THE WILLIAM DAVIDSON INSTITUTE
AT THE UNIVERSITY OF MICHIGAN

Consolidation, Scale Economics and Technological Change in Japanese Banking

By: Solomon Tadesse

William Davidson Institute Working Paper Number 878
February 2005

Consolidation, Scale Economies and Technological Change in Japanese Banking

Solomon Tadesse*
Stephen M. Ross School of Business
University of Michigan

This version: February 2005

Abstract

The paper examines the technological structure of the Japanese banking sector before the onset of the banking crisis and structural reforms of the 90s in order to shade light on the logic of the recent trend to consolidation in the industry. While diseconomies of scale are shown to be pervasive in the large banks, defying the rationale for consolidation, the paper presents evidence of an underlying technological progress that operates to significantly increase the industry's efficient minimum size, generating economies at larger banks, thus justifying the ongoing trend in consolidation. The results suggest that, to the extent that consumers can benefit from lower costs of bank production, policies that promote a more concentrated banking structure might be consistent with public interest.

JEL Classifications: G21; D24; O3
Key Words: Scale Economies; Technical Change; Banking

---

* Corresponding author: Stephen M. Ross School of Business, University of Michigan, Ann Arbor, MI 48109-1234; Tele: (734) 763-5392; Fax: (734) 936-0282; E-mail: stadesse@umich.edu. I am grateful to Haluk Unal for helpful suggestions and comments. I also thank participants at the Financial Management Association Meeting and the Multinational Finance Association Meeting. The research has been financially supported in part by the Center for International Business Education and Research (CIBER) at the University of Maryland at College Park.

1. Introduction

The Japanese Banking industry is undergoing an unprecedented structural reform characterized by a wave of mergers and consolidation (see, e.g., Hall, 1999) for recent developments). The ongoing trend towards bank concentration presupposes the existence of some form of economies that banks could exploit by being larger. The extant empirical literature is ambiguous about the extent of such economies in the industry. Until recently, the consensus has been that significant economies of scale existed before the onset of the crisis and subsequent reform in the 1990s at all output levels throughout the industry (see, e.g., Fukuyama, 1993; McKillop et al., 1996; Tachibanki et al., 1991; and Yoshioka and Nakajima, 1987). This is despite the fact that substantial evidence in other countries, notably in the U.S., suggests that economies of scale in banking commonly get exhausted at a low level of output. In addition to the industry's chronic problems of profitability and the debilitating effects of the banking crisis in the early 1990s, the logic of the recent wave of consolidation might be based on these early findings of significant scale economies. On the other hand, recent research finds that the extent of scale economies reported in the earlier research was overstated and that, in fact, there exists diseconomies of scale in the large banks, thereby questioning the rationale for the recent mergers and consolidation (see, e.g., Altunbas et al., 2000; and Drake and Hall, 2003).

Given the current trend towards bank concentration in Japan, understanding the precise nature of scale economies in the industry is critically important both to comprehend the economic rationale behind the industry's movement to consolidation and to prescribe policy going forward. Part of the ambiguity in the literature about scale economies in the industry lies in the fact that the two sets of studies have focused on two significantly different periods in the history of the Japanese banking industry. While the earlier studies focus on the relatively stable period of the 1980s, the recent studies are based on the industry's experience in the tumultuous period of banking crisis followed by structural reform and consolidation that characterizes much of the 1990s.

The purpose of this paper is to examine the extent of economies of scale in the Japanese banking industry and shade more light on the rationale behind the recent structural changes that are shaping the industry. To do so, the study focuses on the relatively stable period of much of the 1980s and the beginning of the 1990s before the onset of the banking crises that culminated in the recent structural reform. In contrast, Drake and Hall (2003) and Altunbas et al. (2000) study the period of 1993 through 1997, a period in which the industry was in a flux of crises and structural reform. Because the data reflects the impacts of the banking crisis of the early 1990s and the subsequent and ongoing reform, it would be difficult to make meaningful inference about the existence and extent of scale economies as a justification for consolidation, while the industry is at the same time going through the very reforms. It is shown that, in contrast to the early studies, but consistent with the recent ones, while there were significant scale economies in much of the industry, diseconomies was pervasive among the large banks that became the object of the consolidation wave in recent years. While this finding prima-facie defies the logic for large-scale mergers, the paper argues that a significantly scale-biased technological progress has been underway countering the diseconomies of scale in large banks. In other words, despite the static diseconomies observed in the data, there was a dynamic technological process that has been significantly increasing the minimum efficient scale in the industry, reducing the observed diseconomies and potentially creating economies from a larger scale. Focusing on the sub-period after the passage of the 1981 New Banking Law of Japan for robustness, the study reports a much lower level of scale dis-economies, providing additional credence to the argument that the observed diseconomies were dissipating over time.

In addition to providing the economic rationale for the structural changes in the industry, the paper also contributes to the study of banking production economies in general. An extensive literature exists on the cost structure of the banking industry, particularly on the question of whether or not firm size (scale) creates any economies. Despite differences in methodology and data sources[1] the evidence, mainly from the U.S. and few other countries, has been remarkably similar, in that, generally, depository institutions exhaust scale economies at low levels of output, and at the average bank, there is little evidence of economies of scale. Despite the critical role of banks in the Japanese economy, the cost structure of the banking industry has not attracted much attention in academic research. This contrasts to the extensive literature on banks in the U.S. where banks' role relative to financial markets is not as important as in Japan. The paper attempts to fill the void by providing a detailed study of the cost and technological structure of the industry based on a large panel extending over two decades. There exist at least two reasons why Japanese banks yield themselves as an interesting case to examine bank production economies. First, during the decade of 1980s they have proven to be the fastest growing banking industry in the world. Second, since the early 1980s, the Japanese banking industry has undergone a series of financial deregulation, including the recent mergers and consolidation, which should affect the structure of the industry. Hence, investigation of scale

1 The early studies include those by Benston (1965, 1972), Greenbaum (1967), and Bell and Murphy (1968) and are summarized in Benston (1972). Recent works -including Benston, Hanweck, and Humphrey (1982), Murrey and White (1983), Gilligan Smirlock, and Marshall (1984), Hunter and Timme (1986), Kim (1986), Berger, Hanweck, and Humphrey

economies in the process of high growth and structural liberalization provides a unique opportunity to further our knowledge of bank production economies.

Evaluating the extent of these economies per se contributes to the public policy issues related to the appropriate size of banks in the industry. Concern on the social costs of attaining monopoly power through size has long been at the center of the public debate on deregulation. This is particularly true during the recent period of mega mergers in Japan. However, as Hunter and Timme (1986, 1991) argues, the appropriate scale of banks as well as the cost implications of size are also influenced by the characteristics of technological advancement in the industry. If new technologies are non-neutral in terms of their effects on the efficient size of the firm in the industry, then policies that encourage creation of large-scale banks can be socially beneficial. The second objective of the paper is, therefore, to evaluate the impact of technological change on Japanese banking industry. Towards this end, the study follows Hunter and Timme (1991) and examines technological change, its relationship to bank size and its effect on the efficient scale of operation for Japanese banks.

The rest of the paper is organized as follows. Section 2 below presents the empirical model utilized to characterize the Japanese banking production technology and offers operational measures for scale economies, technological change and input elasticities. Section 3 describes the data, and section 4 presents empirical results. Section 5 concludes the paper.

(1987), Mester (1987), Noulas, Ray, and Miller (1990), Fields, Murphy and Tirtirglu (1993) and Berger and Mester (1997) - studied the cost structure of financial institutions in the U.S., Canada, Israel and Turkey.

2. Empirical Model

We follow the parametric approach of inferring the technological characteristics of the bank production process from structured production functions as representation of the underlying technology. Invoking the duality between production and cost functions in characterizing the technology, we use the cost function to infer the extent of scale economies, technological change and other relevant properties of the production process.

