



Size and Scale Economies in Japanese Cooperative Banking

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ABSTRACT

The Japanese banking industry, including the cooperative sector has been restructured following the crisis of the 1990s. Here we examine the relationship between size and scale economies of cooperative banks in Japan (namely Shinkin and credit cooperatives). We use the translog cost-function methodology and intermediation approach coupled with a large set of both cross-sectional and panel data over the period 2003 to 2006. We find significant diseconomies of scale for both the full sample and sub-samples of small and large cooperative banks. It is of interest to note that larger cooperative banks were at cost disadvantage as compared to small ones throughout most of the period. Thus, bigger is not always better. Shinkin and credit cooperative banks need to make further efforts to assess the business environment and strengthen profitability by, for example, expanding the range of financial services they offer in their regional areas and making further progress in risk management.

Keywords: banking, cooperative banks, scale economies, size, shinkin and credit cooperatives, translog-cost function.

JEL classifications: D21, D24, G21, L23, N25

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1. INTRODUCTION

In recent years, the global banking industry has been through a period of restructuring. The mergers and acquisitions boom in the sector has been based on the idea that “bigger is better”. More recent history has shown that even the largest banks have been unable to keep afloat without government help as the credit crisis has deepened. This of course reflects the way banks have managed, or failed to manage risk, but it also calls into question the notion that large banks are more efficient than small ones because they can exploit economies of scale and thereby reduce their costs.

The Japanese banking sector experienced crisis in the 1990s and has emerged apparently better able to deal with major shocks. Japan has an enormous number of banks including a thriving cooperative banking sector which consists of relatively small banks (224 banks and 1493 cooperative type financial institutions that is, Shinkin, credit cooperatives, labour banks, agricultural and fisheries cooperatives, Japanese Bankers Association as at 1 Apr 2008).

This is a good time to study the Japanese cooperative banking sector in order to learn from the experience of a country that has already been through a banking crisis and a sub-sector that has been relatively neglected in previous research. We study economies of scale using the translog model and find that there are significant diseconomies of scale in most size bands within the Japanese cooperative banking sector. This implies that bigger is not always better, at least in cost terms. While the wave of banking mergers in Japan cannot be explained as a means of exploiting economies of scale, perhaps it was instead a response to technological change.

The paper proceeds as follows. Section 2 reviews the literature on economies of scale in banking, highlighting the evidence on Japan. Section 3 gives an overview of the Japanese banking system. Section 4 discusses the methodology, data and definition of variables. Section 5 presents the empirical findings and section 6 concludes the paper.

2. SIZE & SCALE ECONOMIES: A BRIEF REVIEW OF THE LITERATURE

There is a broad literature and debate on the degree to which scale economies exist in banking, but most studies concentrate on the USA and Europe. Studies of US banking usually observe slightly increasing return to scale (i.e. economies of scale) among small banks and slightly decreasing returns (i.e. diseconomies of scale) at large banks. Despite divergences among researchers as to what comprise a bank's outputs and inputs, most studies have concluded that there are no important economies of scale in US banking (see Benston, Berger, Hanweck and Humphrey (BBHH), 1982; Gilbert, 1984; Hunter and Timme, 1986; Hughes, and Mester, 1998). In contrast to the American literature, studies of European banking show robust evidence of scale economies (Hardwick, 1989/90; Altunbas and Molyneux, 1996; Richard Simper, 1999).

The evidence for Japanese commercial banking suggests that size is relevant in that smaller banks are the ones that experience increasing returns in most time periods. The period under consideration is observed to be a critical factor in determining the results. For example, increasing returns to scale for banks of all sizes, including the largest ones were observed for the period 1980-1 and early 1990s, but not in between.

Fukuyama (1993) reports that approximately 81% of Japanese banks experienced increasing returns to scale during the 1980s. This result was most pronounced in the small and medium size categories with just one-third to a half of the largest banks experiencing increasing returns.

Tadesse (2005) studies the cost structure of Japanese banks over the period 1974 to 1991 and observes slight diseconomies of scale for large banks and significant scale economies for small banks. Using a cross-section of banks in 1997, Drake and Hall (2003) find economies of scale were obtained only for smaller banks but not for the larger ones. Studies which account for risk (Altunbas et. al., 2000 and Hughes et. al., 2001) indicate that larger banks take on more risk and that explains the diseconomies they experience.

McKillop et al (1996) get slightly different results, obtaining economies of scale for all banks at sample mean for all years except for the late 1980s and onwards where constant returns prevail for all model specifications tested. They observe that Japan's largest banks demonstrate significant scale economies and attribute it to wide cross-shareholdings between banks and other financial firms in Japan, which in turn provide banks with lower monitoring costs for their lending portfolios on the back of their direct participation in the ownership of many Japanese commercial businesses.

In contrast to the studies mentioned so far that use the translog model, Batchelor et al (2000) using the Fourier flexible form and a more recent data set (1992-8) find that the average cost curve in Japanese banking is flat. This indicates that there are neither economies nor diseconomies of scale.

Given that cooperatives are small, we would expect studies of this sector to provide similar results to those already reported for small commercial banks. Fukuyama (1996) examines the nature and extent of both technical and scale efficiency in Japanese credit associations by employing a nonparametric frontier approach for the year 1992. Using input-based measures, he observes that the majority of credit associations (53.1%) were subject to decreasing returns to scale (DRS) while 43.9% of them operated with increasing return to scale (IRS). This result is confirmed in later work by Fukuyama, Guerra, and Weber (1999) who analyse the overall efficiency and productivity growth of credit cooperatives in Japan during 1992-1996. They find that 73% of credit cooperatives were found to run in the range of DRS while 23% function in the reach of IRS, with the remaining 4% operating with constant returns to scale.

3. OVERVIEW OF THE JAPANESE BANKING SYSTEM

There are three types of financial institution in Japan: the Central Bank, private and public financial institutions. We are interested in a small subset of the private depository institutions namely cooperative banks.

It is important to recall that there has been lots of consolidation of the Japanese banking industry and the total number of Shinkin banks and credit cooperatives has fallen dramatically since 1980 as shown in table 1 below:-

Table 1

	1980	2008
City Banks	13	6
Regional Banks	63	64
Shinkin Banks	462	280
Credit Cooperatives	483	164

Notes: Number of financial institutions in each category as of April 1, 2008

Source: *Japanese Bankers Association*

Shinkin banks were formerly credit cooperatives before being converted to credit associations under the Credit Associations Law of 1951. Their members consist of local residents and small and medium-sized enterprises (SMEs). Total outstanding deposits at Shinkin banks as of March 31, 2008, stood at ¥113, 000 Billion (equivalent to \$1,135 billion), ranking third after the city and regional banks as shown in Table 2. Thus, they play an important role in Japanese financial markets. In addition to that, they enjoy a strong network as they have the biggest branch network spread throughout Japan. They are supervised by the Shinkin Central Bank.

Like commercial banks, Shinkin banks are covered by deposit insurance and exposed to capital adequacy requirements and other banking regulations and supervision. They differ from commercial banks in that they make loans mainly to member SMEs who capitalize the Shinkin banks. Shinkin banks can accept deposits from anyone whereas credit cooperatives can accept deposits only from members. Credit cooperatives are inspected by the prefectural governments while banks, credit associations, securities companies, and insurance companies are under the supervision of the Ministry of Finance. Shinkin banks are usually smaller than city and regional banks but larger than credit cooperatives as reflected by their deposit base as shown in Table 2 below:-

Table 2
Deposit Balance by Bank Segment
(As at March 31, 2008)

	Billions of US dollar
City Banks	2,496
Regional Banks	1,952
Shinkin Banks	1,135
Agricultural Cooperatives	819
Second-tier Regional Banks	554
Credit Cooperatives	163
Labor Credit Associations	151

Source: *Shinkin Central Bank Report, 2008*

Credit cooperatives (also known as Shinkumi banks) are the key non-profit cooperative financial institutions for regional finance in Japan. They are organized under the Law for Small Business Cooperatives of 1949, and are based on the mutual support of owners and workers of small and medium-sized firms. They accept deposits and instalment savings from members of the cooperative, government municipalities, public firms, and non-profit organizations. They also lend and discount bills to members and certain non-members, and join in payments associated with securities transactions.

