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HOMMA Tetsushi
University of Toyama

TSUTSUI Yoshiro
Osaka University

UCHIDA Hirofumi
Kobe University

Research Institute of Economy, Trade & Industry, IAA

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Firm Growth and Efficiency in the Banking Industry: A new test of the efficient structure hypothesis†

HOMMA Tetsushi

Faculty of Economics, University of Toyama

TSUTSUI Yoshiro

Graduate School of Economics, Osaka University

and

UCHIDA Hirofumi‡

Graduate School of Business Administration, Kobe University

Abstract

This paper proposes a new test of the *efficient structure hypothesis* by directly examining the relation between firm efficiency and firm growth. This is also a test of the so-called *quiet-life hypothesis*. Applying this test to large banks in Japan, we find that more efficient banks become larger, which is consistent with the efficient structure hypothesis. We also find that market concentration reduces banks' cost efficiency, which is consistent with the quiet-life hypothesis. These findings imply that there is an intriguing growth-efficiency dynamic throughout the life cycle of banks, although yet another finding suggests that the economic impact of the quiet-life hypothesis is less significant than that of the efficient structure hypothesis.

Keywords: Firm growth, Cost efficiency, Efficient structure hypothesis, Quiet-life hypothesis

JEL classification codes: L11, G21

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‡ Corresponding Author: Graduate School of Business Administration, Kobe University, 2-1 Rokkodai, Nada, Kobe 657-8510, Japan. Tel.& Fax.: 81-78-803-6949, E-mail: uchida@b.kobe-u.ac.jp.

1. Introduction

As proposed by Demsetz (1973), the *efficient structure hypothesis* (hereafter the ES hypothesis) predicts that under the pressure of market competition, efficient firms win the competition and grow, so that they become larger, obtain greater market share, and earn higher profits. As a result, the market becomes more concentrated. Under this hypothesis, a market becomes more efficient as it becomes more concentrated, so that anti-concentration measures cause unnecessary distortion in the economy.

This implication of the ES hypothesis is in sharp contrast with that of the *structure-conduct-performance hypothesis* (hereafter the SCP hypothesis). The SCP hypothesis predicts that a concentrated market engenders a low degree of competition, leading to market inefficiency, e.g., monopolistic pricing and excess (monopoly) profits. Similar to the ES hypothesis, the SCP hypothesis also predicts a positive relation between concentration and profits, but through a completely different mechanism. This hypothesis does call for anti-concentration measures.

Partly due to these contrasting predictions, the ES hypothesis has been "tested" in earlier empirical studies in the context of a test of the SCP hypothesis. As per the standard test of the SCP hypothesis, these studies regress a market performance variable (e.g., the market price or firm profitability) on a market structure variable (e.g., a measure of market concentration).

However, they add market share as an additional independent variable, and if market share has a has a positive effect, they view this as support for the EP hypothesis (see e.g., Weiss 1974 and Smirlock 1985). There are serious shortcomings to this approach. First, it is widely recognized that we cannot infer causal relationships from analyses of this type (see e.g., Tirole 1988, p.1-2). Second, market share is not good measures of firm efficiency. Third, in these papers the ES and the SCP hypotheses are tested as alternatives to each other, but in theory they might be compatible, at least in the short-run.

To resolve these shortcomings in the literature, Berger (1995) proposes to regress firm profitability on a direct measure of firm efficiency. To augment this regression analysis, Berger (1995) also suggests that additional regressions should be run in which a market concentration measure and market shares are modeled as functions of the efficiency measure. Although a direct focus on efficiency is the main contribution of this test, we argue that it still suffers from shortcomings, because the ES hypothesis has no clear predictions for the relationship between market performance and firm efficiency.

In this paper, we propose a new test of the ES hypothesis, which focuses on a core proposition of the hypothesis; that is, *efficient firms win the competition and grow*. In this test, we directly regress a measure of firm growth on a measure of firm efficiency, and examine whether the efficiency contributes to firm growth. Our test is more direct, and thus more fundamental, than existing tests of the ES hypothesis.[1]

Although our primary focus is to test the ES hypothesis with a regression model of firm growth, we also take into account the determination of firm efficiency by simultaneously estimating an equation with the efficiency measure as the dependent variable. The direct merit of this simultaneous estimation is an increase in the efficiency of estimation, but this also allows us to test the so-called *quiet-life hypothesis*, which is closely related to the SCP hypothesis.

The quiet-life hypothesis suggests that in a concentrated market firms do not minimize costs, because of insufficient managerial effort, lack of profit-maximizing behavior, wasteful expenditures to obtain and maintain monopoly power, and/or survival of inefficient managers (Berger and Hannan 1998). To test this hypothesis, we examine in our efficiency regression whether firms in a more concentrated market are more inefficient. Although the ES hypothesis and the quiet-life hypothesis have conflicting implications, their effects might co-exist, at least in the short-run. We thus test the two hypotheses by simultaneous estimation of the growth equation and the efficiency equation.

Applying this test to banks in Japan, we find that more efficient banks tend to become larger.

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[1] Altough the ES hypothesis also predicts that the growth of efficient firms makes the market more concentrated, we do not focus on this growth-concentration nexus. This is because, although the market might ultimately be concentrated with a small number of efficient firms in a steady state, the relationship between firm growth and market concentration is unclear before reaching the steady state. For example, as large inefficient firms lose market share, the market becomes temporarily less concentrated.

This finding supports the ES hypothesis. However, we also find that banks in a more concentrated market are more inefficient, which is consistent with the quiet-life hypothesis. On balance, our findings imply that efficiency allows firms to survive competition and to grow, but the resulting market concentration then erodes firm efficiency. The finding that both the ES hypothesis and the quiet-life hypothesis are supported is, to our knowledge, the first of its kind. We also find that the economic impact of the ES hypothesis is more significant than that of the ES hypothesis. This implies that anti-concentration measures might increase inefficiency in the economy.

The rest of the paper proceeds as follows. In the next section, we review related literature and explain our contribution. Section 3 explains our methodology. We apply the methodology to banks in Japan in section 4. The final section concludes.

2. Literature

2.1. Efficient structure hypothesis

Earlier studies have tested the ES hypothesis (and the SCP hypothesis) by regressing firm profit on market shares, as well as on a measure of market concentration, e.g., market Hirfindahl (e.g., Weiss 1974 and Smirlock 1985). These studies argue that market share is a proxy for relative efficiency of the firms, and that the ES hypothesis is supported if the share has a positive effect on profit. In these studies, the SCP hypothesis is thought to be supported if market concentration has a positive effect on profit.[2]

However, it is unclear whether the two hypotheses are actually supported by such findings. Market shares, the squared sum of which is the Hirfindahl index, also reflects market power of the firm, and so it might support the SCP hypothesis if market share has a *positive* impact on profit.[3] Smirlock (1985) additionally uses an interaction term between market concentration and market shares to separately identify the two hypotheses, but the reasoning behind this identification is again unclear.

Investigating the concentration-profit relationship is also problematic. Much as in the standard test of the SCP hypothesis, the tests of the two hypotheses detailed above cannot identify a causal relationship (see e.g., Tirole 1988, p.1-2). Also, both the ES hypothesis and the SCP hypothesis imply a positive relationship between concentration and profits, although the underlying mechanisms are totally different. Thus, in theory the test explained above cannot differentiate between these hypotheses.

To overcome these problems, Berger and Hannan (1989) propose an alternative test, which

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[2] More recent studies along these lines include Evanoff and Fortier (1988), who take into account entry barriers; Tregenna (2009), who uses panel data from the pre-crisis period in the U.S.; Hsieh and Lee (2010), who allow the effect of market concentration to vary depending on the factors such as foreign or government bank ownership, law and regulation, corporate governance, economic development, and intra-industry competition; and Goddard et al. (2010) the main focus of which is profit convergence, with the hypotheses in this paper relegated to secondary importance.

[3] See Shepherd (1986). Smirlock, Gilligan, and Marshall (1984) disagree with the idea that market share does not necessarily reflect market power, but this is mere speculation on their part.

investigates the price-concentration relationship. Their argument for the identification is the following: On one hand, the SCP hypothesis predicts that in a more concentrated market where firms have more monopoly power, the market price is higher. On the other hand, the ES hypothesis predicts that in a more concentrated market where efficient firms dominate, the market price is lower. Using data on U.S. deposit markets, Berger and Hannan (1989) find a lower interest rate (i.e., a higher price) in a more concentrated market - a finding, they argue, which is consistent with the SCP hypothesis.

However, the test in Berger and Hannan (1989) still suffers from a serious drawback; the prediction of the ES hypothesis with respect to the price-concentration relationship is unclear.[4] Berger and Hannan (1989) argue that efficient firms would set a lower price in order to compete with their rivals. However, as Demsetz (1973) originally articulated, superior competitive performance might be unique to the efficient firms and unobtainable to others, and so efficient firms might set a *higher* price and enjoy more monopoly profits, at least in the short-run. Similar criticism might also hold when profits, rather than a price, is used as a dependent variable; in this case, the predictions are further complicated because we need to take into account the differences in firms' cost levels.

Berger (1995) proposes an alternative and (in our opinion) better approach. Because the

[4] Another problem is that the price equation should have independent variables to control for both supply and demand factors. Brewer and Jackson (2006) deal with this issue.

ES hypothesis concerns firm efficiency, the hypothesis is better tested by explicitly taking it into account; Berger (1995) proposes to use a measure of cost efficiency as the main explanatory variable in a regression model of firm profitability. Furthermore, he also proposes to run regressions of market concentration and market shares as a function of the cost efficiency measure, because, as he argues, the ES hypothesis is supported only if the efficiency measure has positive coefficients in all the three regressions (i.e., on profitability, market concentration, and market share).[5]

This test of Berger (1995) is in a sense more direct than the previous tests, because it includes a measure of firm efficiency. However, its use of firm profitability on the left-hand side of the main regression is still problematic. As explained above, the implications of the ES hypothesis for firm profitability are unclear. Also, there is inconsistency between the predictions in Berger and Hannan (1989) and in Berger (1995). The former predicts a lower price for more efficient firms, but the latter predicts higher profits for them. These predictions are mutually compatible only if the costs of the efficient firms are far smaller than those of less efficient firms. Finally, Berger (1995) treats the efficiency measure as an exogenous variable, but it is more plausible to assume that an efficiency level is endogenously determined, as we assume in our test below.