2.1. The Cost Function

Consistent with the literature (see, e.g., Uchida and Tsutsui (2004) in Japanese banking context), it is assumed that the production process of the Japanese banking industry can be depicted by the following twice differentiable, one-output, four-inputs production function:

$$Y = f(D,L,K,B), \tag{1}$$

where Y is output and D,L,K,B denote the inputs of deposit, labour, capital and borrowing, respectively[2]. We adopt the "intermediation approach" in which deposits combined with labor, capital and borrowing are assumed to be utilized to produce loans as output. Table 1 lists definitions of relevant variables. We model the production process as a one-output technology for Japanese banks to abstract from the study of economies of scope. While the literature is consistent in finding scale economies and technological change in banking, the consensus, though the evidence is mixed, holds that significant scope economies are hard to find in banking (see, e.g., Mester, 1987; and LeCompte and Smith ,1990)). Similarly, Clark (1994) reports large economies of scale for all classes of banks in the U.S., but no evidence of scope economies.

[2] Defining the inputs and outputs for a financial services firm's production process is a major problem in bank production economies studies. For an excellent discussion of the related issues see Clark, 1988.

Insert Table 1 here.

From duality theory, if producers pursue cost minimizing behavior, the production function can be uniquely represented by a dual cost function of the following form:[3]

$$C = h(y,w_i,t) \quad , \text{for } i = D,L,K \text{ and } B \qquad (2)$$

where, C is the total cost (including interest costs), w_i = input prices for i = D,L,K and B, and t is the index of time which proxies for technology. As Hunter and Timme (1991) describes, when time is used as an index of technology, any change in a bank's total cost, holding all other variables constant, is attributed to technological innovation. However, the variable, being a residual index, captures the effects of all other omitted variables including the impact of technology. Hence, caution should be exercised in interpreting the coefficients on the time indicator.

The explicit functional form assumed for equation (2) is the standard translog specification. A translog function provides a flexible functional form where it does not restrict the second-order properties of the cost structure examined.[4] The specification has also been used for characterizing Japanese banks' technologies (see, e.g., Uchida and Tsutsui, 2005)). A recent alternative to the translog functional form is a Fourier Flexible form, which augments the translog function by adding trigonometric terms of the log of output. The extra flexibility associated with the Fourier Flexible form is considered to provide a better fit to data (see, e.g., Bauer and Ferrier, 1996). However, comparing the two forms using data on 3100 Eurpean

---

[3] To be a valid representation of production technology, the cost function should satisfy three conditions: First, it should be a non-negative, non-decreasing function of output y; second, the cost function must be non-negative, non-decreasing, positively linearly homogeneous, concave and continuous in input prices w_i and, finally, it should be twice differentiable with respect to w_i (Chambers (1988)).

[4] In contrast to the conventional Cobb-Douglas or CES functional forms, the translog form enables the estimation of U-shaped average cost functions, for example.

banks, Altunbas and Chakravary (2001) find that despite the Fourier's within-sample fit, the translog form provides superior out-of-sample prediction, and cautions against the growing use of the Fourier specification. Berger and Mester (1997) have also compared the translog to the alternative Fourier Flexible form. Despite the latter's added flexibility, the difference in results between the methods appears to be negligible. Swank (1996) shows that the translog form is also more stable.

The translog form used for estimation is the following second-order Taylor series expansion of the cost function defined in eq. (2):

$$\ln C = B_0 + \Sigma_{i=1}^{4} B_i \ln w_i + 1/2\Sigma_{i=1}^{4}\Sigma_{j=1}^{4} B_{ij} \ln w_i \ln w_j + \Sigma_{i=1}^{4} B_{iy} \ln w_i \ln y + \Sigma_{i=1}^{4} B_{it} \ln w_i T + B_y \ln y + 1/2\, B_{yy} \ln y^2 + B_{yt} \ln y T + B_T T + 1/2\, B_{TT} T^2 \quad (3)$$

By Shephard's Lemma $d\ln C/d\ln w_i$ represents an equation for the cost share of input i. Hence, we have a system of equations, consisting of the cost function given in (3) and the following four share equations, one for each input i:

$$\ln C/\ln w_i = B_i + \Sigma_{j=1}^{4} B_{ij} \ln w_j + B_{iy} \ln y + B_{it} T, \quad i = D,L,K \text{ and } B. \quad (4)$$

Imposing the usual restrictions to reflect homogeneity of degree one in input prices ($\Sigma_{i=1}^{4} B_i = 1$; $\Sigma_{j=1}^{4} B_{ij} = 0$; $\Sigma_{i=1}^{4} B_{iy} = 0$; $\Sigma_{i=1}^{4} B_{it} = 0$) and symmetry ($B_{ij} = B_{ji}$). These restrictions imply dropping the share equation of one of the inputs, using the associated input price as a numeraire. The input price of borrowing was used as a numeraire in the estimation[5].

Having introduced the characterization of the production technology, the empirical

[5] Arbitrarily dropping one share equation raises the issue of whether parameter estimates would be insensitive to the choice of which equation is deleted. However, as long as Iterated Zellner's SUR are used on the remaining share equations, the estimated parameters estimates are invariant to the choice of the share equation. (Oberhofer and Kmenta (1974)).

investigation is organized in the following order. First, we provide a battery of tests to identify the global characteristics of the underlying technology and verify the appropriateness of the particular functional form adopted in the paper in representing this technology. This is done to avoid inappropriate inference owing to econometrically misrepresenting the technology. The empirical tests include tests of whether the underlying production process exhibits homotheticity, homogeneity, constant returns to scale, and whether it is consistent with a more restrictive Cobb-Douglas specification. In addition, to increase confidence in our inference and compare with bank technologies in other countries, we present standard estimates of elasticities of substitution among the identified bank inputs. Second, having established reasonable confidence on the data and estimation, the paper proceeds to investigate the focal issue of the study, namely, the extent of scale economies and its interaction with technological change to find a rationale for the current wave of mega mergers in the industry.

To evaluate the global characteristics of the banking technology, we impose the implied parametric restrictions and conduct standard comparison of the restricted models against the unrestricted translog version. A homothetic technology implies the restriction that

$$B_{yy} = B_{yt} = 0; \tag{5}$$

a homogeneous production function (homogeneous with respect to output) reflects the restrictions of

$$B_{iy} = 0, \text{ in addition to (5) above;} \tag{6}$$

and a technology that exhibits constant returns to scale requires the restriction of (in addition to (5) and (6))

$$B_y = 0. \tag{7}$$

Finally, a Cobb-Douglas specification implies, in addition to (5), (6) and (7), the following restriction:

$$B_{ij} = B_{iy} = 0. \quad (8)$$

To characterize the nature of the production process further as represented by the cost functions, we estimate the Allen elasticities of substitution and elasticities of conditional input demands. From the cost and share equations, the measures of the Allen elasticities of substitutions are defined as (where S_i = cost share of input i):

$$\sigma_{ij} = B_{ij}/S_i*S_j - 1/S_i + 1 \text{ , for } i = j \text{, and} \quad (9a)$$

$$\sigma_{ij} = B_{ij}/S_i*S_j + 1 \text{ for } i \neq j \quad (9b)$$

The related own- and cross-partial elasticities of conditional input demand are given by:

$$\varepsilon_{ij} = B_{ij}/S_i + S_i - 1 \text{ , for } i = j \text{, and} \quad (10a)$$

$$\varepsilon_{ij} = B_{ij}/S_i + S_j \text{ , for } i \neq j. \quad (10b)$$

2.2. Scale Economies

From the cost function, returns to scale[6] measures cost responses associated with changes in output, holding input prices constant. Scale economies are said to exist if an increase in output, at constant input prices, leads to a less than proportional increase in total costs, causing a decline in average costs.