At the end of March 2008, there were 164 credit cooperative banks throughout Japan, with a total of 1,826 outlets, 3,673, 981 members, total deposits of ¥16,330 billion (US\$148 billion: ¥110= US\$1), and outstanding loans of ¥9,382 billion (US\$85 billion). Japan's credit cooperatives are governed by the Shinkumi Federation Bank (SFB) acting as their central bank. There are three types of credit cooperatives: regional, industry-based and occupation-based as shown below:-

Type of Credit Cooperatives	Activities
Regional credit cooperatives	Serve small and medium-sized enterprises and residents within their regions. (Some members are Korean residents in Japan)
Industry-based credit cooperatives	Serve people engaged in the same profession, such as doctors
Occupation-based credit cooperatives	Serve people that work at the same establishment, such as at companies and government offices.

The Japanese banking sector went through a crisis in the late 1980 and 1990s. This followed the bursting of the asset price bubble affecting land and stock prices. During the bubble period, the banks had expanded lending and now found themselves holding bad debts. The Shinkin banks and credit cooperatives were not immune to this problem (see Table 3). The government responded to the crisis by recapitalising some banks, encouraging consolidation in the sector, and introducing a deposit insurance system. It also took over the supervision of the Shinkin banks which had formerly been monitored by local government.

Table 3Number of bankrupted depository institutions^a

	Banks^b	Shinkin Banks	Credit Cooperatives	Total
1990	0	0	0	0
1991	1	0	0	1
1992	0	1	0	1
1993	0	1	1	2
1994	1	0	4	5
1995	1	0	5	6
1996	2	3	3	8
1997	5	0	7	12
1998	3	1	31	35
1999	5	6	15	26
2000	1	5	27	33
2001 ^c	1	9	37	47
Total	20	26	130	176

^aThis table includes not only bank failures dealt with by the government, but also those privately disposed

^bIncludes city banks, regional I and II banks, trust banks and long-term credit banks

^cFigures for 2001 are as at November

Source: Hanazaki, M., and A. Horiuchi, (2003)

4. ESTIMATION METHODOLOGY

4.1 Research Design Issues

In working out the cost function of multi-product firms such as banks, we are faced with the constraint of identifying the appropriate specification. Although there have been many studies on the subject, there is no generally accepted definition of the inputs and outputs of multi-product financial firms.

The two most popular approaches are the production and intermediation techniques. The production approach describes banking activities as the production of services for depositors and borrowers. Deposits and loans are counted as output; capital and labour as input and interest paid on deposits is not included in bank total costs. The drawback of this approach is that it fails to pick up the economically more interesting role of a bank as a financial intermediary and exclude interest expense representing the largest share of total costs.

In that respect, this study in common with many others opts for the intermediation approach, originally devised by Sealey and Lindley (1977), whereby deposits

combined with labour and capital are assumed to be utilised as inputs to produce loans and other earning assets as outputs.

Most studies comparing the ‘translog’ and ‘Fourier flexible’ form find that the translog provides better prediction and is more stable, while the difference between the two forms in terms of results is negligible (Berger & Mester, 1997; Altunbas, 2001). Based on these, we plan to use the ‘Translog’ cost function.

One problem that arises with cost studies is the association of cost among time periods and output. In other words, this occurs when output produced in one period is recorded in another period. In that respect, in order to solve this issue, most cost studies are undertaken using annual data or cross-sectional data.

4.2 The Model

Applying the duality properties, ‘translog’ cost functions are obtained by a second-order Taylor series expansion of the cost function of the form:-

$$\text{LnOC} = f(\text{LnQ}_1, \text{LnQ}_2, \text{LnP}_1, \text{LnP}_2, \text{LnP}_3) \text{ ----- (a)}$$

Where OC : Operating Costs (including interest on deposit)

Qi : the *i*th output (total loans + other earning assets) ; *i* =1,2 and

Pj : the three *j*th input prices for labour, capital and deposits; *j*=1,2,3

Following Kolari & Zardkoohi (1987), the ‘translog’ cost function for the case of this research is a log-linear quadratic local approximation to the arbitrary multi-product cost function specified in equation (a) around a point of expansion :-

$$\begin{aligned} \text{LnOC} = & \alpha_0 + \alpha_1 \text{LnLOA} + \alpha_2 \text{LnEAR} + \frac{1}{2} \sigma_{11} (\text{LnLOA})^2 + \frac{1}{2} \sigma_{22} (\text{LnEAR})^2 \\ & + \sigma_{12} (\text{LnLOA})(\text{LnEAR}) \\ & + \beta_1 \text{LnP}_L + \beta_2 \text{LnP}_K + \beta_3 \text{LnP}_{\text{DEP}} \\ & + \frac{1}{2} \gamma_{11} (\text{LnP}_L)^2 + \frac{1}{2} \gamma_{22} (\text{LnP}_K)^2 + \frac{1}{2} \gamma_{33} (\text{LnP}_{\text{DEP}})^2 \end{aligned}$$

$$\begin{aligned}
 & + \gamma_{12} (\text{Ln}P_L)(\text{Ln}P_K) + \gamma_{13} (\text{Ln}P_L)(\text{Ln}P_{\text{DEP}}) + \gamma_{23} (\text{Ln}P_K)(\text{Ln}P_{\text{DEP}}) \\
 & + \rho_{11} (\text{Ln}P_L)(\text{Ln}LOA) + \rho_{12} (\text{Ln}P_L)(\text{Ln}EAR) \\
 & + \rho_{21} (\text{Ln}P_K)(\text{Ln}LOA) + \rho_{22} (\text{Ln}P_K)(\text{Ln}EAR) \\
 & + \rho_{31} (\text{Ln}P_{\text{DEP}})(\text{Ln}LOA) + \rho_{32} (\text{Ln}P_{\text{DEP}})(\text{Ln}EAR) + e_1 \tag{1}
 \end{aligned}$$

Where:-

Variables

OC : Operating Costs (Sum of personnel expense, other operating expense and interest on deposit)

LOA : Total Loans

EAR : Other Earning Assets including Deposits with banks, Public Bonds, Other investment and equity investment

$P_{L,K,DEP}$: Input prices for Labour, Capital & Deposits

P_L (Prices of labour) : personnel expenses / number of employees

P_K (Prices of capital) : Other operating expenses / fixed assets

P_{DEP} (Price of deposits): Interest expense on deposit / volume of deposit

Inspecting equation 1, we can observe many of the characteristics of the translog cost function. In the first instance, it is obvious that the equation enlarges rapidly with any additional new variable and entails the problem of degrees of freedom. Our model includes 21 variables and a constant. If we were to add one more output, the model would expand to 27 parameters. This characteristic means that a large database is required to run the model. The model assumes that some coefficients are the same by requiring symmetry conditions that $\gamma_{ij} = \gamma_{ji}$. Irrespective of the order of the interaction variable, N_{ij} is regarded identical to N_{ji} .

Most studies using a translog cost function have included cost share factor equations to minimise the problem of degrees of freedom and improve efficiency in the estimation of the model. Consequently, using Shephard's Lemma (Shephard, 1970; Christensen, Jorgenson and Lau, 1973), the associated cost share equations S_i (The derived demand for input X_i) are then calculated by partially differentiating equation (1) with respect to the factor prices $\text{Ln}P_i$.

