshi (2002) derived the distribution of TIE_{ij} conditional on ε_{ij} as

$$F_{TI}(w \mid \varepsilon_{ij}; \mu_{ij}^*, \sigma^*) = Pr\{\ TIE_{ij} \leq w \mid \varepsilon_{ij}\}$$

$$= 1 - \frac{\Phi((\mu_{ij}^{*} + \log(1-w))/\sigma^{*})}{\Phi(\mu_{ij}^{*}/\sigma^{*})} \quad \text{for w } (0 < w < 1), \tag{5}$$

where $\mu_{ij}^{*} \equiv (\sigma_V^2 \mu_i - \sigma_U^2 \varepsilon_{ij})/(\sigma_V^2 + \sigma_U^2)$, $\sigma^{*} \equiv \sqrt{\sigma_U^2 \sigma_V^2 /(\sigma_V^2 + \sigma_U^2)}$, $\Phi(\cdot)$ denotes the standard normal distribution and density functions.

(ii) Prediction for technical inefficiency

A natural predictor for technical inefficiency of production for the *i-th* region at the *j-th* bank conditional on the value of ε_{ij} is given by its conditional expectation:

$$E(TIE_{ij} \mid \varepsilon_{ij}) \equiv ETIE(\mu_i \mid \varepsilon_{ij})$$

$$= 1 - \{\exp(-\mu_{ij}^{*} + \sigma^{*2}/2)\}\{\Phi((\mu_{ij}^{*}/\sigma^{*}) - \sigma^{*})/\Phi(\mu_{ij}^{*}/\sigma^{*})\}. \tag{6}$$

Equation (6) was derived by Battese and Coelli (1993, p.20). We note that μ_{ij}^{*} and σ^{*2} are given by (5) and the former is a function of μ_i. The values of (6) depend on the observations of Y_{ij} and X_{ij} through ε_{it}.

The following inequality, derived by Tsukda and Miyakoshi (2002), clarifies the relation of the predictor for technical inefficiency defined by (6) to μ_i :

$$\partial ETIE(\mu_i \mid \varepsilon_{ij})/\partial \mu_i > 0 \text{ for all } \mu_i. \tag{7}$$

The predictor of technical inefficiency is an increasing function of μ_i. Equation (7) clarifies the role of μ_i as an inefficiency measure in specification and provides a theoretical basis for using the model of the Battese and Coelli (1995). Although Battese and Coelli (1993) derived the equation (6), they did not develop the relationship between μ_i and the predictor for technical inefficiency.

(iii) **Confidence Interval of Prediction for Technical Inefficiency**

We apply a method of constructing a confidence interval of prediction for technical inefficiency proposed by Tsukuda and Miyakoshi (2002). We define the quantile point w for a given level α $(0<\alpha<1)$ as $\alpha=\Pr\{\ TIE_{ij}\leq w\mid\varepsilon_{ij}\}$ Then, we obtain from (5)

$$w\equiv c(\mu_i\mid\varepsilon_{ij};\alpha)=1-\exp\{-\mu_{ij}*+\sigma*\Phi^{-1}((1-\alpha)\Phi(\mu_{ij}*/\sigma*))\}\ . \qquad (8)$$

The following relationship:

$$\partial c(\mu_i\mid\varepsilon_{ij};\alpha)/\partial\mu_i>0 \qquad \textit{for any } 0<\alpha<1 \text{ for all } \mu_i, \qquad (9)$$

clarifies the relationship between μ_i and the quantile point (see Tsukuda and Miyakoshi (2002)). Inequality (9) implies that the conditional quantile is increasing in μ_i for any fixed value of α. The distribution function shifts to the right along with μ_i. A confidence interval, $[c_L,\ c_U]$, with a confidence level of $1-2\alpha$, is obtained from $\alpha=\Pr\{\ TIE_{ij}\leq c_L\mid\varepsilon_{ij}\}$ and $\alpha=\Pr\{\ TIE_{ij}\geq c_U\mid\varepsilon_{ij}\}$. Then, we obtain from (8)

$$c_L=c(\mu_i\mid\varepsilon_{ij};\alpha),\quad c_U=c(\mu_i\mid\varepsilon_{ij};1-\alpha)\ . \qquad (10)$$

The values c_L and c_U depend on the observations through ε_{ij} and can be estimated by replacing the unknown parameters with their estimates.