Given a cost function of the form in (3), the measure of scale economies is defined as follows:

---

[6] Note that, although closely related, the measure of scale economies using the production function (elasticity of scale) is different from the measure of scale economies using the cost function (elasticity of size). The elasticity of scale measures how output changes as one moves out along a ray from the origin in an input space while the elasticity of size measures how cost responds as we move along the locus of cost-minimizing points in input space (i.e., along the expansion path). The two measures coincide only for homothetic production functions (i.e., where we have ray expansion path). In this paper, we will use the concepts of returns to scale and returns to size interchangeably.

$$S = 1/(d\ln C/d\ln y) = 1/\left[A_y + \Sigma_{i=1}^{4} B_{iy}\ln w_i + B_{yy}\ln y + B_{yT}T\right]. \qquad (11)$$

An estimate of S > 1 implies scale economies, indicating that an equiproportional increase in *all* inputs of a firm result in a more than proportional increase in output. Evidence of scale economies, other things constant, could be a rationale for consolidation.

2.3. Technological Change

Technological change refers to an inward movement in the production isoquants in the input space, in which the same level of output can be produced with at least one input bundle in which the quantities of each input is less than what used to be required. From the cost side, holding input prices constant, technological change permits the firm to produce the same level of output at lower expenditure. Given the cost function in (3), the rate of technological change (RTC) can be measured by:

$$RTC = - d\ln C/d\ln T = - (A_T + B_{TT}T + \Sigma_{i=1}^{4} B_{it}\ln w + B_{yt}\ln y) \qquad (12)$$

The estimate of technological change is composed of three components: (a) pure technological change, $A_T + B_{TT}T$; (b) input-biased (non-neutral) technological change, $\Sigma_{i=1}^{4} B_{it}\ln w$; and (c) scale-augmenting technological change, $B_{yt}\ln y$ (see Altunbas et al., 1999). Pure technical change is the rate of reduction in total costs attainable, holding constant both the efficient scale of production and the shares of each of the inputs in total cost. Technological change, however, can be biased with respect to inputs as well as with respect to the scale characteristics of the production technology. With regard to input biases, a technological change is Hicks-neutral, if the slope of the production isoquants is independent of technological change. A cost-neutral technological change, an analogous (but not equivalent) concept, refers to a technical change that does not affect relative cost shares of inputs. From the share equation in

(4), a measure of input bias in technological change is:

$$TIB = dlnSi/dlnT = B_{it},\ i = D, L, K \text{ and } B \qquad (13)$$

A TIB = 0 imply a neutral technical change. TIB > 0 and TIB < 0 imply ith factor-using and ith factor-saving technological advancements respectively.

Technological change could also be biased with respect to the scale property of the production technology. Technological change may be scale-biased or non-neutral in the sense that it might alter the range of outputs over which a given scale economies can be attained, thus resulting in a change in the cost-minimizing efficient firm size. Define the cost elasticity to be C=1/S, S=elasticity of scale. Technological scale bias is given by:

$$TSB = -(dC/Dt) = d\{-dlnC/dlny\}/dT = -B_{yt} \qquad (14)$$

A TSB > 0, implies that technological change increases scale economies and, conversely, if TSB< 0, scale economies are decreasing as a result of technological progress. A scale-increasing technological progress (TSB > 0) implies that the minimum efficient size (MES) at which the average cost is the lowest is increasing due to technological innovations. Thus, a scale-increasing technological change, other things constant, could induce industry consolidation over time; by contrast, a scale-decreasing technical change, could precipitate industry fragmentation.

3. Data

The data set includes end-of-year data on costs and outputs constructed from the financial statements of those Japanese banks with complete financial information for the sample period of 1974-1991. Data are obtained from Nihon Keizai Shimbun America, Inc. The Japanese banking system constitutes four functional categories of banks: City Banks, Long-Term Credit Banks, Trust Banks and Regional Banks. The City bank group is composed of the nation-wide branching financial institutions that are traditionally the major suppliers of short-term finance to the nation's large corporations. They also have significant client base from small businesses and the household sector. In 1996, for example, they account for close to 50 percent of the Japanese loan market (Uchida and Tsutsui, 2005). City banks fund their operations from deposit taking and short-term borrowings. They are also engaged in investment banking activities, have significant international operations, and represent some of the largest banks in the world.

The Long Term Credit banks are specialized banks, established under the Long Term Credit Bank Law of 1952 for the purpose of providing long-term finance to fund the nation's drive to industrialization. They are the only type of banks allowed to issue debentures to fund their lending operations. They are also distinguished from City banks by the length of maturity of their loans, which are considerably longer, and by the extent of their branch networks which are smaller. Two of the original three banks in this category have recently been privatized.

The other specialized banks are the Trust banks that are engaged in long-term financing as well as trust operations. They fund their operations from trust accounts, and provide long-term loans to mainly large corporations. In addition, they are engaged in saving and deposit activities, fund management, stock transfer and real-estate brokering activities.

Regional banks are ordinary banks that are engaged in deposit taking and financing of small businesses at a local level. They are smaller in size, and have limited branching with strong local ties. They raise funds from deposits much of which comes from the household sector, and provide business loans to medium and small enterprises, and invest in local and money markets.

There were 13 City banks, 3 Long-Term Credit banks, 11 Trust banks (including 4 saving and loan associations) and 132 Regional banks, at one time or another, during the sample period. Out of these, 11 City banks, 3 Long-Term Credit banks, 8 Trust banks, and 91 Regional banks have complete records over the entire sample period. The pooled cross-sectional time series data consists of 2034 usable data points.

Insert Table 2

Table 2 presents a summary of the data for the full sample. To standardize the data, the input prices were indexed using the input prices associated with the mean observation (i.e. the firm-year whose output is the closest to the mean output level) as base prices. There is a wide variation in both costs and output in the sample. At the mean level, deposits account for about 60 percent of costs, followed by labor and borrowing. Panel B provides a year-by-year summery of the average size and number of banks of the four types of banks included in the sample. The 11 city banks and the 3 Long-term banks represent the largest banks in the sample and the 91 regional banks, which constitute the majority, consist of the smallest banks.

4. Empirical Results

4.1. Tests of restrictions on the cost function

The cost function in equation (3) and three of the associated four share equations 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)).

The parameter estimates of equation (3), their standard errors and t-statistics are presented in Table 3[7]. All estimates except one are statistically significant at the one percent level. The goodness-of-fit measures for the cost equation and the estimated share equations are given in Panel B of Table 3.

Insert Table 3

Tests of the restrictions imposed on the cost and share functions reject the hypothesis of homotheticity implied in restrictions (5) (see Panel C of Table 3). The cost function, therefore, is not separable between output and input prices, indicating that the relationship among costs, output and input prices cannot be characterized globally.

The strong rejection of homotheticity implies rejection of homogeneity. The direct test for homogeneity, Panel C of Table 3, also rejects the hypothesis. Both global constant returns to scale and Cobb-Douglas specifications are also strongly rejected. In short, none of the assumptions underlying the more restrictive production structures offer a valid representation of the Japanese banking technology. The production technology over the sample period is consistent with a non-homothetic production process, also providing credence for the use of a less restrictive functional form, such as the translog cost function, as a representation of the underlying production process.

To further illuminate on the nature of the production process, Table 4 (Panel A) presents the estimates of the Allen elasticities of substitution computed at the point constituting the 'average' firm in the sample. First, we note that all inputs are substitutes[8]. Borrowing (a financial

---

[7]The matrix of the Allen substitution elasticities, evaluated at the mean of the sample, is negative semidefinete. The cost function is, therefore, concave. Monotonocity is satisfied as the fitted shares are positive at all **observations. Monotonocity** (with respect to output) is satisfied because dlnC/dlnY > 0 at the point of expansion (dlnC/dlnY = 1.0371184).