It is important to highlight that the parameters in the share equations are a subset of those in the translog cost function, and estimation of this system of equations results in more efficient estimates than if we were to estimate Equation (1) alone.

The Associated cost share equations are:

$$S_L = \delta \text{LnOC} / \delta \text{Ln}P_L = P_L X_L / \text{OC}$$

$$= \beta_1 + \gamma_{11} (\text{LnPL}) + \gamma_{12} (\text{LnPK}) + \gamma_{13} (\text{LnPDEP}) + \rho_{11} (\text{LnLOA}) + \rho_{12} (\text{LnEAR}) + e_2 \quad (2)$$

$$S_K = \delta \text{LnOC} / \delta \text{Ln}P_K = P_K X_K / \text{OC}$$

$$= \beta_2 + \gamma_{21} (\text{LnPL}) + \gamma_{22} (\text{LnPK}) + \gamma_{23} (\text{LnPDEP}) + \rho_{21} (\text{LnLOA}) + \rho_{22} (\text{LnEAR}) + e_3 \quad (3)$$

$$S_{DEP} = \delta \text{LnOC} / \delta \text{Ln}P_{DEP} = P_{DEP} X_{DEP} / \text{OC}$$

$$= \beta_3 + \gamma_{31} (\text{LnPL}) + \gamma_{32} (\text{LnPK}) + \gamma_{33} (\text{LnPDEP}) + \rho_{31} (\text{LnLOA}) + \rho_{32} (\text{LnEAR}) + e_4 \quad (4)$$

It is important to note that a critical property of a valid cost function is that it is homogeneous of degree one in factor prices, i.e. the regression coefficients of the first order factor prices should sum to one. Since the duality theorem requires that the cost function must be linearly homogeneous in input prices, the following restrictions have to be imposed on the parameters of the cost-function equation so as to adhere to one of the mentioned properties of a valid cost function (1):-

$$\begin{aligned} \beta_1 + \beta_2 + \beta_3 &= 1 ; & \gamma_{11} + \gamma_{12} + \gamma_{13} &= 0 \\ \gamma_{21} + \gamma_{22} + \gamma_{23} &= 0 & \rho_{11} + \rho_{21} + \rho_{31} &= 0 \\ \rho_{12} + \rho_{22} + \rho_{32} &= 0 & \text{and cross-parameter restrictions } \gamma_{ij} &= \gamma_{ji} \end{aligned}$$

Since the cost shares sum to unity, one must be dropped to avoid a singular covariance matrix (Berndt et al., 1974). It does not matter which one is dropped but we choose to drop S_K . The estimated cost functions above provide the basis for computing economies of scale.

Differentiating the translog cost-function Equation (1) with respect to outputs, gives the measure of economies of scale (SE) i.e. equation (5) in which we use the parameters from the estimated model and the means of the variables:-

$$\begin{aligned}
 SE = & (\hat{\alpha}_1 + \hat{\alpha}_2) + \hat{\sigma}_{11} (\text{LnLOA})^2 + \hat{\sigma}_{22} (\text{LnEAR})^2 + \hat{\sigma}_{12} (\text{LnLOA}) + \hat{\sigma}_{12} (\text{LnEAR}) \\
 & + \hat{\rho}_{11} (\text{LnP}_L) + \hat{\rho}_{12} (\text{LnP}_L) + \hat{\rho}_{21} (\text{LnP}_K) + \hat{\rho}_{22} (\text{LnP}_K) \\
 & + \hat{\rho}_{31} (\text{LnP}_{\text{DEP}}) + \hat{\rho}_{32} (\text{LnP}_{\text{DEP}}) \quad (5)
 \end{aligned}$$

If $SE < 1 \implies$ increasing returns to scale, IRS (i.e. Economies of scale exist)

If $SE = 1 \implies$ constant returns to scale, CRS

If $SE > 1 \implies$ decreasing returns to scale, DRS (i.e. Diseconomies of scale)

Measures of economies of scale of banks are drawn from the derivative of a bank's cost with respect to output (loans plus other earning assets) represented by the parameter estimates. The existence of economies of scale is understood as falling average cost of producing a product in the long run as more of the output is produced. It is worth noting that Equation 5 is suitable to measure economies of scale subject to other regressors included in the cost function remaining unchanged as outputs vary.

4.3 Data

The data sources were individual Japanese Shinkin and credit cooperative banks' balance sheets and income statements obtained from the Fitch IBCA Bankscope database from 2003 to 2006. The sample comprises a large set of cross-sectional and panel data of 293 banks over each of the four years under consideration so as to enable consistent cross-sectional comparison over the years. Shinkin banks dominate the sample, comprising 71% of the total. The number of banks is limited by data availability. Given that a complete set of variables is expected for the analysis of the bank cost structure, many of the banks for which data was partially missing had to be dropped.

The sample is then broken down into small and large cooperative banks based on their asset size. Small cooperative banks are classified as those having an asset size of less than \$2 bn and large cooperative banks with an asset size above \$2bn. Given

the selected intermediation approach, we use two categories of outputs and three types of input variables. All variables in this study are measured in US million dollars.

5. EMPIRICAL RESULTS

Table A1 of Appendix A shows the summary descriptive statistics to give some support to the results in next section. Several facts are noticeable at first sight from the table. On average, all variables showed an increase between 2003 and 2006, with both outputs and total assets registering the highest growth of 23% and 22% respectively. However, outputs, total assets and operating costs declined between 2005 and 2006. This could result from bank closures, consolidation or technological progress.

The translog cost function, assuming the intermediation approach in bank production is being applied. Three econometric models are estimated: (1) SUR analysis for cross-section studies (2) OLS for panel data (3) Fixed effects panel model. Using the intermediation approach in modelling the bank output/cost function, the first output is total loans and the second output is other earning assets.

5.1 Scale Economies in Japanese Cooperative Banking

Results of the Estimation using the Full Sample: All Cooperative Banks

5.1.1 Cross-Section Analysis

The full sample representing balanced data has been reduced to 293 cooperative banks in each year so as to enable consistent cross-sectional comparison over the years 2003 to 2006. It is then broken down into small and large cooperative banks based on their asset size. The sub-sample is unbalanced data as we are interested in comparing small and large banks. It is noticeable that small banks dominate during the first two years representing 59% in 2003 and 54% in 2004, but they fall to 49% of the sample in both 2005 & 2006.

Specifically, the cost function in equation (1) and two of the associated three share equations (2) and (4) are estimated simultaneously using Zellner's Iterative Seemingly Unrelated Regression (SUR) technique in which the estimates are

asymptotically equivalent to maximum likelihood estimators (Kmenta and Gilbert (1968)).

SUR Analysis Estimates

We now turn to the main focus of this study, namely 'To what extent are there economies of scale in Japanese cooperative banks?'. Table B1 of Appendix B shows the translog cost function estimates obtained from regressing the system of equations (1), (2) & (4) using SUR for the full cross-section sample of Shinkin and credit cooperative banks in Japan. It can be observed that most of the parameter estimates are statistically significant at the 5% level for all years and overall our model fits the data well with an R^2 of 0.96, 0.96, 0.91 and 0.96 from 2003 to 2006 respectively for the cost functions.

The system of equations (1), (2) & (4) was also estimated by a 'full information maximum likelihood' process, but as there was little difference in the parameter estimates and the economies of scale measures, the results are not reported. We also carried out the two-step test procedure (promoted by Harwick, 1989/1990) to examine whether there are any relationships between the residuals and the output variable in the translog cost function used in the analysis. Three regressions were estimated using the residuals from the translog and the two share equations on output over each year of the sample as shown in Table A4 of Appendix A. The coefficients were insignificantly different from zero for each regression. A final test for heteroscedasticity was also conducted and at 5% critical levels, the White (1980) test failed to reject the null of homoscedastic errors for all cooperative banks, small and large cooperative banks for all years except for full sample in 2003 and 2004 & 2006, and large ones in 2004 (Appendix A, Table A5.1). In conclusion, the conditions necessary for the function to be classified as flexible functional form are satisfied by most cooperative banks in Japan.