3. Regional Categorization and the Data

3.1 Regional Categorization and Selection of Bank Categories

In this section we define the regions over Japan and determine what categories of banks we use for the empirical analysis in Section 4. We divide the geographical area of Japan into the five regions: Region 1 (Hokkaido, Tohoku), Region 2 (Kantou), Region 3 (Hokuriku, Tokai), Region 4 (Kinki, Chugoku) and Region 5 (Shikoku, Fukuoka, Kyushu, Okinawa). Figure 1 indicates the location of each region. The division is carried out on the basis of the administrative districts supervised by eleven Local Finance Bureaus in the Ministry of Japan, as denoted in parentheses. Some local bureaus are merged into one region for the sake of parsimony of the parameters to be estimated. The our categorization of the regions may be appropriate to specify the regional characteristics for the banks, since the supervisions by the Local Finance Bureaus might produce regional characteristics or the Bureaus are located at the areas with particular regional characteristics.

We restrict the analysis in Section 4 to the Regional banks I and II but exclude other regional banking firms, since the former banks construct major lenders for enterprises in the regions and constitute the core of the local economy.[1] The Regional banks I and II are literally the banks that are operating mainly in the local areas. On the other hand, all other categories of banks (i.e., Shinkin banks, Shoko Chukin banks and Credit Cooperatives) are virtually cooperative associations and non-profit businesses though they are classified as the regional banks.

Each of the five regions has a number of banks: Region 1 has 19 banks, 27 in Region 2, 21 in Region 3, 26 in Region 4 and 31 in Region 5, and totals up to 124 banks in the fiscal year 1999. [2]

3.2 Data Source

We apply a Cobb-Douglas model in which the individual bank produces a single output by using labor and capital stock as inputs. The data for output and input variables are complied from "*Analysis of Financial Statements of All Banks 2000, 2001*" published by *The Japanese Bankers Association*. The model in Section 2

[1] The lending volumes of the Regional banks I and II dominates those of other regional banks. See "*Financial and Economic Statistics Monthly March 2001*", p.286 - 287, Research and Statistics Department, *BANK OF JAPAN*.

[2] One bank is born by the merge and several banks went bankruptcy in fiscal year 1999 but their financial statements exist. Some adjustments are implemented for the values of these banks. Due to the Financial Function Early Strengthening Law, the Financial Reconstruction Commission applied the capital injection scheme to several banks at the aim for disposing bad debts. However, these ratios to loan of those banks are small, we do not pay attention on the amount of the capital injection.

allows the existence of variables that affect the mean (μ_i) for the i-th region. We choose "knowledge" for manipulating technology and "competitiveness" in a ad hock way. Knowledge and/or strong competition will decrease technical inefficiency. The data for inefficiency variables are complied from "*Social Life Statistic Index (in Japanese, Shyakai - Seikatsu - Tokei - Shihyou) 2001*" published by *The Statistics Bureau & Statistics Center of Japan.*

The variables for using the empirical analysis are constructed as follows:

(i) The output variable

ASSET = LOAN + BADLOAN+SECURITIES+VALUATION,

LOAN (Reference Code for Financial Statement (RCFS), dh: Loans and bills discounted in billions of yen),

BADLOAN(RCFS, codeless: billions of yen),

SECURITIES (RCFS, dg: Investment securities in billions of yen),

VALUATION (RCFS,codeless: valuation profit or loss in billions of yen).

(ii) The input varibles

(a) LABOR (Officers and personals in numbers of people),

(b) DEPOSIT (RCFS, aa: Deposits in billions of yen),

(c) STOCK (RCFS, dk: Premises and real estate in billions of yen),

(iii) The inefficiency variables

(a) EDUCATION= the ratio of people having completed up to colleges and universities

(b) WEAKCOMPET

= the number of the private establishments with 100 persons and over divided by the number of banks in the region

Most of the banks accumulated the bad loans or valuation losses in the total loan and securities under the process of the Japanese banking crisis in the 1990s. These assets are written-off or valueless claims. We have to appropriately treat non-performing loans. The Bank Acts of Japan was enforced in the fiscal year 1998, and all banks had to report the amounts of bad-loans and their valuation according to Article 21 in the Bank Acts.[3] We delete the amounts of bad loans and valuation losses.