[8]Inputs are classified as complements if the Allen elasticity of substitution has a negative sign and substitutes if it has a positive sign.

input) is a strong substitute for each of the other factors. There is strong substitutability between the financial inputs (deposits and borrowing), which is consistent with previous research (see, e.g., Noulas et al., 1990 for large U.S. banks). The results also show strong substitutability between the physical inputs (labor and capital), which is again consistent with the extant literature on bank technology (see, e.g., Mester, 1987 and Murray and White, 1983) for the thrift industry in the U.S. and Canada, respectively, and Noulas et al., 1990)). The degree of substitution between deposits (a financial input) and the physical inputs (capital and labor) is relatively small.

Insert Table 4 here

The own- and cross-price elasticities of conditional input demands presented in Panel B of Table 4 provide results consistent with priors and available evidence. All own-price elasticities are negative, with all input demands except for borrowing being slightly price inelastic. The cross-price elasticities contain much of the same information contained in the elasticities of substitution and indicate substitutability among all inputs. Increases in cost of deposit induce increased use of borrowing but very slight response in labor and capital utilization. Bank borrowing in the open market (other than deposits) also responds relatively highly for increases in wages and capital costs. Bank borrowing, in this case, represents mainly bank issuance of marketable instruments such as notes. Increases in capital costs cause a modest increase in labor use. Overall, Table 4 provides additional assurance that our representation of the Japanese banking technology is reasonable and comparable to experiences in other countries.

4.2. Scale Economies

We now return to the main focus of the study, namely the evaluation of the extent of scale economies and technological change in the industry. Rejection of homotheticity (Table 3 above) implies that estimates of scale economies, technological change and elasticities are not constant across observations. As a result, therefore, we follow a convention described by Mester (1987), in which measures of the focal estimates of the paper (scale economies, technological change and elasticities) are evaluated for three representative banks. The first constitutes the observation consisting of the means of output and input prices (the "average" bank), the second is the minimum value of the output variable with mean values of input prices (the "small" bank), and the third is the maximum value of the output with mean values of input prices (the "large" bank). These bank types are identified both for the entire sample and for each banking categories (i.e., City, Long-Term, Trust and Regional banks). The 'average bank', the 'small bank' and the 'large bank' of a banking category consist, respectively, of the mean, the minimum and the maximum output value of the output variable (y) of the bank category with the overall mean values of input prices and the variable t. As these focal estimates are not linear functions of the estimated parameters, exact standard errors cannot be computed. The standard errors of the statistics that are nonlinear in parameter estimates are computed as the standard deviations of the first order Taylor series approximations of the respective statistics around the parameter estimates.[9]

Table 5 presents the estimates of scale elasticities, measured in accordance with

[9] To elaborate, let F be a vector of statistics that are functions of the vector of estimated parameters, B. The approximate variance-covariance matrix of the statistics is given by dFVdF', where, dF is the matrix of the gradients of F with respect to the parameters evaluated at the point estimates and V, being the variance-covariance matrix of the parameter estimates.

expression (11), for both the full sample and each of the bank categories. For the full sample, we have evidence that the scale measure decreases as bank size increases with 'small' banks exhibiting significant scale economies and 'average' and 'large' banks displaying significant dis-economies. This is consistent with the substantial evidence, based on the U.S. experience, as summarized in Clark (1988). The scale elasticity is significantly less than one for the 'average' and 'large' banks. The elasticity is significantly greater than one only for the 'small' banks. Relative to the wide variation in size, the differences in the scale measures do not appear to be significant.

Insert Table 5 here

As noted, the data set includes the few very large City and Long Term banks as well as the small regional banks that constitute the majority; thus the "average" bank at which the scale elasticity is evaluated is not truly representative. (The distribution of size is skewed to the left). In fact, observation of the estimates of scale over the entire data set reveals that about 80 percent of the sample has scale elasticity significantly higher than one. In other words, on a plot of average costs against output, which is a U-shaped, the majority (80 percent) of data points fall on the declining portion (i.e., an average cost function with a much longer declining portion). Thus, except at the few cases of extremely large size, there appears to be significant economies of scale for the majority of banks, particularly banks of smaller size than the "average" size. This is further supported by the sub-sample estimates for Regional banks. Note that Regional banks dominate the sample in number, constituting 91 of the 113 banks in the sample. Moreover, as shown in Table 2, regional banks tend to be small in size, the 'average' Regional banks being the smallest of the average banks of all other bank categories and smaller than the average bank for the full sample. The 'average' Regional bank exhibits significant scale economies. This evidence of scale economies in the majority of banks is consistent with Yoshioka and Nakajima (1987) in which they report significant economies of scale for Japanese City banks and Regional banks.

From the sub-sample estimates, we again observe declining scale elasticity as bank size increases in each bank category. For City bank and Trust bank categories, 'small' banks exhibit significant scale economies with 'average' and 'large' banks exhibiting substantial dis-economies. Long-Term Credit banks appear to be too big to benefit from scale economies. Cross-categorical differences in scale estimates are related to variation in bank size distributions across categories.

To investigate the behavior of scale economies over time, we first define the cost elasticity (C) to be the reciprocal of scale elasticity (S), so that $C < 1$ and $C > 1$ imply existence of economies and dis-economies of scale respectively. $dC/dT = B_{yt}$ measures the degree to which scale economies improve over time. A $dC/dT > 0$ imply that the percentage increase in cost due to a one percent increase in output increases over time, suggesting a decline in the degree of scale economies. Put differently, a $dC/dT > 0$ imply that the minimum efficient firm size (MES) – the firm size at which the long-run cost is at minimum - has decreased over time. This is the size of the firm in long run equilibrium, at which all economies of scale are exhausted.

The *negative* $dC/dT = B_{yt}$ in Table 3 implies that the degree of scale economies for the Japanese banking industry has, on the average, increased over the 1974-91 period. This is also evident from Panel B of Table 5 where the yearly estimates of scale elasticities for the typical bank are provided. The scale dis-economies of the ‘average’ size bank has decreased over the sample period – scale economies for such a bank improved from 0.89 in 1974 to 0.98 in 1991. The output level at which the minimum average cost could be attained has increased over the period, which is to say that the range of output over which average cost can be reduced through increase in scale has expanded over time. A related interpretation is to say that the attained technological advancement (discussed below) exhibits inherent positive scale bias. This finding is consistent with the evidence in Hunter and Timme (1986 and 1991) in which they report a positive scale-biased technological change for large U.S banks, whereby the cost-minimizing bank sizes increased. Furthermore, the evidence implies that the technological progress underlying bank production in Japan has been progressively favoring or requiring larger scale production, justifying the ongoing trend in the industry consolidation.

4.3 Technological Change

Estimates of the rates of technical change are presented in Table 6. Panel A presents estimates for representative banks for the entire sample period. For both the full sample and the sub-samples of bank categories, we have evidence of significant technological advancement in the Japanese banking industry over the sample period. The 'average' bank of the sample exhibits a rate of technical change of 0.011456 (i.e., holding output constant, a decrease in total cost at a rate of 1.1456% per annum); the largest banks experienced a 2.1045% annual reduction in cost; and the smallest banks exhibited no technical change. The results are qualitatively similar across bank categories, with the largest cost savings reported for City banks and the smallest for Regional banks. In Panel B, the rate of technical change has steadily increased during the sample period from 0.5% per annum in 1974 to 1.7% in 1988 and 1.3% in 1991. The overall evidence on existence of technical change is consistent with Hunter and Timme (1986 and 1991) in which they also report significant technological change for large U.S. banks.

Insert Table 6

Furthermore, the rate of technical change (i.e., the percentage reduction in cost per annum) increases with bank size, with the 'small' bank and the 'large' bank, of both the full sample and the respective sub-sample of bank categories, experiencing the smallest and the largest rates in the respective categories. In fact the cross-categorical differences in the rate of technical change are related to variations in size distribution of banks across categories.