Table 4 below shows the estimates of economies of scale, measured in accordance with expression (5), for the full sample. Diseconomies of scale ($SE > 1$) are observed for all cooperative banks throughout 2003 to 2006 but at a decreasing rate. This may reflect the facts observed in Table A1 when describing the data, namely the decline in outputs, total assets and operating costs between 2005 and 2006.

Table 4: Cross-Section Scale Estimates : Japanese Shinkin & Credit Cooperatives

Group	Cross-section Model	2003		2004		2005		2006	
		SE *	R ²	SE	R ²	SE	R ²	SE	R ²
All banks (Full sample)	SUR	2.72	0.96	2.78	0.96	1.72	0.91	1.34	0.96

SE >1 : Diseconomies of scale ; SE <1 : Economies of scale

5.1.2 Panel Data Analysis

The Panel data technique analyses statistical data by combining both time series and cross-section. According to Brooks (2008), there are some advantages of panel data as follows:-

- (1) solves more problems than time series or cross section data separately
- (2) enables us to assess the behaviour of variables or relationships between them over time
- (3) Minimises the problems that crop up with omitted variables when we embody variables with cross section and time series (more informative and variability, less collinearity, more degrees of freedom)

The first technique used in panel data estimation is ordinary least squares (OLS). Panel data techniques analyse missing components as either fixed or random effects. The intercept for each of the individuals is not fixed. Thus the fixed effect model corrects this problem by including variables that lead the intercept to change cross-sectionally but not over time. On the other hand, Greene (2003) calls the random effects model a regression with a random constant term. This is because one way to deal with the ignorance or error is to assume that the intercept is a random outcome variable. The random outcome is a function of a mean value plus a random error.

For the full sample, we have adopted the 'balanced panel' approach, whereby each bank is always represented in each time period. A challenge in modelling a panel with long-time dimension is that variables are likely to be non-stationary. However, our sample has only four years time dimension. We thus investigate the nature of stationarity of our data by conducting unit root tests (Appendix A, Table A2). The test statistics reject the null hypothesis that the variables are non-stationary. This may be due to the short time dimension of our panel data set. We also perform unit root tests on the residuals from the cost function (1) for the full sample and observe that the

cost function is balanced. Table A3 of Appendix A reports the Augmented Dickey-Fuller (ADF) test, introduced by Maddala and Wu (1999).

OLS/ Fixed Effect Estimates

The results in Table C1 of Appendix C correspond to a panel data set using a translog function of Japanese cooperative banks over the four-year period 2003-2006. Given the short time dimension of the data set, we do not add any time trend to capture any technological change over time.

Initially, we run the tests using ordinary least squares (OLS). It can be observed that most of the parameter estimates are statistically significant at the 5% level for the full sample and overall our model fits the data well with an R^2 of 0.95 for the cost functions. A. White Test (1980) for heteroscedasticity (Appendix A: Table A5.2) was also conducted and at 5% critical levels, it failed to reject the null of homoscedastic errors for all cooperative banks; both, small and large. To determine which model to use (Fixed/Random effects), we conducted the Hausman specification Test (Appendix A, Table A6) and observe that there is correlation between unobserved bank-specific random effects and the regressors in the full sample, thus supporting the choice of the fixed effects model.

Table 5 below shows the estimates of economies of scale, measured in line with expression (5), for the full sample using both OLS and fixed effects. We once more obtain diseconomies of scale for all cooperatives banks to the value of 1.88 and 2.30 for both OLS and fixed effects respectively.

Table 5: Panel Data Estimates : Japanese Shinkin & Credit Cooperatives

Group	Data Panel Model	Full sample period 2003-2006	
		SE *	R^2
All banks (full sample)	OLS	1.88	0.95
	Fixed Effects	2.30	0.99

SE^{*} >1 : Diseconomies of scale ; SE^{*} <1 : Economies of scale

We will now consider possible explanations for the significant diseconomies of scale observed for Japanese Shinkin and credit cooperatives banks. Firstly, this may be due to the fact that both Shinkin & credit cooperatives engage primarily in small business lending, which entails significant monitoring costs, thus making it difficult to

exploit scale economies. It may also be attributed to their weak risk management and low profitability level.

The sluggish improvement in earnings of Shinkin banks in FY2006 may also justify the decline in diseconomies of scale. The increase in interest income was offset by increases in credit costs, general and administrative expenses. (Bank of Japan Report, 2007). This may suggest that the motive behind mergers & consolidation among Shinkin & credit cooperatives was mostly for market power, so as to improve their ability to generate profits.

It is important to recall that Shinkin & credit cooperative banks were also hit by the banking crisis and had excessive non-performing loans. Thus they have not been immune to the subsequent restructuring. More than 175 depository institutions have failed between 1990-2001 (Commercial Banks (20), Shinkin (26), and credit cooperatives (130)).

5.2 Does Size Matter in Japanese Cooperative Banking?

Results of the Estimation using Subsamples by Asset Size: Small vs Large Cooperative Banks

5.2.1 Cross Section Analysis

To get a better insight into scale economies, our next step is to investigate whether size matters in Japanese cooperative banking.

SUR Analysis Estimates

Table B2 and B3 of Appendix B show the translog cost function estimates obtained from regressing the system of equations (1), (2) & (4) using SUR for the cross-section sub-sample of small and large Shinkin and credit cooperatives banks in Japan. Most of the parameter estimates are significant at the 5% level.

From the sub-sample estimates in Table 6, significant diseconomies of scale are again obtained for both small and large cooperative banks throughout 2003 to 2006, except for small banks in 2005 where economies of scale ($SE < 1$) were observed.

Table 6: Cross-Section Scale Estimates : Japanese Shinkin & Credit Cooperatives

Group	Cross-section Model	2003		2004		2005		2006	
		SE *	R ²	SE	R ²	SE	R ²	SE	R ²
All banks (Full sample)	SUR	2.72	0.96	2.78	0.96	1.72	0.91	1.34	0.96
Small banks	SUR	1.67	0.90	2.12	0.89	0.79	0.79	1.21	0.89
Large banks	SUR	6.07	0.92	3.02	0.91	3.77	0.85	2.50	0.93

SE^{*} >1 : Diseconomies of scale ; SE^{*} <1 : Economies of scale

We can see that scale diseconomies increase as cooperatives banks' size gets larger within each annual sample. In other words, the small banks in the sample enjoyed a cost advantage over the larger banks as reflected by the indicators of scale economies.

5.2.2 Panel Data Analysis

OLS/ Fixed Effect Estimates

Table C2 and C3 of Appendix C show the results for small and large cooperative banks using the translog function over the four-year period 2003-2006. A White (1980) test for heteroscedasticity was also conducted and at 5% critical levels, it failed to reject the null hypothesis of homoscedastic errors for both small and large cooperative banks. To determine which model to use, the Hausman Specification Test was performed and it is in favour of fixed effects model. It can be observed that most of the parameter estimates are statistically significant at the 5% level for the full sample for OLS regressions. In contrast, few parameters are significant when using fixed effects model. Overall our model fits the data well with an R² of 0.95 and 0.99 for the cost functions using both OLS and fixed effects model respectively.

Table 7 below shows the estimates of economies of scale, measured in line with expression (5), for the full sample using both OLS and fixed effects. For the large banks, the OLS and fixed effects results are consistent, indicating diseconomies of scale to the value of 4.12 and 1.64 respectively. Diseconomies are also observed for small banks, but only in the OLS model.