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[5] Park and Weber (2006) apply this methodology to Korean banks. Al-Muharrami and Matthews (2009) consider four different approaches that include the tests of Berger and Hannan (1989) and of Berger (1995) as special cases.

As explained below, we propose a test of the ES hypothesis that focuses on a more fundamental prediction of the hypothesis – i.e., that efficient firms win competition and grow. Similar to Berger (1995), we also propose to use a measure of cost efficiency; however, we use it to explain firm growth.

2.2. Other related studies

In addition to a regression testing the ES hypothesis, we simultaneously estimate an equation with firm efficiency on the left-hand side. This not only increases the efficiency of our estimation, but also enables us to examine the effect of market structure on firm efficiency. Regarding the market structure-firm efficiency nexus, Berger and Hannan (1998) predict that market structure might negatively impact cost efficiency, because in a concentrated market firms do not minimize costs. They find support for this *quiet-life* hypothesis when they regress a measure of bank efficiency on a measure of market concentration (the Hirfindahl index). Berger and Hannan (1998) recognize that there might be a causal relationship from efficiency to competition, but they only examine the quiet-life hypothesis (after controlling for reverse causality using instrumental variables).

More recent studies focus on the relationship between market power and firm efficiency, employing elaborate methodologies using various market power measures (e.g., Maudos and de

Guevara 2007, Turk Ariss 2010 , Schaeck and Chihak 2010, Färe et al. 2011, and Koetter et al. 2012). However, these studies are only interested in the impact of market power on firm efficiency, and do not test the ES hypothesis.

There are some studies that are methodologically similar to ours. One investigates the co-existence of the market-power hypothesis and the ES hypothesis using a VAR model (Jeon and Miller 2005). However, they use a bivariate VAR model and only examine the relation between a market performance measure and a concentration measure. Casu and Girardone (2009) estimate a similar autoregressive model that is composed of competition variables (Lerner index) and efficiency variables (cost efficiency measures). However, the two regressions are separately estimated, with no control variables.

Finally, because we examine the effect of firm efficiency on firm growth, this paper is related to the literature on firm growth. Goddard, McKillop, and Wilson (2002) test the laws of proportionate effect, which are based on an idea of Gibrat (1931) that firms grow stochastically and so every industry sooner or later exhibits concentration.[6] It is, however, hard to believe that firm growth is a purely stochastic phenomenon. It is more likely that growth is determined by some economic factors (which might themselves be stochastic). In our investigation of the ES hypothesis, we focus on firm efficiency as one such factor.

[6] Goddard, Molyneux, and Wilson (2004) extend this analysis and examine the simultaneous determination of firm growth and profitability.

3. Methodology

3.1. Test of ES hypothesis

Our test directly investigates the effect of firm efficiency on firm growth. The main regression takes the following form:

$$GROWTH_{i,t} = \gamma_i + \gamma_1 EF_{i,t-1} + \gamma_2 X_{i,t} + \varepsilon_{i,t}, \qquad (1)$$

where the indices *i* and *t* respectively represent the firm and the time. The dependent variable is a proxy for firm growth. When we apply this test to banks in Japan in the following section, we use the amount and the growth of loans or assets as the firm growth proxy. The term $EF_{i,t-1}$ is the measure for firm efficiency. This specification assumes that the effect of efficiency is realized with a one-year lag. A vector of independent variables $X_{i,t}$ consists of control variables such as economic conditions and/or firm heterogeneity. The final term $\varepsilon_{i,t}$ is an ordinary error term. We test the ES hypothesis by examining whether the coefficient for $EF_{i,t-1}$ (γ_1) is positive and significant, because the hypothesis predicts that efficient firms grow.

There are several approaches to estimate $EF_{i,t-1}$. They are broadly classified into parametric and non-parametric approaches.[7] However, little consensus has been reached with respect to which is the best measure. The choice among several approaches also depends on

[7] See for example, Schmidt (1985) and Bauer (1990). Berger and Humphrey (1997) survey methodologies used to estimate bank efficiency. Berger (2007) compares international evidence on bank efficiency.

the characteristics of the data used. As explained below, in our application of this test to banks in Japan, we adopt a parametric distribution-free approach that also takes into account time-varying fixed effects.

3.2. Test of quiet-life hypothesis

To increase the efficiency of our estimation and to test the quiet-life hypothesis, we run a regression with firm efficiency on the left-hand side:

$$EF_{i,t} = \beta_i + \beta_1 CONC_{t-1} + \beta_2 Z_{i,t} + \varpi_{i,t} . \qquad (2)$$

The dependent variable is the measure of firm efficiency, $Z_{i,t}$ is a vector of control variables, and $\varpi_{i,t}$ is an ordinary error term.

The main independent variable is $CONC_{t-1}$, a measure for market concentration such as the market Hirfindahl or the three-firm concentration ratio. The quiet-life hypothesis predicts that there is a positive relationship between market concentration and firm *in*efficiency, because of insufficient managerial effort, lack of profit-maximization behavior, wasteful expenditures to obtain and maintain monopoly power, and/or survival of inefficient managers, in a more concentrated market (Berger and Hannan 1998). In our test, a negative and significant coefficient for β_1 is consistent with this hypothesis.

We simultaneously estimate the regressions (1) and (2). From an econometric viewpoint, this has the benefit of increasing the efficiency of estimation. However, the simultaneous estimation has also gives us important economic insight. Most of the existing empirical studies presume that the ES hypothesis and the SCP hypothesis are alternatives. In actuality, however, both mechanisms might work simultaneously, at least in the short-run. Our approach allows for the two hypotheses to be supported at the same time, which is the case when we find γ_1 to be positive and β_1 to be negative.

4. Application to Japanese banks

4.1. Data

Applying the methodology explained in the previous section, we now test the two hypotheses using bank data from Japan from the 1974-2005 period (fiscal years).[8] Unless otherwise specified, the data used are from banks' financial statements (unconsolidated base) compiled in the Nikkei NEEDS Company (Bank) Data File CD-ROM (Nikkei Media Marketing, Inc.).

Banks in Japan are classified into several types.[9] We chose to examine city banks and long-term credit banks that operate in a single nationwide market.[10] We excluded trust banks because they are not ordinary banks, in that they provide trust services. We excluded other

[8] Fiscal years in Japan start in April and end in the following March. The duration of the sample period shortens in some analysis when we use lagged variables.
[9] See Uchida and Udell (2010) for more information about different types of banks in Japan.
[10] City banks are the largest banks and have nationwide branch networks, and long-term credit banks are those legally designated to focus on long-term banking. There used to be three long-term credit banks in Japan, but all of them changed their status to ordinary banks by 2004.

smaller banks because they all operate regionally, mainly targeting small- or medium-sized enterprises in the region, and so their markets are segmented from those in our sample.

The banking industry in Japan has experienced a wave of drastic consolidation since the late 1990s, and in this period many banks in our sample merged with each other and changed their names. Banks grow when a merger takes place, because the new bank is larger in size than each of its predecessors. However, our focus is on growth due to efficiency, and not on growth due to consolidation. Thus, when new banks emerge due to consolidation, we treat the new banks and their predecessors as different entities. As a result, we have 26 banks in our sample.[11]

4.2. Main regressions

This subsection explains how we specify the two regressions explained in section 3. The descriptive statistics for the variables used below are shown in Table 1.

<<Insert Table 1 about here>>

[11] The 26 banks are: Industrial Bank of Japan, Long-Term Credit Bank of Japan, Nippon Credit Bank, Shinsei Bank, Aozora Bank, Daiichi Kangyo Bank, Mizuho Bank, Mitsui Bank, Saskura Bank, Fuji Bank, Mizuho Corporate Bank, Mitsubishi Bank, Tokyo Mitubishi Bank, Kyowa Bank, Asahi Bank, Sanwa Bank, UFJ Bank, Sumitomo Bank, Sumitomo Mitsui Banking Corporation, Daiwa Bank, Resona Bank, Tokai Bank, Hokkaido Takushoku Bank, Taiyo Kobe Bank, Bank of Tokyo, and Saitama Bank. Bank of Tokyo Mitsubishi UFJ is excluded because we have only one observation for them in our sample period.

4.2.1. ES equation

For the ES hypothesis, we use two alternative specifications for equation (1):

$$\ln L_{i,t} = \gamma_0 + \gamma_1 \cdot EF_{i,t-1} + \gamma_2 \cdot \ln GDP_t + \gamma_3 \cdot rc_t + \gamma_4 \cdot CR_{i,t} + \gamma_5 \cdot INFL_t + \varpi^L_{i,t}, \qquad (3)$$

or

$$\Delta \ln L_{i,t} = \gamma_0 + \gamma_1 \cdot EF_{i,t-1} + \gamma_2 \cdot \Delta \ln GDP_t + \gamma_3 \cdot \Delta rc_t + \gamma_4 \cdot \Delta CR_{i,t} + \gamma_5 \cdot \Delta INFL_t + \varpi^L_{i,t}. \quad (3')$$

The variable $L_{i,t}$ is the amount of loans outstanding (in real terms). We focus on bank growth in the lending market, because loans are one of the key products of a bank.[12] The key independent variable $EF_{i,t-1}$ is a measure of banks' cost efficiency. Equations (3) and (3') are alternatives that differ in terms of how they measure bank growth. Equation (3) is a level equation that focuses on the effect of $EF_{i,t-1}$ on the level of $L_{i,t}$. Equation (3') is a difference equation that focuses on the change (difference) in $L_{i,t}$ from the previous period. In either version, the ES hypothesis is supported if we find that γ_1 is positive.