EDUCATION is a proxy variable for "knowledge", and WEAKCOMPET is a proxy for "competitiveness". The private establishments are regarded as borrowers in the regional economy. The increasing number of borrowers per bank in the region means the competition among banks to be weak.

Since the production function is usually expressed in terms of flow variables, the outputs and inputs for the fiscal year 1999 are the averaged values over the fiscal years 1998 and 1999.

4. Empirical Results

4.1 Regional Disparities of Banking Performance

In this section we first overview the summary statistics for the data. Thereafter, we examine whether the regional disparity in the banking performance exists, using the stochastic frontier model.

Table 1 presents the sample mean and standard deviations of the output and input variables for each region in terms of the original units. Region 2, which includes the metropolitan area of Japan, exhibits different values of summary statistics from other regions. Roughly, all regions produce 1.8 trillions yen of asset by 1.9 trillions yen of deposit, 1900 peoples of labor, and 34 billions yen of stock. The average ratio of the BADLOAN to the LOAN are 5%, 8%, 5%,7% and 5% for Regions 1 through 5, respectively. However, the average ratio of the VALUATION to the SECURITIES are 4%, 4%, 8%, 9% and 7% respectively. All regions exhibit valuation profit. The output and input variables for the banking production are loosely correlated each other. The correlation matrix of output and input in logarithms is shown in Table 2. For example, the correlation between LABOR and DEPOSIT is 0.9867.

[3] Though the Japanese banks report bad loans in four different categories, the categorization itself is subjectively judged by the individual banks. Then, we do not deal with the difference in categories of the bad loans in this paper.

Next, we apply the stochastic frontier model for analyzing the regional disparity of banking performance. We normalize the output of banks by the number of labors. Namely, we use the average productivity of labor as dependent variable. The average productivity of labor shows the regional disparity of inefficiency better than the output itself. The Japanese banks have behaved similarly for a long time under the strong protection and guidance by the Japanese government. However, employment may be exception. If the banks cannot choose appropriate numbers of employee, the life-time employment system make them difficult to adjust the number of employees. Battese, Heshmati and Hjalmarsson (2000) have focused on the inefficiency of labor.

We formulate the model in which μ_i simply stands for the mean of the original normal random variables for the i-th region. We use a computer program, FRONTIER 4.1, written by Coelli (1996) for obtaining the maximum likelihood estimates of the parameters. The estimates and their standard errors (in parentheses) are the following:

Stochastic Frontier:

$$\begin{aligned} \mathrm{Log}(\mathrm{ASSET}/\mathrm{LABOR})_{ij} &= \underset{(0.14)}{-0.50} - \underset{(0.051)}{1082}\mathrm{Log}(\mathrm{LABOR}_{ij}) + \underset{(0.034)}{1.059}\mathrm{Log}(\mathrm{DEPOSIT}_{ij}) \\ &\quad + \underset{(0.017)}{0.023}\mathrm{Log}(\mathrm{STOCK}_{ij}) \end{aligned} \tag{11}$$

Inefficiency Mean:

$$\mu_i = \underset{(0.017)}{0.044} \underset{(0.017)}{-0.022}Z_{i2} \underset{(0.027)}{- 0.033}Z_{i3} \underset{(0.016)}{- 0.026}Z_{i4} \underset{(0.016)}{- 0.071}Z_{i5} \tag{12}$$

Variance Parameters: $\hat{\sigma}^2 = \underset{(0.00035)}{0.0025}, \quad \hat{\gamma} = \underset{(0.00037)}{0.0044}$ (13)

Log(likelihood) = 200.91,

where Z_{im} denotes a dummy variable for the i-th region (i.e., $Z_{im} = 1$ if i = m, or Z_{im} = 0 otherwise), σ and γ are defined as $\sigma^2 = \sigma_V^2 + \sigma_U^2$ and $\gamma = \sigma_U^2 / (\sigma_V^2 + \sigma_U^2)$.