Table 7: Panel Data Estimates : Japanese Shinkin & Credit Cooperatives

Group	Data Panel Model	Full sample period 2003-2006	
		SE *	R ²
All banks (full sample)	OLS	1.88	0.95
	Fixed Effects	2.30	0.99
Small banks	OLS	1.49	0.88
	Fixed Effects	0.40	0.96
Large banks	OLS	4.12	0.93
	Fixed Effects	1.64	0.99

SE* >1 : Diseconomies of scale ; SE* <1 : Economies of scale

It can thus be noted from both cross-section and panel data model estimates that once more those larger cooperative banks are at a cost disadvantage as compared to small ones. This suggests that it may be more cost effective for Japanese cooperative banks to expand output at existing branches rather than by adding new branches. This may also indicate there is not much pressure for smaller banks to become larger through mergers and acquisitions or through internal expansion. This leads us to question why cooperative banks merged after the crisis. As a comparison, these findings are consistent with what has been documented by Fukuyama (1996) who obtained decreasing returns to scale for the majority of credit associations in 1992.

6. CONCLUDING REMARKS & FUTURE DIRECTIONS

The comprehensive restructuring of the Japanese banking industry, including the cooperative sector, has motivated questions about its economic rationale. Our contribution to the debate has been to use the intermediation approach and the translog functional form to model economies of scale during the period following the reforms. Our cross-sectional and panel results indicate significant diseconomies of scale for the full sample and the two sub-samples based on size. Larger banks are at a greater cost disadvantage than their smaller competitors.

Nowadays, with the credit crisis hitting the world's economy, many of the world's biggest banks are recommending limiting the size and scope of their business, and thus requesting more spending on technology and risk management. There has been some evidence that technological progress accounts for the advantages of large-scale production in the industry. Further studies should investigate the impact of

technology on scale economies of Japanese cooperative banks to find some rationale behind the recent trend in consolidation.

One limitation of this study is that it ignores risk factors in the cost model. This study could thus be extended by incorporating the risks associated with Japanese cooperative bank's operations on their costs. In other words, testing whether the estimates of scale economies are increased or decreased once risk is taken into account.

An area of research also deserving additional attention is comparing the scale economies and size effects of Japanese Shinkin banks against commercial banks and credit cooperatives. It will also be of great relevance for research and policy purposes to see if the Japanese cooperative banks' results carry over into other nations with cooperative banking markets.

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Appendix A

Table A1: Summary of key data

(US \$ millions)	Mean	Median	Std. Dev*	Minimum	Maximum
Input Prices L (PL)					
2003	0.056805	0.057692	0.010448	0.000053	0.091789
2004	0.062131	0.062497	0.009544	0.016043	0.100032
2005	0.068395	0.066172	0.043516	0.025507	0.790992
2006	0.063233	0.063122	0.009924	0.036254	0.111789
Input Prices K (PK)					
2003	0.373756	0.333333	0.286817	0.011587	4.000000
2004	0.377501	0.333333	0.319981	0.000275	3.728787
2005	0.374109	0.336275	0.043516	0.025507	0.790992
2006	0.399521	0.339806	0.331390	0.000362	3.474519
Input Prices DEP (PDEP)					
2003	0.001562	0.001014	0.002239	0.000001	0.021924
2004	0.001120	0.000811	0.001130	0.000170	0.010345
2005	0.001207	0.000711	0.002061	0.000134	0.020491
2006	0.001678	0.000685	0.011310	0.000189	0.193548
Output 1 (LOAN)					
2003	1,359.376	821.000	1,462.452	23.809	8,948.900
2004	1,541.932	928.528	1,716.834	27.253	12,334.010
2005	1,632.106	964.620	1,838.027	32.014	12,269.780
2006	1,593.167	948.374	1,793.969	69.031	11,438.620
Output 2 (EAR)					
2003	1,112.857	663.368	1,610.143	24.630	22,176.030
2004	1,318.777	807.146	1,908.633	26.580	26,316.860
2005	1,463.856	890.992	2,166.866	51.272	30,229.420
2006	1,440.676	878.805	2,146.165	51.675	29,766.980
Total Assets (TA)					
2003	2,590.102	1,595.203	2,931.657	114.119	27,699.720
2004	2,996.134	1,846.424	3,450.099	133.790	31,832.210
2005	3,246.492	2,039.216	3,766.120	128.425	35,397.360
2006	3,161.633	2,002.755	3,696.816	125.742	34,601.730
Operating Costs (OC)					
2003	38.525	26.272	37.482	2.463	234.806
2004	41.337	27.466	40.045	1.361	231.246
2005	45.046	27.960	46.821	3.022	331.792
2006	41.319	27.435	41.708	1.696	299.130

* standard deviation

Source: Fitch IBCA Bankscope database : Japanese Shinkin & Credit Cooperatives as at 31st Mar

Appendix A - Continued

Unit Root Tests – Variables

Table A2

Unit Root Tests on Variables (All are Stationary)					
	t-Statistic				
<i>Augmented Dickey-Fuller (ADF) test</i>	<i>Total Asset</i>	<i>Deposit</i>	<i>Earning Assets</i>	<i>Fixed Assets</i>	<i>Interest on Deposits</i>
Augmented Dickey-Fuller test statistic	-13.21878	-13.20615	-13.19677	-26.20839	-16.39942
<i>Augmented Dickey-Fuller (ADF) test</i>	<i>Interest Expense</i>	<i>Interest Received</i>	<i>Loan</i>	<i>Operating Costs</i>	<i>Other Operating Expenses</i>
Augmented Dickey-Fuller test statistic	-22.11801	-30.6401	-13.01377	-14.02148	-13.51302
<i>Augmented Dickey-Fuller (ADF) test</i>	<i>PDEP</i>	<i>PE</i>	<i>PK</i>	<i>PL</i>	
Augmented Dickey-Fuller test statistic	-33.66247	-12.97699	-18.63976	-31.77374	

Test critical values: 5% level is -2.8638

Unit Root Tests on Residuals

Table A3

Unit Root Tests on the Cost Function Residuals (Stationary)		
<i>Augmented Dickey-Fuller (ADF) test</i>	t-Statistic	p-value
Augmented Dickey-Fuller test statistic	-17.02299	0.00000
Test critical values: 5% level	-2.863801	

Testing the Relationship Between the Residuals and the Output Variable in the Translog Cost Function

Table A4

	Test Statistics		
	Cost Equation	Share Equations	
		Labour	Deposit
2003			
R ²	0.003265	0.006996	0.008854
t-stats	-0.976381	-1.431815	1.612277
2004			
R ²	0.00084	0.001767	0.002993
t-stats	-0.494722	0.717663	0.934723
2005			
R ²	0.000179	0.00000	0.001242
t-stats	-0.228411	0.002603	0.60155
2006			
R ²	0.000457	0.001364	0.004904
t-stats	-0.364882	-0.630334	1.197484

Cross-section Sur Analysis

Appendix A - Continued

Tests for Heteroscedasticity

Table A5.1 : White Test (1980) Cross section SUR Analysis

All Japanese Cooperative Banks	2003	2004	2005	2006
Critical Chi-squared at 5% critical value	71.42			
Obs*R-squared	202.49	94.17	16.82	111.50
Null hypothesis : Homoscedastic Errors	Reject	Reject	Accept	Reject

* Observed

Small Japanese Cooperative Banks	2003	2004	2005	2006
Critical Chi-squared at 5% critical value	71.42			
Obs*R-squared	15.31	56.93	22.65	48.45
Null hypothesis : Homoscedastic Errors	Accept	Accept	Accept	Accept