To estimate the efficiency measure, $EF_{i,t-1}$, we follow an approach using bank fixed effects. This approach estimates a cost function and obtains an efficiency measure as a bank fixed-effect.[13] We first obtain a cost *inefficiency* measure as the difference between the banks' actual costs and the cost of the most efficient bank on the efficient frontier (i.e., the difference between the levels of the individual bank fixed-effects and the minimum bank fixed-effect). In

[12] In a robustness check in subsection 4.4, we focus on growth in bank assets.
[13] See Schmidt and Sickels (1984) and Schmidt (1985) for this approach. For other approaches, see Bauer (1990).

doing so, we interact the fixed-effect terms with the time trend variable and its square and cube terms, and thereby estimate a time-varying efficiency measure.[14] We then define our measure of cost efficiency by reversing the sign of the inefficiency measure and taking the exponential. The details of the derivation for the cost efficiency measure, including the estimation of the cost function, are elaborated in the Appendix. Note that this efficiency estimation of ours has two notable advantages: First, compared with stochastic-frontier approaches, our estimation is distribution-free. Second, our efficiency measure is flexible in the sense that it is time-varying.

Turning now to our other explanatory variables, because we use the amount of loans as the dependent variable, we control for loan supply and loan demand. We use GDP_t, real GDP, as a measure of demand. For supply variables, we use rc_t, the call rate, which is an interest rate for the most representative interbank market in Japan, and $CR_{i,t}$, the capital-asset ratio. Finally, we use $INFL_t$, the inflation rate defined as the rate of change of the GDP deflator. This variable might capture a demand as well as a supply factor. In equation (3') we take first differences of these variables.[15]

[14] This is the approach of Cornwell et al. (1990), but they do not use the cubic term.

[15] Due to data availability, rc_t is the interest rate for secured overnight lending before 1985 and for unsecured overnight lending after 1985. $CR_{i,t}$ is the Basel capital ratio if available, and is 1 – leverage if otherwise. The data sources are the SNA from the Cabinet Office and the Financial and Economic Statistics Monthly from the Bank of Japan.

4.2.2. Quiet-life equation

For equation (2), the quiet-life hypothesis equation, we use the following two alternative specifications:

$$EF_{i,t} = \beta_1 \cdot HI_{t-1} + \beta_2 \cdot D_{SMLBANK} + \beta_3 \cdot D_{MEDBANK} + \beta_4 \cdot D_{LARBANK} + \beta_5 \cdot D_{HUGBANK}$$
$$+ \beta_6 \cdot D_{MERGER} + \beta_7 \cdot D_{LTCB} + \beta_8 \cdot D_{FHC} + \beta_9 \cdot AGE_i$$
$$+ \beta_{10} \cdot LA_{i,t} + \beta_{11} \cdot DA_{i,t} + \beta_{12} \cdot SDROA_i + \varpi^U_{i,t} . \tag{4}$$

or

$$\Delta EF_{i,t} = \beta_1 \cdot HI_{t-1} + \beta_2 \cdot D_{SMLBANK} + \beta_3 \cdot D_{MEDBANK} + \beta_4 \cdot D_{LARBANK} + \beta_5 \cdot D_{HUGBANK}$$
$$+ \beta_6 \cdot D_{MERGER} + \beta_7 \cdot D_{LTCB} + \beta_8 \cdot D_{FHC} + \beta_9 \cdot AGE_i + \beta_{10} \cdot \Delta LA_{i,t} + \beta_{11} \cdot \Delta DA_{i,t}$$
$$+ \beta_{12} \cdot SDROA_i + \varpi^U_{i,t} . \tag{4'}$$

In these equations, the dependent variable is the measure of cost efficiency $EF_{i,t}$ (or its difference). The key independent variable is HI_{t-1}, the market Hirfindahl representing market concentration, which is calculated using each bank's nominal amount of loans outstanding. Equation (4) (the level equation) focuses on the effect of HI_{t-1} on the level of efficiency, and equation (4') (the difference equation) focuses on its effect on the change in the efficiency level. These equations are simultaneously estimated with equation (3) or (3'), respectively. In either equation (4) or (4'), the quiet-life hypothesis predicts a negative coefficient for β_1.

For control variables, we use several bank-specific characteristics. Dummy variables $D_{SMLBANK}$, $D_{MEDBANK}$, $D_{LARBANK}$, and $D_{HUGBANK}$ respectively indicate that the relevant bank is a small, medium-sized, large, or huge bank. The cut-offs for these size categories are 15 trillion yen, 40 trillion yen, and 65 trillion yen in nominal assets. We use all four dummies, and do not include an intercept in equation (4) or (4'). A dummy variable D_{MERGER} takes a value of unity if the relevant bank has ever experienced a merger before the relevant year.[16] A dummy variable D_{LTCB} takes a value of unity if the relevant bank is a long-term credit bank. Another dummy variable D_{FHC} indicates that the bank is affiliated with a financial holding company.[17] Firm age is represented by AGE_i.

We also include some financial variables. Two financial ratios are used to capture the difference in efficiency levels due to banks' varying dependence on traditional deposit-to-loan business models: $LA_{i,t}$ is the ratio of total loans to total assets, and $DA_{i,t}$ is the ratio of total deposits to total assets. To control for bank risk, we use $SDROA_i$, the standard deviation of ROA over the sample period.

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[16] More specifically, D_{MERGER} takes a value of unity for Nippon Credit Bank, Mizuho Bank, Mizuho Corporate Bank, Bank of Tokyo Mitsubishi, Sumitomo Mitsui Banking Corporation, Resona Bank, Asahi Bank, UFJ Bank, and Taiyo Kobe Bank, and D_{LTCB} takes a value of unity for Industrial Bank of Japan, Long-Term Credit Bank of Japan, Nippon Credit Bank, Shinsei Bank, and Aozora Bank.

[17] This variable takes a value of unity for Industrial Bank of Japan, Daiichi Kangyo Bank, Mizuho Bank, Fuji Bank, Mizuho Corporate Bank, Bank of Tokyo Mitsubishi, Asahi Bank, Sanwa Bank, UFJ Bank, Sumitomo Mitsui Banking Corporation, Daiwa Bank, and Resona Bank.

4.2.3. Additional specification and estimation method

In addition to the baseline specifications explained above, we estimate the equations by allowing for different impacts of the key independent variables for different time periods. Specifically, we add interaction terms between our key independent variables (i.e., $EF_{i,t-1}$ in equation (3) or (3') and HI_{t-1} in equation (4) or (4')) and three dummy variables, D^{7689}, D^{9000} and D^{0105}, which respectively take the value of unity for the periods 1976-89, 1990-2000, and 2001-2005. The first period corresponds to the period when deregulation measures were taken and the famous "Japanese bubble" occurred. The second period corresponds to the post-bubble period, which saw a serious economic slump and financial crisis. The third period is a period of recovery from that slump.

We simultaneously estimate the two equations (3) and (4), or (3') and (4'), by Generalized Method of Moments (GMM). We deal with many potential problems in the estimation. First, we explicitly control for heterosckedascity of the error term. Second, we correct for serial correlation when it is found. This is of particular importance because our panel data have large T (time period). Third, we take into account endogeneity of some variables by using different instrumental variables for each equation.[18] In ordinary approaches based on the

[18] In our two equations, neither of the two dependent variables enter in the other equation as an independent variable. However, we cannot completely rule out the possibility that $\ln GDP_t$ and $CR_{i,t}$ in equation (3) ($\Delta \ln GDP_t$ and $\Delta CR_{i,t}$ in equation (3')) and $LA_{i,t}$ and $DA_{i,t}$ in equation (4) ($LA_{i,t}$ and $DA_{i,t}$ in equation (4')) are endogenous variables due to reverse

estimation of a stochastic frontier cost function where the inefficiency term follows a specific distribution, it is extremely difficult to cope with this endogeneity problem.[19] Thus, our approach here has methodological advantages over the typical approach.

4.3. Results

4.3.1. Level equations

The estimation results are shown in Table 2. In this table, panel (A) reports the results for the simultaneous estimation of equations (3) and (4) (the level equations), while panel (B) reports those of equations (3') and (4') (the difference equations). In each panel, column (i) shows the results for the baseline regression, and column (ii) shows those when we interact the key independent variables with the three period dummies D^{7689}, D^{9000} and D^{0105}. The test statistic for the overidentification restriction is far from significant (the p-value is 0.58). Therefore, we cannot reject the null hypothesis of overidentification. This means that the likelihood that there is an error in the specification of the two equations is small. The

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causality. For instrumental variables, we use the individual bank dummies for both equations, $\ln GDP_{t-1}$, rc_t, $CR_{i,t-1}$, $INFL_t$, $EF_{i,t-1}$, (or $EF_{i,t-1} \cdot D^{7689}$, $EF_{i,t-1} \cdot D^{9000}$, and $EF_{i,t-1} \cdot D^{0105}$ when these interaction terms are used) for the ES equation, and HI_{t-1}, $D_{SMLBANK}$, $D_{MEDBANK}$, $D_{LARBANK}$, D_{MARGER}, D_{FHC}, $LA_{i,t-1}$, $DA_{i,t-1}$ (or $HI_{t-1} \cdot D^{7689}$, $HI_{t-1} \cdot D^{9000}$, and $HI_{t-1} \cdot D^{0105}$) for the quiet-life equation.

[19] One needs, for example, to specify the generating process of the endogenous variables as well as a joint distribution of the inefficiency term and other error terms. The overall likelihood function is thus difficult to derive.

coefficients of interest are the coefficient on $EF_{i,t-1}$ (in each subperiod) in the ES regression, and the coefficient on HI_{t-1} (in each subperiod) in the quiet-life regression.

<<Insert Table 2 about here>>

From column (i) of Panel (A), we see that the coefficient on $EF_{i,t-1}$ is positive and significant. This means that efficient banks become larger. This finding lends support to the ES hypothesis. As for the quiet-life hypothesis, we find that the coefficient for HI_{t-1} is negative and significant. This finding is consistent with the prediction from the hypothesis that banks in a more concentrated market become more inefficient.

Turning to column (ii), we find that the effect of $EF_{i,t-1}$ on bank growth is always positive and significant even when we divide the sample period. The impact is the largest in the middle of our three periods, and the smallest in the 2001-2005 period. In the quiet-life equation, the hypothesis is supported in the 1990-2000 and the 2001-2005 periods, since HI_{t-1} has a negative coefficient for $EF_{i,t-1}$ in these periods. We also find that the coefficient is the largest in the 1990s-2000 period, so the deterioration of efficiency due to market concentration is the highest in the 1990s. The sign of the point estimate is opposite in the 1976-1989 period, but is statistically insignificant.