The signs of the coefficients of the stochastic frontier are as anticipated.

The coefficient of labor is negative significant, -1.082 (but the null hypothesis of - 1.00 cannot be rejected), which indicates the average production decreases by the same degree as the labor. The estimated coefficient for the deposit variables (1.059) is very large and highly significant, while that of stock is very small and insignificant.

The coefficients for the dummy variables in the equation (12) are of particular interest. We test the hypothesis that there is no inefficiency disparity among the regions. This hypothesis is expressed as all coefficients for regional dummies are simultaneously zero. The likelihood ratio test rejects the null hypothesis H_0 as reported in Table 3. Thus, we may conclude that there is disparity among the regions in terms of the technical inefficiency in the stochastic frontier production for the banks. The second column in Table 4 shows the values of μ_i. The region 1 is highest and the region 5 is lowest.

We look at the predicted values of technical efficiency for production. We can calculate $\sigma* = \{\gamma(1-\gamma)\sigma^2\}^{1/2} = 0.0033$. We evaluate the predicted value of (6) and the confidence interval of (10) for each region at the average of $\mu_{ij}*$ over banks,

$$\bar{\mu}_i * = \frac{1}{R_i}\sum_{j=1}^{Ti}\mu_{ij}^* = (1-\gamma)\mu_i - \gamma\bar{\varepsilon}_i \quad , \quad \bar{\varepsilon}_i = \frac{1}{R_i}\sum_{j=1}^{Ri}\varepsilon_{ij} . \tag{14}$$

The fourth column in Table 4 indicates the values of $\bar{\mu}_i*$. The $\bar{\mu}_i*$ are almost the same as those of μ_i, because γ is very small. The 5 - 7th columns show the predicted values and the lower and upper confidence limits. The predicted inefficiency for production in the region 1 is 0.043. The inefficiency in the region 1 lies on the interval [0.038, 0.048] with 90% confidence level. The other four regions have smaller inefficiency than the region 1. Figure 2 illustrates the relationship of the predicted inefficiency for production to the value of $\mu_{ij}*$. The 90% confidence band is quite narrow for all values of $\mu_{ij}*$ between -
distribution is highly concentrated around $\mu_{ij}*$. The main reason for the concentration of the distribution is attributed to the fact that $\sigma*$ is very small. Tsukuda nad Miyakoshi (2002) numerically illustrated the conditional distribution,

its expectation and the lower and upper confidence limits for several sets of parameters in the model.

We can also calculate the average of the predicted values over the banks in the i-th region:

$$AETIE(i) = \frac{1}{R_i}\sum_{j=1}^{R_i} ETIE(\mu_i \mid \varepsilon_{ij}) . \tag{15}$$

The third column in Table 4 shows the values of *AETIE(i)*, which exhibit almost the same values as the column 6 except for the region 1.

In conclusion, the technical inefficiencies for production about the Japanese banks are less than 5% in the fiscal year 1998. Even though the level of inefficiency is not so high, there still exists the regional disparity among the regions over Japan. The region 1 is least efficient among the five regions.

4.2 Causes of Regional Disparity

In Section 4.1 we find that the banks in the region 1 utilize production technology more efficiently than the banks in the other regions. In this subsection, we examine what factors cause the inefficiency disparity across the regions.

The experience, knowledge and other factors may represent the non-physical inputs that influence the bank to use efficiently its available production technology. The efforts to find the factors that cause inefficiency for production appeared in the studies by Kumbhakar, Ghosh and McGuckin (1991), Reifschneider and Steveson (1991), Battese and Coelli (1995), and Huang and Liu (1994). We choose two factors that might cause inefficiency in a ad hock manner. The first factor is knowledge for manipulating technology and the second is competitiveness that motivates the banks to avoid waste. We defined EDUCATION and WEAKCOMPETI as the proxy variables for knowledge and competitiveness in Section 3.