Large Japanese Cooperative Banks	2003	2004	2005	2006
Critical Chi-squared at 5% critical value	71.42			
Obs*R-squared	51.31	75.19	19.83	53.07
Null hypothesis : Homoscedastic Errors	Accept	Reject	Accept	Accept

Table A5.2 : White Test (1980) Panel Data Analysis (2003-2006)

Japanese Cooperative Banks	Full Sample	Small	Large
Critical Chi-squared at 5% critical value	71.42		
OLS			
Obs*R-squared	15.54	17.98	28.48
Null hypothesis : Homoscedastic Errors	Accept	Accept	Accept
Fixed Effects			
Obs*R-squared	15.62	19.02	27.71
Null hypothesis : Homoscedastic Errors	Accept	Accept	Accept

Hausman Specification Test

Table A6

Hausman Secification Tests			
Test cross-section random effects			
All banks			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	152.665933	20	0
Small Banks			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	41.66064	20	0.0031
Large Banks			
Test Summary	Chi-Sq. Statistic	Chi-Sq. d.f.	Prob.
Cross-section random	153.271103	20	0

Appendix B: Parameter Estimates of the Cross-Section Models
Table B1 : All Japanese Shinkin & Credit Cooperative Banks (SUR Analysis)

Estimates from the Translog-cost function obtained from regressing the system of equations (1), (2) & (4) using SUR analysis for the full cross-section sample are reported using the natural log of operating costs (LnOC) as the dependent variable. The columns report the results obtained for Shinkin and credit cooperatives banks over the years 2003 to 2006. Independent variables for each bank include the natural log of : outputs given by total loans (LnLOA) and other earning assets (LnEAR), inputs given by employee costs calculated as total personnel expenses divided by the number of employees (LnP_L), capital costs proxied by other operating expenses to fixed assets ratios (P_K), and interest paid on deposits calculated as interest expense on deposit divided by volume of deposit (P_{DEP}).

Variable	Coefficient			
	2003	2004	2005	2006
Cost Equations				
Intercept	0.49598** (0.1449)	0.55607** (0.1327)	0.42149*** (0.2406)	0.47617** (0.1645)
LnLOA	0.80511** (0.1073)	1.08652** (0.0853)	0.87413** (0.1653)	0.99197** (0.1294)
LnEAR	-0.03047 (0.1055)	-0.40123** (0.0919)	0.03712 (0.1737)	-0.26953* (0.1272)
(LnLOA) ²	0.57361** (0.0826)	0.46753** (0.0795)	0.21813 (0.1353)	0.03009 (0.1114)
(LnLOA)(LnEAR)	-0.66071** (0.0812)	-0.61954** (0.0824)	-0.29612* (0.1310)	-0.15111 (0.1009)
(LnEAR) ²	0.75736** (0.0850)	0.82745** (0.0850)	0.35275** (0.1347)	0.29208** (0.1005)
LnP _L	0.56475** (0.0309)	0.55731** (0.0297)	0.50915** (0.0387)	0.65567** (0.0330)
LnP _K	-0.20393** (0.0262)	-0.14566** (0.0321)	-0.25036** (0.0577)	-0.14210** (0.0331)
LnP _{DEP}	0.63918** (0.0261)	0.58835** (0.0230)	0.74121** (0.0421)	0.48644** (0.0252)
(LnP _L) ²	0.34722** (0.0144)	0.19396** (0.0164)	0.16770** (0.0214)	0.16463** (0.0187)
(LnP _K) ²	0.03555*** (0.0206)	0.04552** (0.0117)	-0.04184* (0.0190)	0.06145** (0.0152)
(LnP _{DEP}) ²	0.23367** (0.0095)	0.24132** (0.0095)	0.31446** (0.0137)	0.14879** (0.0088)
(LnP _L)(LnP _K)	-0.18472** (0.0098)	-0.08938** (0.0129)	-0.05784** (0.0172)	-0.11855** (0.0134)
(LnP _L)(LnP _{DEP})	-0.16250** (0.0102)	-0.10458** (0.0099)	-0.10986** (0.0131)	-0.04608** (0.0110)
(LnP _K)(LnP _{DEP})	0.14917** (0.0103)	0.04386** (0.0078)	0.01586 (0.0142)	0.05710** (0.0083)
(LnP _L)(LnLOA)	0.02531 (0.0174)	0.03097* (0.0156)	0.02198 (0.0193)	0.01143 (0.0190)
(LnP _L)(LnEAR)	-0.07242** (0.0178)	-0.06838** (0.0153)	-0.06019** (0.0189)	-0.03921* (0.0185)
(LnP _K)(LnLOA)	0.02369* (0.0105)	-0.01511 (0.0106)	-0.02927*** (0.0171)	0.01851 (0.0112)
(LnP _K)(LnEAR)	0.05260** (0.0097)	0.05522** (0.0083)	0.05559** (0.0101)	0.03558** (0.0096)
(LnP _{DEP})(LnLOA)	-0.04900** (0.0105)	-0.01586*** (0.0086)	0.00729 (0.0133)	-0.02994** (0.0105)
(LnP _{DEP})(LnEAR)	0.01981* (0.0088)	0.01316 (0.0083)	0.00460 (0.0106)	0.00364 (0.0098)
No. of observations (N)	293	293	293	293
R-squared (R ²)	0.956	0.961	0.913	0.959
Share Equations				
R-squared- Labour	0.477	0.373	0.186	0.236
- Deposits	0.597	0.670	0.589	0.519

Note: *, **, ***, denote significance at the 1, 5, and 10 per cent levels, respectively. Standard errors are in parentheses.

Appendix B – Continued

Table B2 : Small Japanese Shinkin & Credit Cooperative Banks (SUR Analysis)

Estimates from the Translog-cost function obtained from regressing the system of equations (1), (2) & (4) using SUR analysis for the small cross-section sample are reported using the natural log of operating costs (LnOC) as the dependent variable. The columns report the results obtained for small Shinkin and credit cooperatives banks (asset size of less than \$2 bn) over the years 2003 to 2006. Independent variables for each bank include the natural log of : outputs given by total loans (LnLOA) and other earning assets (LnEAR), inputs given by employee costs calculated as total personnel expenses divided by the number of employees (LnP_L), capital costs proxied by other operating expenses to fixed assets ratios (P_K), and interest paid on deposits calculated as interest expense on deposit divided by volume of deposit (P_{DEP}).