4.3.2. Difference equations

The results for the difference equations (i.e., equations (3') and (4')) are shown in panel (B) of Table 2. They are on balance similar to, and consistent with, those in panel (A). In column (i), the ES hypothesis is supported, since the coefficient for $EF_{i,t-1}$ is positive and statistically significant. The coefficient for HI_{t-1} in the quiet-life equation is again negative and significant, so the quiet-life hypothesis is also supported. In column (ii), we find that the main results are unchanged even if we allow for different impacts of the main independent variables in the three sub-sample periods. The only difference between panel (A) and panel (B) is that the coefficient for $HI_{t-1} \cdot D^{7689}$ is now negative and significant.

We also find that the control variables generally have the anticipated impacts on the dependent variables, and that these effects are statistically significant. The amount of loans ($\ln L_{i,t}$ or $\Delta \ln L_{i,t}$) is larger when loan demand is larger (larger GDP), or when loan supply is larger (a smaller interbank lending rate or a higher capital ratio (panel (A) only)). Banks are more efficient when they are large (not huge), probably due to economies of scale. Post-merger banks are more efficient, probably because the merger enables them to cut costs; long-term credit banks are more efficient, probably because they are less dependent on deposit funding; and banks affiliated with a financial holding company are less efficient, probably because of their complex and hierarchical organizational structure. We also find that younger banks and less risky banks are more efficient, and banks with a higher loan to asset ratio or deposit to asset ratio are more efficient.

4.3.3. Discussion

On balance, our findings support both the ES hypothesis and the quiet-life hypothesis. These findings are robust to alternative measures of bank growth (i.e., levels or differences). Note that as discussed above, the two hypotheses are not mutually exclusive in theory, at least in the short run. However, existing empirical studies did not allow for this possibility. This paper is therefore the first study to find evidence supporting both hypotheses at once.

Our findings are intriguing from an economic point of view. The finding for the ES hypothesis implies that efficient banks grow more. However, if the banking market becomes more concentrated due to the growth of such (efficient) banks, the finding for the quiet-life hypothesis then implies that the banks lose efficiency. As they become inefficient, they then lose the size they had previously gained (the ES hypothesis). Thus, our findings seem to imply the existence of an interesting cyclical dynamic of banks growth and decline, due to the interaction between size and efficiency.

To further pursue this possibility, we calculate the economic impact of the two hypotheses. As for the ES hypothesis, when we focus on the results for the baseline specification in Table 2 (column (i) of panel A,), the point estimate for the coefficient for $EF_{i,t-1}$ in the ES equation is 1.643. This indicates that for an average bank, an increase in the cost efficiency measure by one standard deviation (0.150) leads to an increase in $\ln L_{i,t}$ by 0.246, which is equivalent to a 1.279-fold increase in $L_{i,t}$. The impact is therefore economically significant.

The economic significance of the impact of the QL hypothesis can similarly be calculated. As shown in the same column in Table 2, the point estimate for the coefficient for HI_{t-1} in the QL equation is -0.684. Because the standard deviation of the Hirfindahl index for the 30-year period (1976-2005, N=30) is 0.074, an increase in the index by one standard deviation leads to a decrease in $EF_{i,t}$ by 0.050. Because the standard deviation of $EF_{i,t}$ is 0.150, we can conclude that the economic impact of the QL hypothesis is less significant than that of the ES hypothesis. Although this comparison depends on different assumptions, it suggests that anti-concentration measures might *increase* inefficiency in the economy.

4.4. Robustness check

In this subsection, we check the robustness of our findings using yet another measure of bank growth. Instead of focusing on bank growth in terms of loan size, we now focus on growth in terms of asset size. In this check, we estimate the same equations ((3) and (4) or (3') and (4')) but replace $L_{i,t}$ with $A_{i,t}$, the size of banks' assets.

<<Insert Table 3 about here>>

Table 3 shows the results when we focus on asset growth. Again, panels (A) and (B) respectively report the results for the level equations (equations (3) and (4)) and for the difference equations (equations (3') and (4')), and in each panel columns (i) and (ii) are respectively for the specification without and with the interactions of the key independent variables with the period dummies.

We can see that the results for the ES and the quiet-life hypotheses are robust to this alternative specification. Compared with Table 2, the coefficients for the main independent variables ($EF_{i,t-1}$ and HI_{t-1}) have the same signs and comparable significance levels, the only exception being the effect of $EF_{i,t-1}$ on the asset growth during the 1990s. On balance, irrespective of whether we measure bank growth by loan size or by asset size, both the ES hypothesis and the quiet-life hypothesis are supported. This reinforces our conclusions in the previous section.

5. Conclusion

This paper proposes a new test of the efficient structure (ES) hypothesis by directly examining the relationship between firm efficiency and firm growth. It also tests the quiet-life hypothesis. Applying this test to data on large banks in Japan, we consistently find that more efficient banks become larger, which is consistent with the efficient structure hypothesis. We also find that market concentration erodes banks' cost efficiency, which is consistent with the quiet-life hypothesis. These findings imply that banks undergo an intriguing life-cycle dynamic: banks grow more as they become more efficient, but the resulting market concentration assures a "quiet life" for banks, which makes them lose efficiency and shrink. However, yet another finding suggest that the economic impact of the quiet life hypothesis is less significant than that of the ES hypothesis, implying that anti-concentration measures might increase inefficiency in the economy.

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Appendix: Estimation of cost efficiency measure

This appendix explains how we estimate the measure of cost efficiency.

A.1. Equations

A.1.1. Cost function and cost efficiency

We estimate a translog cost function that takes the following form:

$$\ln\left(C_{i,t}^{V}/p_{V,i,t}*\right)=\sum_{i}a_{i}\left(\tau_{t}*\right)\cdot D_{i}^{B}+a_{YL}\cdot\ln y_{L,i,t}*+a_{YD}\cdot\ln y_{D,i,t}*$$

$$+\left(\sum_{i}a_{Li}\cdot D_{i}^{B}\right)\cdot\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)+\left(\sum_{i}a_{Ki}\cdot D_{i}^{B}\right)\cdot\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)$$

$$+\left(\sum_{i}a_{Bi}\cdot D_{i}^{B}\right)\cdot\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)$$

$$+(1/2)\cdot a_{YLYL}\cdot\left(\ln y_{L,i,t}*\right)^{2}+(1/2)\cdot a_{YDYD}\cdot\left(\ln y_{D,i,t}*\right)^{2}$$

$$+(1/2)\cdot a_{LL}\cdot\left\{\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)\right\}^{2}+(1/2)\cdot a_{KK}\cdot\left\{\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)\right\}^{2}$$

$$+(1/2)\cdot a_{BB}\cdot\left\{\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)\right\}^{2}$$

$$+a_{YLYD}\cdot\ln y_{L,i,t}*\cdot\ln y_{D,i,t}*+a_{YLL}\cdot\ln y_{L,i,t}*\cdot\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)$$

$$+a_{YLK}\cdot\ln y_{L,i,t}*\cdot\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)+a_{YLB}\cdot\ln y_{L,i,t}*\cdot\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)$$

$$+a_{YLT}\cdot\ln y_{L,i,t}*\cdot\tau_{t}*$$

$$+a_{YDL}\cdot\ln y_{D,i,t}*\cdot\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)+a_{YDK}\cdot\ln y_{D,i,t}*\cdot\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)$$

$$+a_{YDB}\cdot\ln y_{D,i,t}*\cdot\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)+a_{YDT}\cdot\ln y_{D,i,t}*\cdot\tau_{t}*$$

$$+a_{LK}\cdot\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)\cdot\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)+a_{LB}\cdot\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)\cdot\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)$$

$$+a_{LT}\cdot\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)\cdot\tau_{t}*$$

$$+a_{KB}\cdot\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)\cdot\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)+a_{KT}\cdot\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)\cdot\tau_t*$$

$$+a_{BT}\cdot\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)\cdot\tau_t*$$

$$+v_{i,t},$$

where $a_i\left(\tau_t*\right)\equiv a_i+a_{iT}\cdot\tau_t*+a_{iTT}\cdot\left(\tau_t*\right)^2+a_{iTTT}\cdot\left(\tau_t*\right)^3$ represents the level of cost inefficiency, and the variables are defined as follows.

- $C_{i,t}^V$: Total (variable) costs = costs for current goods + labor costs + costs for physical capital goods + costs of financing by debts other than deposits.
- $p_{V,i,t}*$: price of current goods.
- τ_t*: time trend （= t – 1985）.
- D_i^B: a dummy for individual bank (bank fixed-effect).
- $y_{L,i,t}*$: amount of real loans outstanding (= loans outstanding / GDP deflator).
- $y_{D,i,t}*$: amount of real deposits outstanding (= deposits outstanding / GDP deflator).
- $p_{L,i,t}*$: wage (= labor costs / amount of labor inputs).
- $p_{K,i,t}*$: price of physical capital goods.
- $p_{B,i,t}*$: interest rate (price) for debts other than deposits = (total financing costs – deposit interests) / (total liabilities – total deposits).
- $v_{i,t}$: an ordinary error term.

Variables marked with * are normalized by dividing them by their sample mean. The data sources and more detailed definitions of the variables are explained below.

The assumption underlying this cost function is that banks produce loans using current goods (including advertisement and fringe-benefits), labor, physical capital (land, buildings, and movable assets), and debts other than deposits. As no consensus has been reached regarding whether deposits are inputs or outputs, we do not make such an assumption *a priori*; instead we classify deposits as inputs or outputs based on the sign of the estimated partial derivative of the costs with respect to deposits.[1] The cost function must be linearly homogeneous in factor prices. This is why we divide $C_{i,t}^{V}$, $p_{L,i,t}*$, $p_{K,i,t}*$, $p_{B,i,t}*$, and $p_{L,i,t}*$ by $p_{V,i,t}*$.