The estimation results are given in the same format as in Section4.1:

Stochastic Frontier:

$\text{Log(ASSET/LABOR)}_{ij}$

$$= -0.44 - 1072Log(LABOR_{ij}) + 1.047Log(DEPOSIT_{ij}) \quad (16)$$
$$(0.93) \quad (0.29) \quad (0.21)$$
$$+0.024Log(STOCK_{ij})$$
$$(0.0079)$$

Inefficiency Mean:

$$\mu_i = 0.0089 - 0.015(EDUCATION)_i + 0.00018(WEAKCOMPETI)_i \quad (17)$$
$$(0.029) \quad (0.0061) \quad (0.000070)$$

Variance Parameters: $\hat{\sigma}^2 = 0.0021$, $\hat{\gamma} = 0.037$ (18)

(0.00035) (0.0033)

Log(likelihood) = 208.38

The coefficients in the equation (16) are close to those in (11) as expected. We focus on the results for the mean μ_i. The coefficients for EDUCATION and WEAKCOMPETI are significant. The increase in EDUCATION implies that the decrease in the inefficiency. Weaker competition increases the inefficiency. The second raw in Table 3 naturally shows the hypothesis that neither EDUCATION nor WEAKCOMPETI affects μ_i is rejected.

Table 5 indicates that the average expected inefficiency (*ATEIE(i)*) are all close to zero and virtually there is no difference among the regions.
This fact is reasoned as follows. Since σ * (0.0087) is small, the graph of the predictor for technical inefficiency is close to that of Figure 1 though we do not produce here. On the other hand, the estimates of μ_i and μ_i* for the *i-th* region are reported in the second and third columns in Table 5. All of these values are negative and almost equal. Hence, we can see the predicted values are virtually zero for negative μ_i*.

In summary, EDUCATION and WEAKCOMPETI significantly affect the value of μ_i* to be negative. However, the difference of μ_i (or μ_i*) does not cause the disparity of technical inefficiency among the regions. Although we chose EDUCATION and WEAKCOMPETI as possible candidates for causing the disparity of inefficiency, the results reveal that EDUCATION and WEAKCOMPETI do not satisfactorily explain the disparity found in Section 4.1. We need further research for determining what factors cause the disparity of inefficiency among the regions.

5. Concluding Remarks

The paper analyzed the regional structure of the Japanese banking industry in the fiscal year 1998 in order to determine whether disparity among the regions in the technical inefficiency for production exists using a stochastic frontier model, and found that there actually exists the disparity.

The paper then investigated what factors cause the disparity. We chose two factors for possible causes: the first one is knowledge disparity for manipulating the banking technology and the second one is competitiveness disparity for motivating avoiding waste. These factors significantly affect the levels of the mean parameter of the normal distribution that is truncated at zero. However, these two variables do not satisfactorily explain the disparity of technical inefficiency for production among the regions. We need further research for determining the causes of regional disparity.

References

Amos,O.M.and Wingender,J.P.(1993),"A model of the interaction between regional financial markets and regional growth",Regional Science and Urban Economics 23:85-110.

Aigner, D., K. Lovell, and P. Schmidt, 1977, Formulation and Estimation of Stochastic Frontier Production Function Model, Journal of Econometrics 6, 21 - 37.

Battese, G. and T. Coelli, 1988, Prediction of Firm-Level Technical Efficiencies with a Generalized Frontier Production Function and Panel Data, Journal of Econometrics, 38, 387 - 399.

Battese, G. and T. Coelli, 1993, A Stochastic Frontier Production Function Incorporating a Model for Technical Inefficiency Effects, Working Papers, No. 69, in Econometrics and Applied Statistics, Department of Economics, University of New England.

Battese, G. and T. Coelli, T. 1995, A Model for Technical Inefficiency Effects in a Stochastic Frontier Production Function for Panel Data, Empirical Economics 20, 325 - 332.

Battese, G., Heshmati, A., and Hjalmarsson, L., 2000, Efficiency of labor use in Swedish banking industry: a stochastic frontier approach, Empirical Economics 25, 623 - 640.

Coelli,T.(1996),"A Guide to FRONTIER Version 4.1: A Computer Program for Stochastic Frontier Production and Cost Function Estimation", CEPA Working Papers, 96/07, Department of Economics, University of New England.