Variable	Coefficient			
	2003	2004	2005	2006
Cost Equations				
Intercept	0.95110** (0.3189)	0.41372 (0.3418)	0.68507 (0.6271)	0.76212* (0.3981)
LnLOA	0.66576** (0.2240)	1.03727** (0.2050)	0.29597 (0.3970)	0.67001* (0.2866)
LnEAR	-0.24067 (0.1900)	-0.37700*** (0.1973)	0.45030 (0.3955)	-0.12004 (0.2582)
(LnLOA) ²	0.34189** (0.1063)	0.54206** (0.1020)	0.13781 (0.1770)	0.14252 (0.1371)
(LnLOA)(LnEAR)	-0.36833** (0.1012)	-0.66411** (0.1124)	0.01794 (0.1706)	-0.13118 (0.1141)
(LnEAR) ²	0.53522** (0.1261)	0.86392** (0.1351)	-0.18407 (0.2445)	0.24244 (0.1650)
LnP _L	0.47724** (0.0515)	0.40066** (0.0513)	0.36439** (0.0786)	0.50702** (0.0613)
LnP _K	-0.18317** (0.0412)	0.03736 (0.0473)	-0.17726*** (0.1018)	-0.14185* (0.0616)
LnP _{DEP}	0.70593** (0.0428)	0.56198** (0.0302)	0.81287** (0.0674)	0.63482** (0.0373)
(LnP _L) ²	0.39142** (0.0177)	0.18593** (0.0235)	0.16144** (0.0412)	0.17935** (0.0277)
(LnP _K) ²	0.04634 (0.0425)	0.00202 (0.01960)	-0.03684 (0.0574)	0.01840 (0.0214)
(LnP _{DEP}) ²	0.24418** (0.0120)	0.23451** (0.0118)	0.31457** (0.0192)	0.25380** (0.0124)
(LnP _L)(LnP _K)	-0.20617** (0.0118)	-0.06632** (0.0196)	-0.03995 (0.0325)	-0.07739** (0.0219)
(LnP _L)(LnP _{DEP})	-0.18525** (0.0131)	-0.11961** (0.0131)	-0.12149** (0.0234)	-0.10196** (0.0147)
(LnP _K)(LnP _{DEP})	0.15983** (0.0157)	0.06430** (0.0105)	0.07679** (0.0219)	0.05899** (0.0118)
(LnP _L)(LnLOA)	0.03882*** (0.0220)	0.04291** (0.0205)	0.05170*** (0.0297)	0.04054 (0.0254)
(LnP _L)(LnEAR)	-0.05899* (0.0238)	-0.03789*** (0.0207)	-0.04684 (0.0309)	-0.06308** (0.0232)
(LnP _K)(LnLOA)	0.02768*** (0.0160)	-0.03733* (0.0160)	-0.03306 (0.0344)	-0.03226 (0.0221)
(LnP _K)(LnEAR)	0.04658** (0.0131)	0.04419** (0.0116)	0.05965** (0.0158)	0.05136** (0.0126)
(LnP _{DEP})(LnLOA)	-0.06650** (0.0152)	-0.00558 (0.0111)	-0.01865 (0.0222)	-0.00827 (0.0141)
(LnP _{DEP})(LnEAR)	0.01242 (0.0116)	-0.00630 (0.0118)	-0.01282 (0.0185)	0.01172 (0.0133)
N	174	158	144	145
R ²	0.903	0.892	0.794	0.887
Share Equations				
R-squared- Labour	0.570	0.429	0.209	0.381
- Deposits	0.629	0.763	0.622	0.744

Note: *, **, ***, denote significance at the 1, 5, and 10 per cent levels, respectively. Standard errors are in parentheses.

Appendix B – Continued
Table B3 : Large Japanese Shinkin & Credit Cooperative Banks (SUR Analysis)

Estimates from the Translog-cost function obtained from regressing the system of equations (1), (2) & (4) using SUR analysis for the large cross-section sample are reported using the natural log of operating costs (LnOC) as the dependent variable. The columns report the results obtained for large Shinkin and credit cooperatives banks (asset size above \$2 bn) over the years 2003 to 2006. Independent variables for each bank include the natural log of : outputs given by total loans (LnLOA) and other earning assets (LnEAR), inputs given by employee costs calculated as total personnel expenses divided by the number of employees (LnP_L), capital costs proxied by other operating expenses to fixed assets ratios (P_K), and interest paid on deposits calculated as interest expense on deposit divided by volume of deposit (P_{DEP}).

Variable	Coefficient			
	2003	2004	2005	2006
Cost Equations				
Intercept	2.20825** (0.8418)	1.04621*** (0.6175)	-0.76038 (1.2022)	0.03849 (0.8106)
LnLOA	-0.25595 (0.3373)	1.53271** (0.3221)	-0.29549 (0.5353)	0.65596 (0.4108)
LnEAR	0.02781 (0.2877)	-1.09109** (0.2882)	1.98747** (0.4789)	0.19057 (0.3645)
(LnLOA) ²	1.32374 (0.1196)	0.16048 (0.2052)	1.03073** (0.2375)	0.35092 (0.2195)
(LnLOA)(LnEAR)	-1.08318** (0.1625)	-0.44403** (0.1710)	-0.76854** (0.2127)	-0.36434* (0.1654)
(LnEAR) ²	1.14956** (0.1472)	0.85521** (0.1380)	0.26527 (0.1999)	0.38513** (0.1317)
LnP _L	0.85289** (0.0809)	0.86035** (0.0760)	0.63063** (0.0808)	0.96099** (0.0759)
LnP _K	-0.29560** (0.0741)	-0.37857** (0.0781)	-0.41777** (0.1173)	-0.18853** (0.0709)
LnP _{DEP}	0.44271** (0.0520)	0.51821** (0.0643)	0.78714** (0.0971)	0.22755** (0.0549)
(LnP _L) ²	0.18550** (0.0209)	0.19787** (0.0226)	0.15625** (0.0241)	0.11459** (0.0218)
(LnP _K) ²	0.02903 (0.0214)	0.10020** (0.01370)	0.10838** (0.0222)	0.07453** (0.0188)
(LnP _{DEP}) ²	0.20505** (0.0126)	0.22700** (0.0163)	0.31923** (0.0205)	0.08512** (0.0107)
(LnP _L)(LnP _K)	-0.09742** (0.0196)	-0.12329** (0.0161)	-0.07478** (0.01870)	-0.11767** (0.01582)
(LnP _L)(LnP _{DEP})	-0.08807** (0.0110)	-0.07458** (0.0151)	-0.08147** (0.0164)	0.00308 (0.0136)
(LnP _K)(LnP _{DEP})	0.06839** (0.0113)	0.02309* (0.0115)	-0.03360*** (0.0194)	0.04314** (0.0103)
(LnP _L)(LnLOA)	0.04663*** (0.0200)	0.02752 (0.0216)	0.00814 (0.0308)	0.03376 (0.0199)
(LnP _L)(LnEAR)	-0.16315** (0.0141)	-0.13236** (0.0146)	-0.06302** (0.0155)	-0.12436** (0.0147)
(LnP _K)(LnLOA)	-0.00542 (0.0269)	0.00127 (0.0282)	-0.01491 (0.0283)	0.00273 (0.0281)
(LnP _K)(LnEAR)	0.09557** (0.0280)	0.08333** (0.0285)	0.05018** (0.0300)	0.07480** (0.0290)
(LnP _{DEP})(LnLOA)	-0.04121** (0.0139)	-0.02880** (0.0182)	0.00677 (0.0258)	-0.03649 (0.0171)
(LnP _{DEP})(LnEAR)	0.06758** (0.0153)	0.04903** (0.0150)	0.01284 (0.0159)	0.04956** (0.0149)
N	119	135	149	148
R ²	0.925	0.916	0.853	0.932
Share Equations				
R-squared- Labour	0.369	0.405	0.242	0.243
- Deposits	0.681	0.585	0.569	0.385

Note: *, **, ***, denote significance at the 1, 5, and 10 per cent levels, respectively. Standard errors are in parentheses.

Appendix C: Parameter Estimates of the Panel Data Models

Table C1 : All Japanese Shinkin & Credit Cooperative Banks

Estimates from the Translog-cost equation (1) using OLS and fixed effects analysis for the full panel data sample are reported using the natural log of operating costs (LnOC) as the dependent variable. The columns report the results obtained for Shinkin and credit cooperatives banks over the years 2003 to 2006. Independent variables for each bank include the natural log of : outputs given by total loans (LnLOA) and other earning assets (LnEAR), inputs given by employee costs calculated as total personnel expenses divided by the number of employees (LnP_L), capital costs proxied by other operating expenses to fixed assets ratios (P_K), and interest paid on deposits calculated as interest expense on deposit divided by volume of deposit (P_{DEP}).