After estimating this cost function, we calculate the measure of banks' cost efficiency in the following manner. We first calculate the measure of cost *in*efficiency that is defined by the ratio of actual costs to the cost on the efficient frontier.

$$LIE_{i,t} = a_i\left(\tau_t *\right) - \min_i a_i\left(\tau_t *\right),$$

where $\min_i a_i\left(\tau_t *\right)$ is the minimum of $a_i\left(\tau_t *\right)$ in year *t*. Our measure of cost efficiency is defined as follows:

$$EF_{i,t} = \exp\left(-LIE_{i,t}\right) = \exp\left\{\left(\min_i a_i\left(\tau_t *\right)\right) - a_i\left(\tau_t *\right)\right\}.$$

Schmidt and Sickles (1984) is the first study of efficiency estimation using fixed effects, and Kumbhakar (1989) was the first to use a flexible functional form like ours. However, the estimations in these earlier studies are restrictive, because their estimates are not functions of time trends and so constant across time. Cornwell et al. (1990) first estimate a time-varying efficiency measure. The difference between their and our approaches is that the bank fixed effect ($a_i(\cdot)$) is a quadratic function of time trend in their model, whereas it is a cubic function in our model.

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[1] This approach is justified by a characteristic of a variable cost function. That is, the function is non-decreasing with respect to outputs, and non-increasing with respect to inputs. See Chambers (1988) for more details.

A.1.2. Cost share equations

To obtain efficient estimates, we estimate the above cost function together with the cost share equations, which are partial derivatives of the cost function with respect to $\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)$, $\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)$, and $\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)$.

The cost share equations take the form:

$$S_{i,t}^{L}=\sum_{i}a_{Li}\cdot D_{i}^{B}+a_{YLL}\cdot\ln y_{L,i,t}*+a_{YDL}\cdot\ln y_{D,i,t}*+a_{LL}\cdot\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)$$

$$+a_{LK}\cdot\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)+a_{LB}\cdot\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)+a_{LT}\cdot\tau_{t}*+\varepsilon_{i,t}^{L},$$

$$S_{i,t}^{K}=\sum_{i}a_{Ki}\cdot D_{i}^{B}+a_{YLK}\cdot\ln y_{L,i,t}*+a_{YDK}\cdot\ln y_{D,i,t}*+a_{KK}\cdot\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)$$

$$+a_{LK}\cdot\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)+a_{KB}\cdot\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)+a_{KT}\cdot\tau_{t}*+\varepsilon_{i,t}^{K},$$

$$S_{i,t}^{B}=\sum_{i}a_{Bi}\cdot D_{i}^{B}+a_{YLB}\cdot\ln y_{L,i,t}*+a_{YDB}\cdot\ln y_{D,i,t}*+a_{BB}\cdot\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)$$

$$+a_{LB}\cdot\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)+a_{KB}\cdot\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)+a_{BT}\cdot\tau_{t}*+\varepsilon_{i,t}^{B},$$

where $S_{i,t}^{L}$ is the cost share of labor (= $\left(p_{L,i,t}\cdot x_{L,i,t}\right)/C_{i,t}=\partial\ln\left(C_{i,t}/p_{V,i,t}*\right)/\partial\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)$, where $x_{L,i,t}$ is labor input) and $\varepsilon_{i,t}^{L}$ is the error term, $S_{i,t}^{K}$ is the cost share of capital goods (= $\left(p_{K,i,t}\cdot x_{K,i,t}\right)/C_{i,t}=\partial\ln\left(C_{i,t}/p_{V,i,t}*\right)/\partial\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)$, where $x_{K,i,t}$ is capital input) and $\varepsilon_{i,t}^{K}$ is the error term, and $S_{i,t}^{B}$ is the cost share of debts other than deposits (= $\left(p_{B,i,t}\cdot x_{B,i,t}\right)/C_{i,t}$ = $\partial\ln\left(C_{i,t}/p_{V,i,t}*\right)/\partial\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)$, where $x_{B,i,t}$ is the amount of debts other than deposits) and $\varepsilon_{i,t}^{B}$ is the error term.

A.2. Method of estimation

We simultaneously estimate the cost function and the cost share equations by GMM. In this GMM estimation, we correct for conditional heteroscedascitity and serial correlation of the error terms. We include a moving average of the error terms in the estimation of the orthogonality conditions of the variance-covariance matrix. We follow Newey and West (1987) and use Bartrett's spectral density kernel to assure that the estimate of the matrix is positive definite. The order of the moving average is one.

To improve the precision of estimation, we use different instrumental variables for each equation. Specifically, the instrumental variables that we use are as follows:

- Instruments for all the equations: D_i^B, $L_{i,t-1}/A_{i,t-1}$, $D_{i,t-1}/A_{i,t-1}$, $E_{i,t-1}/A_{i,t-1}$,

  $\ln y_{h,i,t-1}*\cdot\left(E_{i,t-1}/A_{i,t-1}\right)$ $(h = L, D)$, D_{8790}^Y, and $\ln y_{h,i,t-1}*\cdot D_{8790}^Y$ $(h = L, D)$,

- Instruments for the cost function: $D_i^B \cdot \tau_t *$, $D_i^B \cdot \left(\tau_t *\right)^2$, $D_i^B \cdot \left(\tau_t *\right)^3$,

  $D_i^B \cdot \ln\left(p_{j,i,t}*/p_{V,i,t}*\right)$, $\left\{\ln\left(p_{j,i,t}*/p_{V,i,t}*\right)\right\}^2$ $(j = L, K, B)$,

  $\ln\left(p_{L,i,t}*/p_{V,i,t}*\right)\cdot\ln\left(p_{j,i,t}*/p_{V,i,t}*\right)$ $(j = K, B)$,

  $\ln\left(p_{K,i,t}*/p_{V,i,t}*\right)\cdot\ln\left(p_{B,i,t}*/p_{V,i,t}*\right)$, and $\ln\left(p_{j,i,t}*/p_{V,i,t}*\right)\cdot\tau_t *$ $(j = L, K, B)$,

  $D_i^B \cdot \ln y_{h,i,t-1}*$ $(h = L, D)$, $\left(\ln y_{h,i,t-1}*\right)^2$ $(h = L, D)$, $\ln y_{h,i,t-1}*\cdot\ln\left(p_{j,i,t}*/p_{V,i,t}*\right)$ $(h = L, D; j = L, K, B)$, $\ln y_{h,i,t-1}*\cdot\tau_t *$ $(h = L, D)$, $\ln y_{L,i,t-1}*\cdot\ln y_{D,i,t-1}*$,

  $\left(L_{i,t-1}/A_{i,t-1}\right)\cdot D_{8790}^Y$, $\left(D_{i,t-1}/A_{i,t-1}\right)\cdot D_{8790}^Y$, and $\left(E_{i,t-1}/A_{i,t-1}\right)\cdot D_{8790}^Y$, and

- Instruments for the (respective) cost share equations: $\ln\left(p_{j,i,t}*/p_{V,i,t}*\right)$ $(j = L, K, B)$

  and $\ln y_{h,i,t-1}*$ $(h= L, D)$,

where $L_{i,t}$ is the (nominal) amount of loans outstanding, $A_{i,t}$ is the (nominal) amount of financial assets, $D_{i,t}$ is the (nominal) amount of deposits outstanding, $E_{i,t}$ is the nominal amount of equity capital, and D^{Y}_{8790} is a dummy variable for the bubble period (taking a value of one for 1987-1990).

Because we use lagged variables as instrumental variables, the sample period for this estimation is from fiscal year 1975 to 2005 (starts on April 1975 and ends on March 2006). Due to mergers, we have too few observations to estimate the parameters for some banks. For these banks, we assume that the parameters a_{Li}, a_{Ki}, a_{Bi}, and a_{Vi} are the same between the new banks and their predecessors.

A.3. Data and variable definitions

This subsection explains how we use information from different sources to define the variables explained above. Descriptive statistics and the correlation matrix for the variables are found in Table A1.

<<Insert Table A1 about here>>

A.3.1. Current goods

First, we calculate the *cost* of current goods as Non-personnel expenses minus Depreciation and Rent of land, buildings, and machinery (source: banks' balance sheets in Nikkei NEEDS CD-ROM (non-consolidated base)). Second, we calculate the *price* of current goods, which is described below. Finally, the *amount* of current goods is obtained as the *cost* of current goods divided by the *price* of current goods.

To obtain the *price* of current goods, we divide current goods into three components: advertisement, fringe benefits, and other current goods. The price of current goods is then defined as a bilateral price index of the price of these components, with the weights of these prices being the ratio of the cost of each component to the total cost of current goods.[2] Formally, the price of current goods p_V for bank *i* and year *t*, is defined as follows:

$$p_{V,i,t} = \exp\left[\sum_{j\in\{A,B,C\}}\left(\frac{w_{j,i,t}^{VM} + \overline{w}_j^{VM}}{2}\right)\cdot\left(\ln p_{V,t}^{j} - \overline{\ln p_V^{j}}\right)\right],$$

where $p_{V,t}^{j}$ ($j \in \{A,B,C\}$) is the price of each component of the current goods (*A*: advertisement, *B*: fringe benefits, *C*: other current goods) which is defined below, $\overline{\ln p_V^{j}}$ is the sample mean of $\ln p_{V,t}^{j}$, $w_{j,i,t}^{VM}$'s ($j \in \{A,B,C\}$) are respectively the ratio of the cost of advertisement, the cost of fringe benefits, and the cost of other current goods to the cost of current goods, and $\overline{w}_j^{VM}$ is the sample mean of $w_{j,i,t}^{VM}$.