To provide more insight into the relationship between technological change and scale, we define TSB = d{- dlnC/dT)}/dlnY (i.e., the derivative of the rate of technical change with respect to scale). From equation (14), TSB = $-B_{yt}$. From Table 3, TSB = 0.0036 with a t-stat of 4.99, implying that larger Japanese banks attain significantly higher rate of technical change than smaller banks. While this may not be conclusive about differences in the innovative capacity of banks of different size,[10] the evidence indicates that technological change operated to reduce costs for larger banks more rapidly than for smaller banks. The question of innovative advantages aside, therefore, a public policy that promotes larger banks appear to be justified on the basis of the discriminatory effects of technological change which tend to favor larger banks.

Moreover, the technological change appears to be biased with respect to factor use. The measures of factor share bias, TIB = B_{it} (in accordance with equation (13)) are positive for deposits and negative for labor, capital and borrowing (see Table 3), all being statistically

---

[10]An issue related to the relationship between scale and technological change concerns whether larger firms innovate faster than smaller firms. Large-scale operation might be argued to be conducive for technological advancements. The traditional Galbraith-Schumpter hypothesis is that, since development of innovations is costly, large firms operating with larger research budget should be able to innovate faster than small-scale firms, reducing costs at a faster rate than small-scale firms do (Stevenson (1980)). Also certain technical advances can only be utilized in large-scale firms. Some production techniques may not be employed by or simply may not be available to small-scale firms.

significant. The cost share of deposit input goes up while that of labor, capital and borrowing falls.

Another perspective can be gained from decomposing the total technical change into its components – pure, scale augmenting and input biased technical changes. From Table 2, the coefficients of pure technical change, A_T and B_{TT} are both positive and significant, implying that the impact of pure technical change has been to increase rather than decrease total costs during the period. One the other hand, the coefficient of the scale augmenting technical change, B_{yt}, is negative and significant. This implies that the technological change has been scale biased, increasing the efficient minimum size of production; this bias, in turn has resulted in cost reductions for banks at an increasing rate during the sample period. The impact of input bias technical change has been to increase the use of deposit at the expense of the other inputs. The decomposition of the rate of technological change for the 'average' bank, which is 1.145 % is -3.93% attributable to pure technical change, -0.27% to input-biased technical change, and 5.35% attributable to scale augmenting technical change. Thus it appears that the inherent scale-bias of the technological change was a significant force that was dictating the economics of bank production during the sample period.

As a comparison, these findings for Japanese banks are broadly consistent with what has been documented for U.S. banks in the 80s and early 90s. A number of studies measured productivity growth, including technical change for U.S. banks in the 1980s. Summarizing the literature, Berger (2003) concludes that a general finding was that bank productivity growth was negative in early 1980s and may have improved slightly in the latter 1980s and early 1990s. Stiroh (2001) and Berger and Mester (2003) report increases in total cost for U.S. banks over

1991 through 1997. Humphrey (1993) finds that technical change had a negative impact in the U.S. after deregulation. Berger and Mester (2003) find a decline in bank productivity of 12.5% per annum, reflecting mainly negative impacts of technical change, while at the same time reporting positive profit productivities. This could be a reflection that banks have provided an improved set of services (e.g., mutual funds, on-line services, etc.) that has increased bank costs, and that they were able to raise revenue to cover these costs. However, for this to happen, the banks must have enjoyed some form of market power, perhaps through increased scale.

To summarize, the foregoing provides evidence of technological patterns that favor industry concentration. On the one hand, the production technology exhibits existence of static diseconomies of scale for the largest banks during the period, defying, prima-facie, the logic for consolidation. On the other hand, the evidence also indicates an underlying technological progress that has been operating to increase the comparative advantages of large-scale operations in the industry. First, the size of the scale economies has been increasing over time. This means that the technological progress has been operating to increase the minimum efficient size, the scale of operation at which total cost is minimized, making large-scale production the efficient competitive size. Second, the production process exhibits a scale-biased technological progress, a process whereby technological innovations and inventions appear to benefit larger-scale production. We should also note that diseconomies were not pervasive throughout the industry; in fact, the majority of the banks, Regional banks in particular, exhibit economies of scale. Hence, contrary to the implications of the observation on the static diseconomies of scale, the dynamics of the technological progress that has been shaping the Japanese industry provides strong rationale for bank consolidation and concentration.

5. Scale Economies and Technological Progress in 1982-91

To check for the robustness of the results so far, we present additional evidence based on the industry's experience during the sub-period in the 1980s. The banking sector of Japan underwent a series of liberalization during this period. While the financial reform of the industry had many facets and has been a continuous process, the consensus is that one of the major events that marked the beginning of the reform process is the passage of the 1981 New Japanese Bank Law (see, e.g., Bank of Japan (1995)). We evaluate scale economies and technological change over the relatively more liberalized period of the sample period over 1982 through 1991.

The results are presented in Table 7. Again the cost function is consistent with a non-homothetic production process. Panel A indicates that, as in the full sample, during this sub-period, the industry exhibits significant diseconomies of scale. Economies of scale decrease as bank size increases with 'small' banks exhibiting significant scale economies and 'average' and 'large' banks displaying significant dis-economies. The sub-sample estimates, in each bank category, also show declining scale elasticity with increase in bank size. For Long-term bank and City bank categories, all sizes of firms exhibit substantial dis-economies while the small and average Regional firms report significant economies of scale. Cross-categorical differences in scale estimates are related to variation in bank size distributions across categories.

Again, although the 'mean' bank of the sample reports dis-economies, the majority of banks have smaller size than the average firm. The distribution of firm size is skewed to the left. Observation of the estimates of scale economies over the entire data set reveals that, in both sub-periods, the majority of banks have scale elasticity significantly higher than one. Thus, except at the few cases of extremely large size, there appears to be significant economies of scale for the majority of banks. This is further supported by the presence of significant scale economies in Regional banks, which constitute above 80 percent of the sample.

Moreover, the behavior of scale economies during this sub-period indicates a technological progress that significantly increased the minimum efficient size. Defining C to be the cost elasticity (1/S), the dynamics of scale elasticity over time is measured by dC/dT, which is evaluated to be significantly negative for the sub-period, implying increases in the minimum efficient size. dC/dT= B_{yt} = -0.0020562 (with standard error of 0.000239) for the sub-period.

Panel B reports the estimates of rates of technical change (RTC) for the sub-period. We have evidence of significant technological advancement in Japanese banking industry over the sub-period. The 'average' bank of the sample exhibits a rate of technical change of 0.013864 (i.e., holding output constant, a decrease in total cost at a rate of 1.3864 percent per annum); the largest firm experienced a 1.718 percent annual reduction in cost; and the smallest firm exhibits no technical change. The results are qualitatively similar across bank categories, with the largest cost savings reported for city banks and the smallest for regional banks. Cross-categorical differences in the rate of technical change are related to variations in size distribution of banks across categories.

Furthermore, the technological progress exhibits significant scale bias. TSB = d{-dlnC/dT)}/dlnY measures the impacts of scale on technological change, and are -B_{yt} = 0.0020562. This is consistent with the presence of underlying technical progress that is evolving to increase the comparative advantages of larger-scale bank production relative to small banks.

The evidence based on the data in the 1982-91 sub-period supports the main results from the full sample. While Japanese banks exhibit significant scale diseconomies, particularly at large banks, before the onset of the recent banking crises and subsequent reform, there is evidence of an underlying technological progress that worked to increase the efficient size of the average bank. Hence, the dynamics of technological change that has been operating to favor and necessitate large-scale banking, despite the observation of diseconomies, provide the economic rational for consolidation in the industry.

5. Conclusion

The unprecedented structural reform of the Japanese Banking industry has prompted questions about its economic rationale. While industry consolidation presupposes the existence of some form of economies of large-scale production, recent studies fail to find significant scale economies to justify the recent wave of mergers and consolidation. This paper argues that the rationale for the recent trend in consolidation lies in the nature of the technological progress that has swept the industry in recent times.