Hara,S. (1990), Regional Finance and Institutional Reform,(in Japanese), Toyokeizai, Tokyo.

Huang,C.J. and Liu J-T.(1994),"Estimation of a Non-Neutral Stochastic Frontier Production Function", The Journal of Productivity Analysis 5:171-180.

Kumbhakar,S.C., Ghosh,S. and McGuckin, J.T.(1991),"A Generalized Production

Frontier Approach for Estimating Determinants of Inefficiency in U.S. Dairy Farms", Journal of Business and Economic Statistics 9:279–

Muramoto,T.(1994),Institutional Reform and Retail Finance Yuhikaku, (in Japanese), Tokyo.

Reifschneider,D.and Stevenson,R.(1991),"Systematic Departures from the Frontier: A Framework for the Analysis of Firm Inefficiency",International Economic Review 32:715-723.

Samolyk,K.(1994),"Banking conditions and regional economic performance: Evidence of a regional credit channel", Journal of Monetary Economics 34:259-278.

Tsukuda,Y. and Miyakoshi,T.(2002),"A Re-consideration on Theoretical Inefficiency in Stochastic Frontier Production Models", Discussion Paper Series No. 993, Institute of Policy and Planning Science, University of Tsukuba.

Table 1. Mean and standard deviation for variables in each region

Re-gion	ASSET		LABOR		DEPOSIT		STOCK	
	Mean	Std.	Mean	Std.	Mean	Std.	Mean	Std.
1	1551	1232	1644	805	1663	1271	24	17
2	2328	2192	2203	1347	2409	2154	39	36
3	1889	1599	1927	1163	1961	1637	35	31
4	1787	1376	1868	1010	1870	1410	32	26
5	1560	1264	1692	927	1569	1205	38	32
Ave	1829	1586	1873	1075	1896	1583	34	30

Notes: *ASSET, DEPOSIT* and *STOCK* are measured in a billion yen; Labor is in number of people. Aver. and Std. denote an average over the regions and standard deviation respectively.

Table 2. Correlation among input-output data in logarithms

	ASSET/LABOR	LABOR	DEPOSIT	STOCK
ASSET/LABOR	1.0000	0.8519	0.9205	0.8221
LABOR		1.0000	0.9867	0.9371
DEPOSIT			1.0000	0.9275
STOCK				1.0000

Table 3. Test of hypotheses for parameters of the inefficiency model

Null hypothesis	Log(Likelihood) under H_0	χ^2-statistic	DF	$\chi^2_{0.95}$-value
Disparity				
H_0: No disparity among regions	193.23	15.36	4	9.49
Causes				
H_0: No causes	193.23	30.30	2	5.99

Notes: X^2-statistic denotes the likelihood-ratio test statistic, $\lambda = -2\{\log[\text{Likelihood}(H_0)] - \log[\text{Likelihood}(H_1)]\}$. DF indicates the degree of freedom.

Table 4. Estimated-inefficiency mean μ_i and expected conditional inefficiency

Region	μ_i	AETIE(i)	μ_i*	C_L	ETIE(μ_i* | $\bar{\varepsilon}_i$)	C_U
1	0.0439	0.093	0.0437	0.038	0.043	0.048
2	0.0223	0.022	0.0222	0.017	0.022	0.027
3	0.0110	0.011	0.0110	0.006	0.011	0.016
4	0.0179	0.018	0.0179	0.012	0.018	0.023
5	-0.0273	0.000	-0.0271	- [a)]	- [a)]	- [a)]

Note: The entries are calculated by EXCEL.

a) EXCEL does not calculate the quantile point in equation (8) for this value of μ_i*.