The prices of the three components of the current goods ($p_{V,t}^{j}$) are defined as follows. Firstly, the definition of the price of advertisement is:

$$p_{V,t}^{A} = \begin{cases} \text{Advertising services price} & (\text{1985 and after}) \\ \exp\left[\sum_{j=1}^{6} w_{P,j}^{VA}\cdot\ln p_{V,j,t}^{A}\right] & (\text{before 1985}) \end{cases}$$

The best proxy for the price of advertisement is the advertising services price (from the Corporate Services Price Index of the Bank of Japan). However, because this price is available only after 1985, we assume, for the period before 1985, that the price equals the weighted average of $\ln p_{V,j,t}^{A}$ ($j = 1,\ldots,6$), or the natural logarithms of the prices of six "other current goods" (Personal service, Public service, Repairs & maintenance, Transportation & communication, Commodities (other manufacturing), Fuel, light & water charges) (source: the Consumer Price Index of the Statistical Bureau of Director-General for Policy Planning & Statistical Research and Training Institute, the Ministry of Internal Affairs and

[2] Note that a ratio of any two of these indices is a multilateral index (see Caves, Laurits, and Diewert 1982 and its application to banking in Fixler and Zieschang 1993).

Communications). The weights $w_{P,j}^{VA}$'s are the ratios of the base-year weights for $p_{V,j,t}^{A}$ ($j=1,\ldots,6$) to their sum.

Secondly, the price of fringe benefits is defined as a weighted average of the logarithm of the price for medical care ($p_{V,1,t}^{B}$) and education ($p_{V,2,t}^{B}$) (source: the Consumer Price Index of the Statistical Bureau of Director-General for Policy Planning & Statistical Research and Training Institute, the Ministry of Internal Affairs and Communications). Formally,

$$p_{V,t}^{B}=\exp\left[\sum\nolimits_{j=1}^{2} w_{P,j}^{VB}\cdot\ln p_{V,j,t}^{B}\right],$$

where the weights $w_{P,j}^{VB}$'s are the ratios of the base-year weights for $p_{V,j,t}^{B}$ ($j=1,2$) to their sum.

Thirdly, the price of other current goods is defined as follows:

$$p_{V,t}^{C}=\begin{cases}\exp\left[\sum\nolimits_{j=2}^{6} w_{P,j}^{VA}\cdot\ln p_{V,j,t}^{A}+\sum\nolimits_{j=1}^{12} w_{P,j}^{VC}\cdot\ln p_{V,j,t}^{C}\right] & (\text{1995 and after})\\ \exp\left[\sum\nolimits_{j=1}^{6} w_{P,j}^{VA}\cdot\ln p_{V,j,t}^{A}\right] & (\text{before 1995})\end{cases}$$

where $p_{V,j,t}^{A}$ and $w_{P,j}^{VA}$ ($j=1,\ldots,6$) are the same as those defined above. $p_{V,j,t}^{C}$'s ($j=1,\ldots,12$) are the prices for Building maintenance services, Machinery repair, Transportation, Communication, Information services, Rent paid for real estate (offices), Rent paid for real estate (stores), Rent paid for real estate (parking lots), Leasing (computers), Leasing (communications equipment), Leasing (office equipment), Computer Rental (source: the Consumer Price Index of the Statistical Bureau of Director-General for Policy Planning & Statistical Research and Training Institute, the Ministry of Internal Affairs and Communications). The weights $w_{P,j}^{VC}$'s are the ratios of the base-year weights for $p_{V,j,t}^{C}$ ($j=1,\ldots,12$) to the sum of the base-year weights, multiplied by the base-year weight of Individual services in the CPI ($w_{P,1}^{VA}$).

A.3.2. Labor

As the *cost* of labor we use banks' personnel expenses (source: banks' balance sheets in Nikkei NEEDS CD-ROM (non-consolidated base)). To calculate the *amount* of labor (labor input) $x_{L,i,t}$, we first calculate the amounts of male and of female labor $x^j_{L,i,t}$ ($j \in \{M(\text{male}), F(\text{female})\}$), derive their bilateral aggregation, and double it.[3] More precisely, we define:

$$x_{L,i,t} = 2 \cdot \exp\left[\sum_{j \in \{M,F\}} \left(\frac{w^{LM}_{j,i,t} + \bar{w}^{LM}_j}{2} \right) \cdot \ln x^j_{L,i,t} \right],$$

where

$x^j_{L,i,t}$ = [the number of employees of gender *j* (source: Nikkei NEEDS CD-ROM)]×[the hours worked by gender (for gender *j*) in Finance and insurance industry (source: Monthly Labour Survey of the Ministry of Health, Labour and welfare)]×12/1000 ($j \in \{M(\text{male}), F(\text{female})\}$),

$w^{LM}_{j,i,t} = \left(p^j_{L,i,t} \cdot x^j_{L,i,t}\right) \big/ \left(p^M_{L,i,t} \cdot x^M_{L,i,t} + p^F_{L,i,t} \cdot x^F_{L,i,t}\right)$ ($j \in \{M, F\}$),

$p^j_{L,i,t}$ = the amount of salary in cash by gender (for gender *j*) in Finance and Insurance industry (source: Monthly Labour Survey of the Ministry of Health, Labour and welfare)

$\bar{w}^{LM}_j$ = the sample mean of $w^{LM}_{j,i,t}$. [4]

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[3] We double the aggregate because it represents a geometric average of male and female labor.

[4] We do not normalize $\ln x^j_{L,i,t}$ by its sample mean $\overline{\ln x^j_L}$, because $p_{L,i,t}$ is obtained by dividing the cost of labor by $x_{L,i,t}$, and so the price is qualitatively different from the bilateral price index (such as the price of current goods). This definition also makes for an easier interpretation of the results.

Note that the number of employees by gender is not available after 1998. We thus use for $x^{j}_{L,i,t}$ the product of the number of total employees and the average ratio of the number of employees of gender *j* to that of total employees over the period up to 1998, because we find more variation in these variables across banks in the same year than across years for each bank. Finally, the *price* of labor, or wage $p_{L,i,t}$, is defined as the *cost* of labor divided by the *amount* $x_{L,i,t}$.

A.3.3. Capital goods

We assume that capital goods are composed of two parts: Land and Buildings, and movable assets. The cost of Land is a product of the amount of Land, $x^{L}_{K,i,t}$ and its service price $p^{L}_{K,t}$, while the cost of Buildings and movable assets is the product of its amount $x^{B}_{K,i,t}$ and its service price $p^{B}_{K,i,t}$. Thus the *cost* of capital goods is $C^{K}_{i,t} = p^{L}_{K,t} \cdot x^{L}_{K,i,t} + p^{B}_{K,i,t} \cdot x^{B}_{K,i,t}$. The *amount* (input) of capital goods $x_{K,i,t}$ is then defined as $C^{K}_{i,t}$ divided by $p_{K,i,t}$ (the price of capital goods as a whole). Below, we explain how to calculate $x^{L}_{K,i,t}, x^{B}_{K,i,t}, p^{L}_{K,t}, p^{B}_{K,i,t}$ and $p_{K,i,t}$.

We derive $x^{L}_{K,i,t}$ and $x^{B}_{K,i,t}$, in three steps. First, we calculate (i) the nominal outstanding amount of Land, and of Buildings and movable assets. Second, we calculate (ii) the real outstanding amount of Land, and of Buildings and movable assets, for the year when the data is first available, by deflating (i) for the year. Finally, we calculate (iii) the real increase or decrease (i.e., difference) of Land, and of Buildings and movable assets in each year, by deflating the respective differences in (i). Third, we obtain (iv) the real outstanding amount of Land, and of Buildings and movable assets, for the year after the data is first available, by successively adding (iii) in each year to (ii).

For (i) Land, we use the book value of Primary land in possession (source: banks' balance sheets in Nikkei NEEDS CD-ROM (non-consolidated base)) before 1997. In 1997, we subtract from this value the Revaluation difference, because from this year on the revaluation of Land by market prices was mandated by law (the Act on Revaluation of Land). On the same ground, we further subtract Deferred tax liability from 1998 onward.[5] For some banks data on Deferred tax liabilities are not available, and therefore we average the ratio of Deferred tax liabilities to Revaluation differences over several years prior to 1998, and multiply the ratio by Revaluation difference in 1998. To calculate (i) for Buildings and movable assets, we subtract the book value of Primary land in possession from the book value of Land, buildings, and movable assets (source: banks' balance sheets in Nikkei NEEDS CD-ROM (non-consolidated base)).

To calculate (ii) and (iii), we use different deflators for Land and for Buildings and movable assets. The deflator for Land is the Urban Land Price Index (Commercial urban land of nationwide) (source: Urban Land Price Index National Wooden House Market Index (Japan Real Estate Institute)). The deflator for Buildings and movable assets is that for Gross Capital Formation (Private Non-Residential Investment) (source: SNA (Cabinet Office, the Government of Japan).

Turning to the prices, we define $p^L_{K,t}$ and $p^B_{K,i,t}$ as:

$$p^L_{K,t} = p^L_{D,t} \cdot r^K_t \text{, and}$$

$$p^B_{K,i,t} = p^B_{D,t} \cdot \left[r^K_t + d^K_{i,t} - \frac{p^B_{D,t} - p^B_{D,t-1}}{p^B_{D,t}} \right],$$

where $p^L_{D,t}$ is the Urban Land Price Index (Commercial urban land nationwide) (source: Urban Land Price Index National Wooden House Market Index (Japan Real Estate Institute)), r^K_t is the yield on bank coupon debentures (5 years) (source: Financial and Economic Statistics Monthly from the Bank of Japan), $p^B_{D,t}$ is the deflator for Gross Capital Formation (Private

[5] If the resulting value was negative, we concluded that the book value was inaccurate, and thus corrected the book value by averaging the ratio of the book value to the revaluation difference and the deferred tax liability (for the years in which it takes a value greater than 1) and by multiplying it by the sum of the revaluation difference and the deferred tax liability.