In spite of observation of diseconomies of scale, there has been an underlying change in bank technology that has increased the minimum efficient size as well as favored large banks to smaller ones. Studying the evolution of the industry over a relatively long period of 1974 through 1991, the paper examines the degree of scale economies and the dynamics of the technological progress of the underlying banking production. It reports slight dis-economies of scale for particularly the large banks, and significant scale economies for smaller banks, that constitute about 80 percent of the industry. This is particularly true for Regional banks that dominate the industry in number. On the other hand, the evidence shows existence of a technological change that has operated to lower the cost of production, with larger banks achieving higher cost reductions. There is evidence that the underlying technological progress has increased the comparative advantages of large-scale production in the industry. Furthermore, and more directly, the evidence shows that, over the period, the underlying technological progress sweeping the industry has been increasing the industry's minimum efficient size – i.e., the scale of production at with total cost is minimized. Hence, the technological dynamics that have been operating to favor and necessitate large-scale banking, despite the observation of diseconomies, provide the economic logic for consolidation in the industry. The results further suggest that, to the extent that consumers can benefit from lower costs of bank production, policies that promote a more concentrated banking structure would not be inconsistent with public interest.

References

Altunbas, Y., M. Liu, P. Molyneux and R. Seth, 2000, Efficiency and risk in Japanese banking, Journal of Banking and Finance 24, 1605-28.

Altunbas, Y. and S. P. Chakravarty, 2001, Frontier cost functions and bank efficiency, Economics Letters 72, 233-40.

Altunbas, Y., J. Goddard and P. Molyneux, 1999, Technical change in banking, Economic Letters 64, 215-21.

Bauer, P. and G. D. Ferrier, 1966, Scale Economies, cost efficiencies, and technological change in federal reserve payments processing, Journal of Money, Credit, and Banking 28, 1004-39.

Bank of Japan, 1995, Financial system in Japan (edition in Japanese), Bank of Japan, Tokyo.

Bell, F. and N. Murphy, 1968, Costs in commercial banking: A quantitative analysis of bank behavior and its relation to bank regulation, Research Report No. 40 (Federal Reserve Bank of Boston).

Benston, G., 1965, Branch banking and economies of scale, Journal of Finance 20, 312-331.

Benston, G., 1972, Economies of scale in financial institutions, Journal of Money Credit and Banking 4, 312-341.

Benston, G., G. Hanweck and D. Humphrey, 1982, Scale economies in banking: A restructuring and reassessment, Journal of Money Credit and Banking, 435-456.

Berger, A. N., 2003, The Economic effects of technological progress: Evidence from the banking industry, Journal of Money, Credit, and Banking 35,141-76.

Berger, A., G. Hanweck and D. Humphrey, 1987. Competitive viability in banking. Journal of Monetary Economics 20, 501-520.

Berger, A.N. and L. J. Mester, 1997, Inside the black box: what explains differences in the efficiencies of financial institutions, Journal of Banking and Finance 21, 895-947.

Berger, A.N. and L. J. Mester, 2003, Explaining the dramatic changes in the performance of U.S. Banks: technological change, deregulation, and dynamic changes in competition, Journal of Financial Intermediation 12, 57-95.

Chambers, R., 1988, Applied Production Analysis: A Dual Approach (Cambridge University Press).

Clark, J., 1988, Economies of scale and scope at depository financial institutions: A review of the literature, Economic Review 73, 16-33 (Federal Reserve Bank of Kansas).

Clark, J., 1994, Economies of scale and scope in banking: evidence from a generalized translog cost function, Quarterly Journal of Business and Economics 33, 3-25.

Drake, L. and M. L. Hall, 2003, Efficiency in Japanese banking: An empirical analysis, Journal of Banking and Finance 27, 891-917.

Fields, J., N. Murphy and D. Tirtiroglu, 1993, An international comparison of scale economies in banking: evidence from Turkey, Journal of Financial Services Research 7, 111-125.

Fukuyama, H., 1993, Technical and scale efficiency in Japanese commercial banks: A non-parametric approach, Applied Economics 25, 1101-12.

Gilligan, T. and M. Smirlock, 1984, An empirical study of joint production and scale economies in commercial banking, Journal of Banking and Finance 8, 67-77.

Gilligan, T., M. Smirlock and W. Marshall, 1984, Scale and scope economies in the multiproduct banking firm, Journal of Monetary Economics 13, 393-405.

Greenbaum, S., 1967, A study of bank costs, National banking review 4, 415-434.

Hall, M.J.B., 1999, Japan's big bang: The likely winners and losers, Journal of International Banking Law 7, 204-16.

Humphrey, D.B., 1993, Cost and technical change: effects from bank deregulation, Journal of Productivity 4, 9-34.

Hunter, W. and Timme, S., 1986, Technical change, organizational form, and the structure of bank production, Journal of Money, Credit and Banking, 152-166.

Hunter, W. and S. Timme, 1991, Technological change in large U.S. commercial banks, Journal of Business 64, 339-362.

Kane, E. and H. Unal, 1988, Capital positions of Japanese banks, in: Rhee, S. G. and R.P. Chang, eds., Pacific-Basin Capital Markets Research 2,125-41 (North Holland).

Kim, Y., 1986, Economies of scale and scope in multiproduct financial institutions: further evidence from credit unions, Journal of Money, Credit, and Banking 18, 220-226.

Kim, M., 1986, Banking technology and the existence of a consistent output aggregate, Journal of Monetary Economics 18,181-195.

Kmenta, J. and R. Gilbert, 1968, Small sample properties of alternative estimators of seemingly unrelated regressions, Journal of American Statistical Association 63, 1180-2000.

McKillop, D.G., J.C. Glass and Y. Morikawa, 1996, The composite cost function and efficiency in giant Japanese banks, Journal of Banking and Finance 20, 1651-71.

LeCompte, R. and S. Smith, 1990, Changes in the cost of intermediation: the case of saving and loans, Journal of Finance 45, 1337-46.

Mester, L.,1987, A multiproduct cost study of savings and loans, Journal of Finance 42, 423-445.

Murrey, J. and W. White, 1983, Economies of scale and economies of scope in multiproduct financial institutions: A study of British Columbia credit unions, Journal of Finance 3, 887-902.

Noulas, A., S. Ray and S. Miller, 1990, Returns to scale and input substitution for large U.S. banks, Journal of Money Credit and Banking 22, 95-107.

Oberhofer, W. and J. Kmenta, 1974, A general procedure for obtaining maximum likelihood estimates in generalized regression models, Econometrica 42, 579-590.

Stiroh, K.J., 2001, How did bank holding companies prosper in the 1990s?, Journal of Banking and Finance 24, 1703-45.

Stevenson, R., 1980, Measuring technological bias, The American Economic Review 70, 163-73.

Swank, J., 1996, How stable is the multi-product translog cost function: Evidence from the Dutch banking industry, Kredit und Kapital 29, 53-172.

Tachibanaki, T., K. Mitsue, and H. Kitagawa, 1991, Economies of scope and shareholding of banks in Japan, Journal of Japanese and International Economies 5, 261-281.

Yoshioka, K. and T. Nakajima, 1987, Economies of scale in Japan's banking industry, Bank of Japan Monetary and Economic Studies 5, 35-70.

Uchida, H., and Tsutsui, Y., 2005, Has competition in the Japanese banking sector improved? Journal of Banking and Finance 29, 419-439.