Variable	Coefficient	
	OLS	Fixed Effects
Cost Equations		
Intercept	0.12255 (0.1343)	-0.65829* (0.2712)
LnLOA	0.85217** (0.0978)	0.91529** (0.1827)
LnEAR	-0.04697 (0.0969)	0.57033** (0.1562)
(LnLOA) ²	0.33021** (0.0614)	0.55156** (0.1158)
(LnLOA)(LnEAR)	-0.33592** (0.0580)	-0.65651** (0.0947)
(LnEAR) ²	0.33530** (0.0585)	0.49320** (0.0949)
LnP _L	0.50320** (0.1021)	0.56274** (0.1114)
LnP _K	0.04859 (0.0850)	0.14048 (0.0950)
LnP _{DEP}	0.44821** (0.0622)	0.29678** (0.0643)
(LnP _L) ²	-0.20123** (0.0522)	-0.11071** (0.0415)
(LnP _K) ²	-0.10635** (0.0252)	-0.01723 (0.0250)
(LnP _{DEP}) ²	0.01843 (0.0181)	-0.03436** (0.0163)
(LnP _L)(LnP _K)	0.03638 (0.0328)	-0.05768* (0.0274)
(LnP _L)(LnP _{DEP})	0.16485** (0.0285)	0.16840** (0.0246)
(LnP _K)(LnP _{DEP})	0.06997** (0.0254)	0.07491** (0.0218)
(LnP _L)(LnLOA)	-0.19368** (0.0399)	-0.27401** (0.0457)
(LnP _L)(LnEAR)	0.21681** (0.0404)	0.30743** (0.0455)
(LnP _K)(LnLOA)	0.06974*** (0.0486)	0.12544** (0.0545)
(LnP _K)(LnEAR)	-0.04600 (0.0525)	-0.13474** (0.0608)
(LnP _{DEP})(LnLOA)	0.12394** (0.0298)	0.14857** (0.0337)
(LnP _{DEP})(LnEAR)	-0.17082** (0.0317)	-0.17269** (0.0416)
N	1172	1172
R ²	0.953	0.985

Note: *, **, ***, denote significance at the 1, 5, and 10 per cent levels, respectively. Standard errors are in parentheses.

Appendix C – Continued

Table C2 : Small Japanese Shinkin & Credit Cooperative Banks

Estimates from the Translog-cost equation (1) using OLS and fixed effects analysis for the small panel data sample are reported using the natural log of operating costs (LnOC) as the dependent variable. The columns report the results obtained for small Shinkin and credit cooperatives banks (asset size of less than \$2 bn) over the years 2003 to 2006. Independent variables for each bank include the natural log of : outputs given by total loans (LnLOA) and other earning assets (LnEAR), inputs given by employee costs calculated as total personnel expenses divided by the number of employees (LnP_L), capital costs proxied by other operating expenses to fixed assets ratios (P_K), and interest paid on deposits calculated as interest expense on deposit divided by volume of deposit (P_{DEP}).

Variable	Coefficient	
	OLS	Fixed Effects
Cost Equations		
Intercept	1.26880** (0.3589)	1.05462** (0.3019)
LnLOA	0.40203* (0.1985)	0.54675* (0.2151)
LnEAR	-0.25569 (0.2368)	0.03937 (0.3326)
(LnLOA) ²	0.31545** (0.0919)	-0.08915 (0.2037)
(LnLOA)(LnEAR)	-0.23336* (0.0915)	0.20978 (0.2616)
(LnEAR) ²	0.35095** (0.1323)	-0.37305 (0.2294)
LnP _L	0.43614*** (0.2318)	0.54012** (0.0701)
LnP _K	-0.20520 (0.1587)	-0.26602** (0.0450)
LnP _{DEP}	0.76907** (0.1662)	0.72590** (0.1054)
(LnP _L) ²	-0.27940* (0.1200)	0.06607 (0.1080)
(LnP _K) ²	-0.21327** (0.0525)	-0.03699 (0.0477)
(LnP _{DEP}) ²	0.14029** (0.0424)	0.07991 (0.0630)
(LnP _L)(LnP _K)	0.17340* (0.0759)	-0.09467* (0.0456)
(LnP _L)(LnP _{DEP})	0.10600*** (0.0559)	0.02860 (0.0794)
(LnP _K)(LnP _{DEP})	0.03987 (0.0536)	0.13166** (0.0073)
(LnP _L)(LnLOA)	-0.01341 (0.0681)	-0.24208** (0.0682)
(LnP _L)(LnEAR)	-0.05082 (0.0764)	0.21827*** (0.0580)
(LnP _K)(LnLOA)	0.04920 (0.0851)	0.10379 (0.0837)
(LnP _K)(LnEAR)	0.08552 (0.1092)	0.03277 (0.1144)
(LnP _{DEP})(LnLOA)	-0.03580 (0.0560)	0.13829 (0.0970)
(LnP _{DEP})(LnEAR)	-0.03471 (0.0733)	-0.25104** (0.1079)
N	619	619
R ²	0.881	0.956

Note: *, **, ***, denote significance at the 1, 5, and 10 per cent levels, respectively. Standard errors are in parentheses.

Appendix C – Continued
Table C3 : Large Japanese Shinkin & Credit Cooperative Banks

Estimates from the Translog-cost equation (1) using OLS and fixed effects analysis for the large panel data sample are reported using the natural log of operating costs (LnOC) as the dependent variable. The columns report the results obtained for large Shinkin and credit cooperatives banks (asset size above \$2 bn) over the years 2003 to 2006. Independent variables for each bank include the natural log of : outputs given by total loans (LnLOA) and other earning assets (LnEAR), inputs given by employee costs calculated as total personnel expenses divided by the number of employees (LnP_L), capital costs proxied by other operating expenses to fixed assets ratios (P_k), and interest paid on deposits calculated as interest expense on deposit divided by volume of deposit (P_{DEP}).

Variable	Coefficient	
	OLS	Fixed Effects
Cost Equations		
Intercept	0.85703 (0.6079)	3.26669** (1.319)
LnLOA	0.18090 (0.2932)	-1.17899** (0.3690)
LnEAR	0.81718* (0.3281)	1.15965 (0.7059)
(LnLOA) ²	0.99190** (0.1027)	0.64946** (0.1555)
(LnLOA)(LnEAR)	-0.78979** (0.0999)	-0.23701 (0.1706)
(LnEAR) ²	0.47202** (0.1059)	-0.19242 (0.1842)
LnP _L	1.55562** (0.2640)	0.17353 (0.5844)
LnP _K	-1.45190** (0.2680)	-0.43185 (0.5531)
LnP _{DEP}	0.89628** (0.1792)	1.25833** (0.3323)
(LnP _L) ²	-0.21957** (0.0624)	-0.25945 (0.0717)
(LnP _K) ²	0.61830** (0.0707)	0.18331 (0.1444)
(LnP _{DEP}) ²	-0.03151 (0.0236)	-0.08146 (0.0298)
(LnP _L)(LnP _K)	-0.37460** (0.0793)	-0.08425** (0.1563)
(LnP _L)(LnP _{DEP})	0.59417** (0.0654)	0.34370* (0.1418)
(LnP _K)(LnP _{DEP})	-0.24370** (0.0458)	-0.09906 (0.0981)
(LnP _L)(LnLOA)	0.24774* (0.0698)	0.08996 (0.0881)
(LnP _L)(LnEAR)	-0.21411*** (0.0919)	0.18445 (0.1304)
(LnP _K)(LnLOA)	-0.26952** (0.1043)	-0.02760 (0.1543)
(LnP _K)(LnEAR)	0.34407** (0.1120)	0.06559 (0.1489)
(LnP _{DEP})(LnLOA)	0.02178 (0.0744)	-0.06236 (0.1510)
(LnP _{DEP})(LnEAR)	-0.12996** (0.0712)	-0.25004** (0.1276)
N	546	546
R ²	0.926	0.986

Note: *, **, ***, denote significance at the 1, 5, and 10 per cent levels, respectively. Standard errors are in parentheses.