Non-Residential Investment) (source: SNA from the Cabinet Office, Government of Japan), and $d_{i,t}^{K}$ is the rate of depreciation (= depreciation (source: Nikkei NEEDS CD-ROM) / $x_{K,i,t}^{B}$).[6]

Finally, similar to the case of current goods, we define $p_{K,i,t}$, the price of capital goods (as a whole), as a bilateral index of $p_{K,t}^{L}$ and $p_{K,i,t}^{B}$. More specifically,

$$p_{K,i,t} = \exp\left[\left(\frac{w_{L,i,t}^{KM} + \bar{w}_{L}^{KM}}{2}\right)\cdot\left(\ln p_{K,t}^{L} - \overline{\ln p_{K}^{L}}\right) + \left(\frac{w_{B,i,t}^{KM} + \bar{w}_{B}^{KM}}{2}\right)\cdot\left(\ln p_{K,i,t}^{B} - \overline{\ln p_{K}^{B}}\right)\right],$$

where the weights $w_{j,i,t}^{KM}$ ($j \in \{L, B\}$) are defined as

$$w_{L,i,t}^{KM} = \left(p_{K,t}^{L}\cdot x_{K,i,t}^{L}\right) / \left(p_{K,t}^{L}\cdot x_{K,i,t}^{L} + p_{K,i,t}^{B}\cdot x_{K,i,t}^{B}\right) \text{ and}$$

$$w_{B,i,t}^{KM} = \left(p_{K,i,t}^{B}\cdot x_{K,i,t}^{B}\right) / \left(p_{K,t}^{L}\cdot x_{K,i,t}^{L} + p_{K,i,t}^{B}\cdot x_{K,i,t}^{B}\right),$$

$\bar{w}_{j}^{KM}$ ($j \in \{L, B\}$) are the sample means of $w_{j,i,t}^{KM}$ ($j \in \{L, B\}$), and $\overline{\ln p_{K}^{L}}$ and $\overline{\ln p_{K}^{B}}$ are respectively the sample means of $\ln p_{K,t}^{L}$ and $\ln p_{K,i,t}^{B}$.

A.4. Results

<<Insert Table A2 about here>>

<<Insert Table A3 about here>>

Table A2 reports the regression results for the stochastic frontier cost function. The estimates of a_{Li}, a_{Ki}, a_{Bi}, a_{Vi} (i= 1,2,4,6,8-10,12,13,15-17,19,21,23-27) are not shown in the table. Instead, the estimates of a_{VV}, a_{YLV}, a_{YDV}, a_{LV}, a_{KV}, a_{BV}, and a_{VT} are shown, which

[6] We do not take into account depreciation and capital gains in calculating $p_{K,t}^{L}$. This is because depreciation for land is zero, and because capital gains in the bubble period (1987-1990) are so huge that taking them into account makes the service price of land negative.

are calculated from the condition of linear homogeneity with respect to factor prices (i.e., $a_{VV} = a_{LL} + a_{KK} + a_{BB} + 2 \cdot a_{LK} + 2 \cdot a_{LB} + 2 \cdot a_{KB}$, $a_{YLV} = -(a_{YLL} + a_{YLK} + a_{YLB})$, $a_{YDV} = -(a_{YDL} + a_{YDK} + a_{YDB})$, $a_{LV} = -(a_{LL} + a_{LK} + a_{LB})$, $a_{KV} = -(a_{LK} + a_{KK} + a_{KB})$, $a_{BV} = -(a_{LB} + a_{KB} + a_{BB})$, $a_{VT} = -(a_{LT} + a_{KT} + a_{BT})$). The estimates of cost efficiency for individual banks that are obtained from the regression results are shown in Table A3.

Table 1 Descriptive statistics for simultaneous estimation

Variables		Definition	Source	# of obs.	Mean	Std Dev	Minimum	Maximum
Efficiency Hypothesis regression	$y_{L,i,t}$	Real loans outstanding = loans outstanding / GDP deflator (million yen)	(a), (b)	384	16,039,100	10,597,000	2,559,613	56,489,700
	$EF_{i,t-1}$	Cost effiicency measure	Our calculation (see Appendix)	384	0.772	0.150	0.424	1.000
	GDP_t	Real GDP	(b)	384	392,717	88,959	247,834	548,249
	rc_t	Call rate (interbank rate) (collateralized rate before 1986 and uncollateralized rate afterwards)	(c)	384	0.029	0.014	0.007	0.127
	CR_t	Regulatory capital ratio (if unavailable, capital/assets)	(a)	384	0.035	0.029	0.007	0.142
	$INFL_t$	Inflation rate (the rate of change in GDP deflator)	(b)	384	0.017	0.024	-0.03	0.078
Quiet-life Hypothesis regression	HI_{t-1}	Hirfindahl index (market concentration measure)	(a)	384	0.087	0.04	0.071	0.424
	$D_{SMLBANK}$	Small bank dummy (= 1 if total assets < 15 trillion yen)	(a)	384	0.346	0.476	(NA)	(NA)
	$D_{MEDBANK}$	Medium bank dummy (= 1 if 15 trillion yen =< total assets < 40 trillion yen)	(a)	384	0.391	0.489	(NA)	(NA)
	$D_{LARBANK}$	Large bank dummy (= 1 if 40 trillion yen =< total assets < 65 trillion yen)	(a)	384	0.224	0.417	(NA)	(NA)
	$D_{HUGBANK}$	Huge bank dummy (= 1 if total assets >= 65 trillion yen)	(a)	384	0.039	0.194	(NA)	(NA)
	D_{MERGER}	Merger dummy (= 1 if the bank experienced a merger)	Hand collected (different sources)	384	0.094	0.292	(NA)	(NA)
	D_{LTCB}	LTCB dummy (= 1 if the bank is a long-term credit bank)	Hand collected (different sources)	384	0.201	0.401	(NA)	(NA)
	D_{FHC}	Holding company dummy (= 1 if the bank is affiliated with a financial holding company)	Hand collected (different sources)	384	0.057	0.233	(NA)	(NA)
	AGE_i	Bank age	Hand collected (different sources)	384	65.479	28.111	3.083	104.833
	$LA_{i,t}$	Loans/assets	(a)	384	0.568	0.072	0.330	0.732
	$DA_{i,t}$	Deposits/assets	(a)	384	0.581	0.197	0.132	0.794
	$SDROA_i$	Standard deviation of ROA (ROA= (total interest income - total interest expenses - ordinary costs)/assets)	(a)	384	0.002	0.001	0.000	0.003

Data sources: (a) Nikkei NEEDS CD-ROM, (b) SNA of the Cabinet Office, (c) Financial and economic statistics monthly of the Bank of Japan.

Table 2. Estimation results for the ES and the QL hypotheses

This table shows the results for the GMM estimation of the efficient structure (ES) hypothesis equation and the quiet-life (QL) hypothesis equation. The dependent variable in the ES equation is banks' loan level $\ln L_{i,t}$ (in Panel (A)) or loan growth $\Delta \ln L_{i,t}$ (in Panel (B)). The main independent variable is the bank efficiency measure $EF_{i,t-1}$ (in column (i)) or its interactions with period dummies (in column (ii)). The dependent variable in the QL equation is the bank efficiency measure $EF_{i,t}$ and the main independnt variable is the measure for market concentration (Hirfindahl index) $HI_{i,t-1}$ (in column (i)) or its interactions with period dummies (in column (ii)). For more detailed definitions of these and other variables, see Section 4.2. ***, **, and * respectively represent that the estimated coefficient is significant at a 1%, 5%, and 10% level.

(A) Dependent variable: $\ln L_{i,t}$ for the ES equation and $EF_{i,t}$ for the QL equation

	Independent variable	(i) Baseline regression Estimate	t-statistic		(ii) With period dummies Estimate	t-statistic	
ES equation	(intercept)	-9.3568	-4.9937	***	-9.7267	-5.0949	***
	$EF_{i,t-1}$	1.6429	26.7299	***	NA		
	$EF_{i,t-1} \cdot D^{7689}$	NA			1.4803	22.8522	***
	$EF_{i,t-1} \cdot D^{9000}$	NA			1.7363	26.4944	***
	$EF_{i,t-1} \cdot D^{0105}$	NA			1.3702	27.6018	***
	$\ln GDP_t$	1.9358	13.4672	***	1.9622	13.3719	***
	rc_t	-29.1109	-42.2625	***	-26.3154	-36.3041	***
	$CR_{i,t}$	10.6659	22.0355	***	10.6968	22.6059	***
	$INFL_t$	1.0935	0.8749		2.3538	2.0566	**
QL equation	HI_{t-1}	-0.6842	-6.5825	***	NA		
	$HI_{t-1} \cdot D^{7689}$	NA			0.1529	0.4262	
	$HI_{t-1} \cdot D^{9000}$	NA			-1.4574	-4.5602	***
	$HI_{t-1} \cdot D^{0105}$	NA			-0.4329	-3.6786	***
	$D_{SMLBANK}$	0.2272	7.3620	***	0.1331	3.2526	***
	$D_{MEDBANK}$	0.2671	9.3913	***	0.2165	5.5281	***
	$D_{LARBANK}$	0.4209	14.8058	***	0.3913	9.9878	***
	$D_{HUGBANK}$	0.2215	7.0374	***	0.2074	4.7401	***
	D_{MERGER}	0.0548	4.5290	***	0.0500	3.0520	***
	D_{LTCB}	0.2235	9.0928	***	0.1283	4.8876	***
	D_{FHC}	-0.0566	-4.8623	***	-0.0875	-4.5692	***
	AGE_i	-0.0002	-1.6451	*	-0.0002	-1.0930	
	$LA_{i,t}$	0.3701	6.8200	***	0.7255	9.1481	***
	$DA_{i,t}$	0.6696	16.4805	***	0.4426	8.8203	***
	$SDROA_i$	-55.5862	-8.7794	***	-59.6685	-10.7600	***
R^2		0.4148 (ES) 0.5191 (QL)			0.4639 (ES) 0.4928 (QL)		
Obs.		384			384		
Order of MA for the error term		10			10		
Test for overidentification [P value]		44.3696 [0.582]			44.2691 [0.586]		
Value function		0.1155			0.1153		

(B) Dependent variable: $\Delta \ln L_{i,t}$ for the ES equation and $\Delta EF_{i,t}$ for the QL equation