Table 1: Variable Definitions

Output (y)	Personal loans + industrial loans + investments in cash dues
and	securities
Costs (C)	personnel expenditures + fees and commissions + capital related expenses + interest expenses
Inputs:	
Labor (L)	number of employees
Capital (K)	area of building occupied by the bank's facilities
Deposits (D)	total deposits
Borrowing (B)	total funds borrowed from intermediary sources
Input Prices:	
Labor (w_L)	Personnel expenditures/# of employees
Capital (w_K)	Capital costs (Depreciation, rentals etc)/area of building
Deposits(w_D)	interest on deposits/total deposits
Borrowing(w_B)	interest costs of funds obtained/total borrowing

Table 2: Summary of Data

Panel A: Summary of variables

Variable		Minimum Value	Mean Value	Maximum Value
C	Total Cost (million Yen)	2821	203067	4210019
y	Output (million Yen)	110470	3186165	46518392
SD	Share of Deposits	.00757	.599519	.812597
SL	Labor share	.018473	.194755	.374311
SK	Capital share	.01186	.093599	.210333
SB	Share of Borrowing	.000945	.112127	.869266
w_D	Price of Deposits	.000786	.033870	.100504
w_L	Price of Labor	.925023	5.031902	14.9334
w_K	Price of Capital	.011799	.086060	0.907335
w_B	Price of Borrowing	.014111	.277735	0.437200

Panel B: Size of the average bank and the number of banks in the sample by year

Year	City Banks	Regional Banks	Trust Banks	Long Term Banks	Year	City Banks	Regional Banks	Trust Banks	Long Term Banks
1974	15.55 (11)	13.24 (91)	14.88 (8)	15.64 (3)	1983	16.58 (11)	14.19 (91)	15.81 (8)	16.50 (3)
1975	15.66 (11)	13.38 (91)	15.00 (8)	15.78 (3)	1984	16.70 (11)	14.28 (91)	15.97 (8)	16.62 (3)
1976	15.76 (11)	13.51 (91)	15.11 (8)	15.88 (3)	1985	16.74 (11)	14.34 (91)	16.05 (8)	16.68 (3)
1977	15.86 (11)	13.62 (91)	15.18 (8)	15.96 (3)	1986	16.90 (11)	14.42 (91)	16.20 (8)	16.77 (3)
1978	15.97 (11)	13.75 (91)	15.25 (8)	16.03 (3)	1987	17.02 (11)	14.52 (91)	16.25 (8)	16.89 (3)
1979	16.10 (11)	13.86 (91)	15.34 (8)	16.09 (3)	1988	17.15 (11)	14.63 (91)	16.36 (8)	16.96 (3)
1980	16.20 (11)	13.93 (91)	15.45 (8)	16.21 (3)	1989	17.31 (11)	14.78 (91)	16.51 (8)	17.10 (3)
1981	16.38 (11)	14.03 (91)	15.61 (8)	16.33 (3)	1990	17.43 (11)	14.89 (91)	16.52 (8)	17.15 (3)
1982	16.49 (11)	14.11 (91)	15.76 (8)	16.44 (3)	1991	17.44 (11)	14.91 (91)	16.51 (8)	17.16 (3)

Table 3: Estimate of the Cost Function

Panel A: Parameter Estimates

Parameter	Estimate	Std Err	T-stat	Prob>|T|
A0	2.140025	0.44548	4.80	0.0001
A1	0.357368	0.02823	12.66	0.0001
A2	0.848069	0.0094660	89.59	0.0001
A3	0.358044	0.0055355	64.68	0.0001
AY	-0.292148	0.06408	-4.56	0.0001
AT	0.029323	0.0098414	2.98	0.0029
B11	0.134691	0.0030313	44.43	0.0001
B12	-0.105281	0.0019550	-53.85	0.0001
B13	-0.051066	0.0011483	-44.47	0.0001
B1Y	0.006624	0.0019577	3.38	0.0007
B1T	0.010831	0.0004378	24.74	0.0001
B22	0.100367	0.0017828	56.30	0.0001
B23	0.002000	0.0009538	2.10	0.0361
B2Y	-0.038541	0.0006345	-60.74	0.0001
B2T	-0.007720	0.0001769	-43.64	0.0001
B33	0.045861	0.0008693	52.76	0.0001
B3Y	-0.016601	0.0003685	-45.05	0.0001
B3T	-0.002214	0.0000999	-22.15	0.0001
BYY	0.088088	0.0046300	19.03	0.0001
BYT	-0.003576	0.0007172	-4.99	0.0001
BTT	0.001054	0.0002941	3.59	0.0003

Panel B: Goodness-of-fit Measures

Equation	DF	SSE	MSE	Adj R-Sq
LTC	2003	62.41184	0.03116	0.9909
SDEPOSIT	2013	21.80300	0.01083	0.1519
SLABOR	2013	1.71090	0.0008498	0.8047
SCAPITAL	2013	0.54938	0.0002729	0.6432

Panel C: Structural Tests

Test	Restrictions	LLR	Π^2 (at 0.001)
Homotheticity	4	2046.20	18.5
Homogeneity	5	2124.81	20.5
CRS	6	1955.35	22.5
Cobb-Douglas	12	4814.18	32.9

Table 4: Elasticity of Substitution

Panel A: Allen Elasticities

	Deposit	Labor	Capital	Borrowing
Deposit	-0.29326*			
	(0.08433)			
Labor	0.09831*	-1.4885*		
	(0.01674)	(0.04700)		
Capital	0.08997*	1.1097*	-4.4491*	
	(0.02046)	(0.0532)	(0.09923)	
Borrowing	1.3222*	1.1335*	1.3054*	-10.1277*
	(0.03213)	(0.03626)	(0.04376)	(0.21118)

Panel B: Direct Elasticities

	Deposit	Labor	Capital	Borrowing
Deposit	-0.17582*	0.019146*	0.008421*	0.14825*
	(0.00506)	(0.00326)	(0.00192)	(0.00360)
Labor	0.058937*	-0.28989*	0.10387*	0.12709*
	(0.00990)	(0.00902)	(0.00483)	(0.00401)
Capital	0.053938*	0.21612*	-0.41643*	0.14637*
	(0.01227)	(0.01019)	(0.00929)	(0.004907)
Borrowing	0.79266*	0.22074*	0.122218*	-1.13558*
	(0.0000)	(0.00706)	(0.00410)	(0.023668)

* Significant at 1%.

Table 5: Elasticity of Scale Estimates

Panel A: Scale Elasticity estimates over full sample period.

Bank Type	'Small' Bank	'Average' Bank	'Large' Bank
Long Term Credit Banks*	0.97119	0.86270	0.80588
	(0.00205)	(0.00856)	(0.01283)
City Banks*	1.00529	0.85246	0.78537
	(0.00118)	(0.00929)	(0.01452)
Regional Banks*	1.41466	1.05168	0.87017
	(0.01531)	(0.00272)	(0.00804)
Trust Banks*	1.34662	0.91670	0.83148
	(0.01344)	(0.00503)	(0.01083)
Full Sample*	1.41466	0.96421	0.78537
	(0.01531)	(0.00238)	(0.01452)

Panel B: Yearly estimates of Scale Elasticity for the "Average" bank.

1974	0.896089*	1983	0.973987*
	(0.0024)		(0.0023)
1975	0.914615*	1984	0.964235*
	(0.0034)		(0.0024)
1976	0.924334*	1985	0.970613*
	(0.0032)		(0.0023)
1977	0.936865*	1986	0.982246*
	(0.0029)		(0.0021)
1978	0.936648*	1987	0.976554*
	(0.0032)		(0.0023)
1979	0.934204*	1988	0.99273*
	(0.0031)		(0.0020)
1980	0.931084*	1989	0.996069*
	(0.003)		(0.00198)
1981	0.944056*	1990	0.988869*
	(0.0027)		(0.00216)
1982	0.961146*	1991	0.978255*
	(0.0040)		(0.00219)

The 'average' bank represents the observation consisting of the average of output and input prices, the "small" bank represents the observation with the minimum value of the output variable with mean values of input prices, and the "large" bank constitutes the observation with the maximum value of the output with mean values of input prices.
* Significant at 1%. Figures in parenthesis are approximate standard errors of 1/S, where S= elasticity of scale.