Table 5. Estimates of μ_i, μ_i* and averaged predictor for inefficiency

Region	μ_i	μ_i*	*AETIE(i)*
1	-0.0382	-0.0375	0.002
2	-0.0303	-0.0293	0.002
3	-0.0613	-0.0592	0.001
4	-0.0718	-0.0692	0.001
5	-0.0731	-0.0704	0.001

Figure1 . Regions based on the prefectures in JAPAN

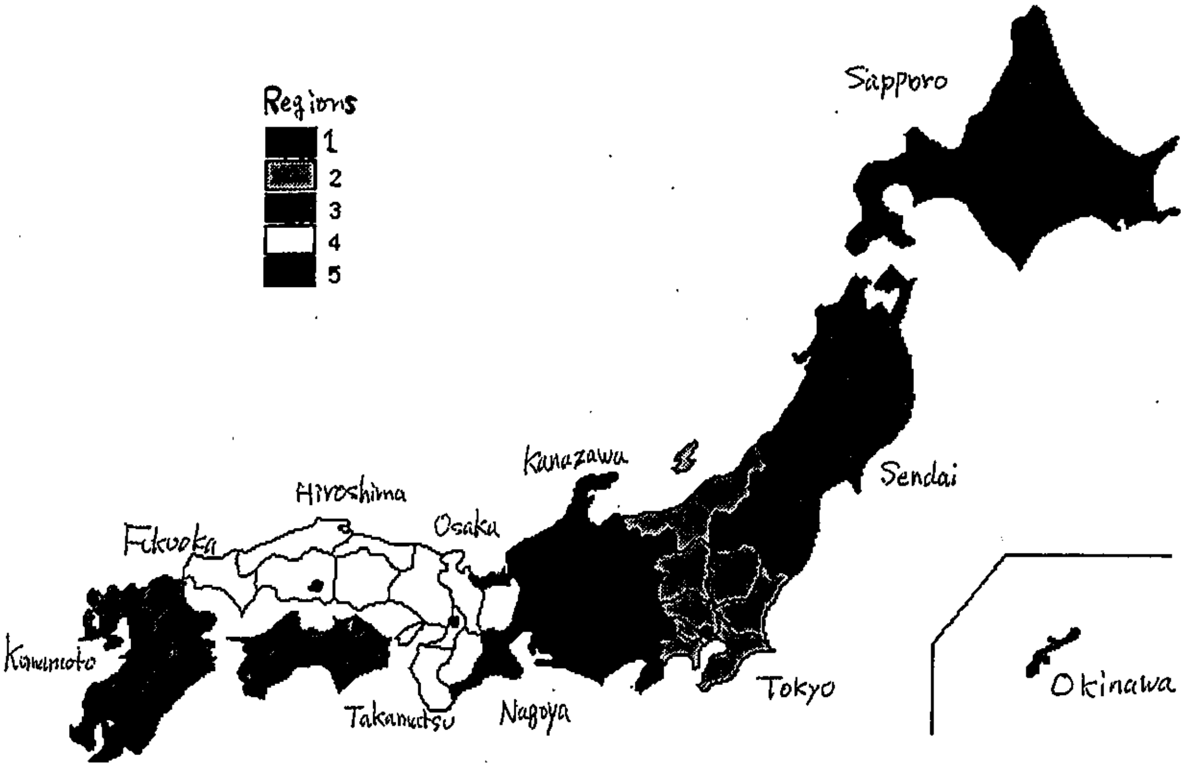
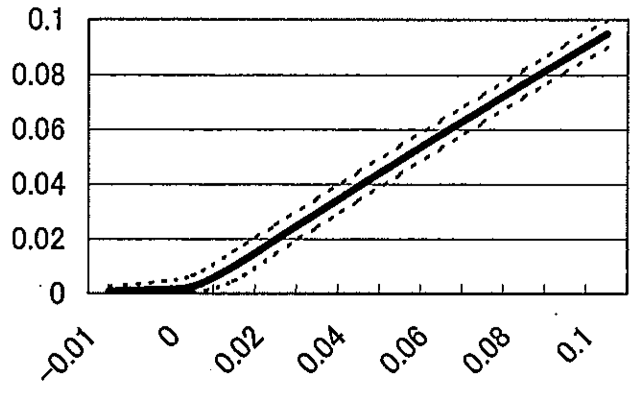


Figure 2. Prediction of technical inefficiency and confidence limits against $\mu*$ at $\sigma*$=0.0033



Note: prediction ····· upper and lower limits