Table 6: Estimates of Rates of Technical Change

Panel A: Rates of Technical Change over full sample period.			
Bank Type	'Small' Bank	'Average' Bank	'Large' Bank
Long Term Credit Banks	0.011153*	0.016411*	0.019729*
	(0.00098)	(0.00176)	(0.00237)
City Banks	0.009350*	0.016976*	0.021045*
	(0.00088)	(0.00186)	(0.00261)
Regional Banks	-0.0019532	0.0079534*	0.016007*
	(0.002037)	(0.001303)	(0.00169)
Trust Banks	-0.0005028	0.013638*	0.018178*
	(0.002037)	(0.001303)	(0.002078)
Full Sample	-0.0019532	0.011456*	0.021045*
	(0.002305)	0.001013)	(0.00261)

Panel B: Yearly estimates of Rates of Technical Change.			
1974	0.005409*	1983	0.011063*
	(0.0014)		(0.00108)
1975	0.005973*	1984	0.011838*
	(0.0013)		(0.001148)
1976	0.007818*	1985	0.012422*
	(0.00128)		(0.001318)
1977	0.009668*	1986	0.014648*
	(0.00125)		(0.001133)
1978	0.012363*	1987	0.016564*
	(0.00133)		(0.001211)
1979	0.010596*	1988	0.017154*
	(0.00129)		(0.00115)
1980	0.007699*	1989	0.016146*
	(0.00123)		(0.001112)
1981	0.009246*	1990	0.012402*
	(0.001193)		(0.001059)
1982	0.010307*	1991	0.012797*
	(0.001126)		(0.00108)

The ‘average’ bank represents the observation consisting of the averages of the output variable and input prices, the “small” bank represents the observation with the minimum value of the output variable with mean values of input prices, and the “large” bank constitutes the observation with the maximum value of the output with mean values of input prices.

* Significant at 1%.

Table 7: Estimates of Elasticity of Scale and Technological Change (1982-1991)

Bank Type	'Small' Bank	'Average' Bank	'Large' Bank
	Panel A: Elasticity of Scale		
Long Term Credit Banks	0.97100*	0.87712*	0.82668*
	(0.0000)	(0.00976)	(0.01540)
City Banks	0.99986*	0.86810*	0.80824*
	(0.0000)	(0.01073)	(0.01762)
Regional Banks	1.32432*	1.03865*	0.88368*
	(0.02045)	(0.00331)	(0.00907)
Trust Banks	1.27306*	0.92424*	0.84952*
	(0.01802)	(0.00488)	(0.01278)
Full Sample	1.32432*	0.96505*	0.80824*
	(0.02045)	(0.00643)	(0.01762)
	Panel B: Technological Change		
Long Term Credit Banks	0.013759*	0.015577*	0.016725*
	(0.00629)	(0.00703)	(0.00792)
City Banks	0.013269*	0.015773*	0.01718*
	(0.00627)	(0.00716)	(0.00834)
Regional Banks	0.009228	0.012653*	0.015438*
	(0.00868)	(0.00635)	(0.00694)
Trust Banks	0.097291	0.014619*	0.016188*
	(0.00819)	(0.01386)	(0.01718)
Full Sample	0.009227	0.013864*	0.017180*
	(0.00868)	(0.00630)	(0.00834)

* Significant at 1%. Figures in parenthesis are approximate standard errors for 1/S, where S=elasticity of scale

DAVIDSON INSTITUTE WORKING PAPER SERIES - Most Recent Papers

The entire Working Paper Series may be downloaded free of charge at: www.wdi.umich.edu

CURRENT AS OF 06/25/07

Publication	Authors	Date
No. 878: Consolidation, Scale Economics & Technological Change in Japanese Banking	Solomon Tadesse	Feb 2005
No. 877: Innovation, Information and Financial Architecture	Solomon Tadesse	June 2007
No. 876: Corporate Cash Holdings, National Culture, and Multinationality	Andres Ramirez and Solomon Tadesse	June 2007
No. 875: The Economic Value of Regulated Disclosure: Evidence from the Banking Sector	Solomon Tadesse	Jan 2006
No. 874:Banking Fragility & Disclosure: International Evidence	Solomon Tadesse	Sept 2006
No. 873: The Impact of Outward FDI on Home-Country Employment in a Low-Cost Transition Economy	Jaan Masso, Urmas Varblane and Priit Vahter	May 2007
No. 872: Local Distributional Effects of Government Cash Transfers in Chile	Claudio A. Agostini and Philip Brown	May 2007
No. 871: How do Workers Fare During Transition?Perceptions of Job Insecurity among Russian Workers, 1995-2004	Susan J. Linz and Anastasia Semykina	April 2007
No. 870: Does Reform Work? An Econometric Examination of the Reform-Growth Puzzle	Ian Babetskii and Nauro Campos	April 2007
No. 869: Perceptions and Behavior: Analyzing Wage Arrears in Russia	Susan Linz, Anastasia Semykina and Charles Petrin	June 2006
No. 868: The Endogeneity of Association Agreements and their Impact on Trade for Eastern Countries: Empirical Evidence for Romania	Christophe Rault, Ana Maria Sova and Robert Sova	April 2007
No. 867: Institutions & Entrepreneurship Development in Russia: A Comparative Perspective	Saul Estrin, Ruta Aidis and Tomasz Mickiewicz	Feb 2007
No. 866: Dutch Disease Scare in Kazakhstan: Is it real?	Balázs Égert and Carol S. Leonard	March 2007
No. 865: Minimum Wage and Tax Evasion: Theory and Evidence	Mirco Tonin	Jan 2007
No. 864: Dynamics of the Financial Wealth of the Institutional Sectors in Bulgaria: Empirical Studies of the Post-Communist Period	Nikolay Nenovsky and Gergana Mihaylova	March 2007
No. 863: Impact of Derivatives Trading on Emerging Capital Markets: A Note on Expiration Day Effects in India	Sumon Kumar Bhaumik and Suchismita Bose	March 2007
No. 862: Short- & Medium- Term Determinants of Current Account Balances in Middle East & North Africa Countries	Aleksander Aristovnik	March 2007
No. 861: Time-Varying Comovements in Developed and Emerging European Stock Markets: Evidence from Intraday Data	Balázs Égert and Evžen Kočenda	March 2007
No: 860: Giving Children a Better Start: Preschool Attendance & School-Age Profiles	Sam Berlinski, Sebastian Galiani and Marco Manacorda	Jan 2007
No. 859: Real Exchange Rates in Small open OECD & Transition Economies: Comparing Apples with Oranges?	Balázs Égert, Kirsten Lommatzsch and Amina Lahreche-Revil	Jan 2007
No. 858: Is Education the Panacea for Economic Deprivation of Muslims? Evidence from Wage Earners in India, 1987-2004	Sumon Kumar Bhaumik and Manisha Chakrabarty	Jan 2007
No. 857: Human Capital, Economic Growth, and Regional Inequality in China	Belton Fleisher, Haizheng Li and Min Qiang Zhao	Jan 2007
No. 856: Does Better Environmental Performance Affect Revenues, Costs, or Both? Evidence From a Transition Economy	Dietrich Earnhart and Lubomir Lizal	Feb 2007
No. 855: Media Coverage & Charitable Giving After the 2004 Tsunami	Philip Brown and Jessica Minty	Dec 2006
No. 854: Default Rates in the Loan Market for SMEs: Evidence from Slovakia	Jarko Fidrmuc, Christa Hainz and Anton Maleisch	Nov 2006
No. 853: Monetary Policy before Euro Adoption: Challenges for EU New Members	Jan Filáček, Roman Horváth and Michal Skorepa	Nov 2006