	Independent variable	(i) Baseline regression Estimate	t-statistic		(ii) With period dummies Estimate	t-statistic	
ES equation	(intercept)	-0.0716	-4.3809	***	-0.0610	-2.9994	***
	$EF_{i,t-1}$	0.0741	4.1062	***	NA		
	$EF_{i,t-1} \cdot D^{7689}$	NA			0.1144	6.3861	***
	$EF_{i,t-1} \cdot D^{9000}$	NA			0.0461	2.4200	**
	$EF_{i,t-1} \cdot D^{0105}$	NA			0.0541	2.0677	**
	$\Delta \ln GDP_t$	1.9404	6.1116	***	1.2298	4.1799	***
	Δrc_t	0.2540	0.3687		-0.8406	-1.6572	*
	$\Delta CR_{i,t}$	-1.6677	-2.4387	**	-0.2083	-0.5230	
	$\Delta INFL_t$	-0.0498	-0.3195		-0.0990	-0.9283	
QL equation	HI_{t-1}	-0.9472	-19.8616	***	NA		
	$HI_{t-1} \cdot D^{7689}$	NA			-2.2824	-11.6058	***
	$HI_{t-1} \cdot D^{9000}$	NA			-1.8475	-12.3069	***
	$HI_{t-1} \cdot D^{0105}$	NA			-1.1408	-29.4724	***
	$D_{SMLBANK}$	0.0919	8.5882	***	0.1809	11.9026	***
	$D_{MEDBANK}$	0.0969	9.5025	***	0.1784	11.7840	***
	$D_{LARBANK}$	0.1050	8.7632	***	0.1694	11.2464	***
	$D_{HUGBANK}$	0.1079	8.4225	***	0.1687	12.3409	***
	D_{MERGER}	0.0096	1.4041		0.0157	3.0676	***
	D_{LTCB}	0.0036	0.5060		-0.0001	-0.0182	
	D_{FHC}	0.0387	5.5857	***	0.0112	1.5361	
	AGE_i	-0.0001	-1.0165		0.00004	0.6584	
	$\Delta LA_{i,t}$	-0.0919	-0.6092		-0.4502	-3.7898	***
	$\Delta DA_{i,t}$	0.7781	6.0029	***	0.2123	1.9406	*
	$SDROA_i$	-9.2732	-2.2257	**	-8.5338	-3.2575	***
R^2		0.2728 (ES) 0.3545 (QL)			0.4690 (ES) 0.4420 (QL)		
Obs.		384			384		
Order of MA for the error term		3			5		
Test for overidentification [P value]		45.1245 [0.551]			49.5029 [0.374]		
Value function		0.1175			0.1289		

Table 3. Robustness Check: Asset growth

This table shows the results for the GMM estimation of the efficient structure (ES) hypothesis equation and the quiet-life (QL) hypothesis equations. The specifications are the same as those in Table 2, except that the dependent variable in the ES equation is banks' asset level $\ln A_{i,t}$ (in Panel (A)) or asset growth $\Delta \ln A_{i,t}$ (in Panel (B)). ***, **, and * respectively represent that the estimated coefficient is significant at the 1%, 5%, or 10% level.

(A) Dependent variable: $\ln A_{i,t}$ for the ES equation and $EF_{i,t}$ for the QL equation

		(i) Baseline regression			(ii) With period dummies		
		Estimate	t-statistic		Estimate	t-statistic	
ES equation	(intercept)	-7.5958	-4.0937	***	-8.4228	-3.9375	***
	$EF_{i,t-1}$	1.3579	22.0450	***	NA		
	$EF_{i,t-1} \cdot D^{7689}$	NA			1.2955	15.3250	***
	$EF_{i,t-1} \cdot D^{9000}$	NA			1.4232	20.9330	***
	$EF_{i,t-1} \cdot D^{0105}$	NA			1.1889	19.3441	***
	$\ln GDP_t$	1.8625	13.1084	***	1.9217	11.7809	***
	rc_t	-30.0980	-74.4652	***	-28.0184	-53.5050	***
	$CR_{i,t}$	11.2982	28.0618	***	11.6685	29.9260	***
	$INFL_t$	1.4611	1.1724		2.5429	2.1276	**
QL equation	HI_{t-1}	-0.6066	-6.6838	***	NA		
	$HI_{t-1} \cdot D^{7689}$	NA			0.0796	0.1961	
	$HI_{t-1} \cdot D^{9000}$	NA			-1.2618	-3.7576	***
	$HI_{t-1} \cdot D^{0105}$	NA			-0.3186	-2.5015	**
	$D_{SMLBANK}$	0.3705	9.8781	***	0.3029	5.7440	***
	$D_{MEDBANK}$	0.4145	11.4563	***	0.3821	7.6686	***
	$D_{LARBANK}$	0.5626	16.5634	***	0.5471	11.5179	***
	$D_{HUGBANK}$	0.3628	9.9574	***	0.3544	7.0592	***
	D_{MERGER}	0.0521	3.8112	***	0.0344	2.2622	**
	D_{LTCB}	0.1862	6.4472	***	0.0769	2.6175	***
	D_{FHC}	-0.0862	-6.1316	***	-0.1115	-5.7451	***
	AGE_i	-0.0004	-2.2245	**	-0.0004	-2.2711	**
	$LA_{i,t}$	0.1682	3.3809	***	0.5268	6.4990	***
	$DA_{i,t}$	0.6189	13.9704	***	0.3808	7.0306	***
	$SDROA_i$	-47.1487	-7.3962	***	-54.6401	-8.9812	***
R^2		0.3907 (ES) 0.5083 (QL)			0.4102 (ES) 0.4949 (QL)		
Obs.		384			384		
Order of MA for the error term		10			10		
Test for overidentification [P value]		45.0666 [0.553]			44.873 [0.561]		
Value function		0.1174			0.1169		

(B) Dependent variable: $\Delta \ln A_{i,t}$ for the ES equation and $\Delta EF_{i,t}$ for the QL equation

		(i) Baseline regression			(ii) With period dummies		
		Estimate	t-statistic		Estimate	t-statistic	
ES equation	(intercept)	-0.0711	-6.3981	***	-0.1075	-4.4869	***
	$EF_{i,t-1}$	0.0415	4.0365	***	NA		
	$EF_{i,t-1} \cdot D^{7689}$	NA			0.0885	5.4116	***
	$EF_{i,t-1} \cdot D^{9000}$	NA			0.0282	1.5050	
	$EF_{i,t-1} \cdot D^{0105}$	NA			0.0966	4.1645	***
	$\Delta \ln GDP_t$	2.7817	7.6949	***	3.1306	5.4440	***
	Δrc_t	-3.4835	-4.0774	***	-6.8801	-5.5926	***
	$\Delta CR_{i,t}$	0.5773	0.6405		4.3528	5.0199	***
	$\Delta INFL_t$	0.1226	0.6490		0.1278	0.7298	
QL equation	HI_{t-1}	-0.9702	-21.2590	***	NA		
	$HI_{t-1} \cdot D^{7689}$	NA			-2.4582	-10.5871	***
	$HI_{t-1} \cdot D^{9000}$	NA			-1.9796	-11.2853	***
	$HI_{t-1} \cdot D^{0105}$	NA			-1.1917	-24.7775	***
	$D_{SMLBANK}$	0.0897	9.5884	***	0.1806	9.8701	***
	$D_{MEDBANK}$	0.0953	10.3644	***	0.1838	10.1481	***
	$D_{LARBANK}$	0.1036	9.5136	***	0.1821	9.8694	***
	$D_{HUGBANK}$	0.0995	7.9288	***	0.1804	10.0970	***
	D_{MERGER}	0.0132	2.1420	**	0.0125	2.3936	**
	D_{LTCB}	0.0017	0.2762		-0.0085	-1.4141	
	D_{FHC}	0.0454	6.6030	***	0.0002	0.0165	
	AGE_i	-0.00003	-0.4502		0.0001	1.2258	
	$\Delta LA_{i,t}$	-0.1102	-0.7683		-0.6206	-3.9290	***
	$\Delta DA_{i,t}$	0.7620	6.5925	***	0.3872	2.9075	***
	$SDROA_i$	-8.2640	-2.3280	**	-3.7070	-1.0905	
R^2		0.2472 (ES) 0.3559 (QL)			0.2207 (ES) 0.4140 (QL)		
Obs.		384			384		
Order of MA for the error term		3			5		
Test for overidentification [P value]		42.0602 [0.677]			41.8537 [0.685]		
Value function		0.1095			0.1090		

Table A1 Descriptive statistics for variables in cost function estimation

		# of obs.	Mean	Std Dev.	Min.	Max.
$y_{L,i,t}$	(million yen)	410	15,957,200	10,904,800	2,531,535	56,489,700
$y_{D,i,t}$	(million yen)	410	16,629,700	13,287,300	971,360	70,883,200
$p_{B,i,t}$		410	0.04	0.017	0.003	0.079
$p_{V,i,t}$		410	1.031	0.166	0.629	1.221
$p_{L,i,t}$		410	3.848	1.275	1.689	8.415
$p_{K,i,t}$		410	1.072	0.247	0.355	1.762
$C^V_{i,t}$	(million yen)	410	569,638	403,874	42,873	2,064,571
Share of cost for ordinary goods		410	0.123	0.085	0.011	0.47
$S^L_{i,t}$		410	0.214	0.122	0.024	0.528
$S^K_{i,t}$		410	0.05	0.028	0.005	0.162
$S^B_{i,t}$		410	0.614	0.21	0.1	0.956

Table A2 Regression result for stochastic frontier cost function

Coef.	Estimates	St. Error	*t*	*P*
a_{YL}	1.3300	0.0727	18.2903	0.000
a_{YD}	-0.3148	0.0483	-6.5193	0.000
a_{YLYL}	0.7368	0.0944	7.8031	0.000
a_{YDYD}	-0.1247	0.0477	-2.6163	0.009
a_{LL}	0.0883	0.0090	9.8355	0.000
a_{KK}	0.0272	0.0016	17.4921	0.000
a_{BB}	0.2313	0.0044	51.9804	0.000
a_{VV}	0.1055	0.0120	8.8087	0.000
a_{YLYD}	-0.1572	0.0530	-2.9656	0.003
a_{YLL}	-0.0841	0.0058	-14.6016	0.000
a_{YLK}	-0.0082	0.0020	-4.1899	0.000
a_{YLB}	0.1489	0.0075	19.7364	0.000
a_{YLV}	-0.0566	0.0048	-11.7741	0.000
a_{YLT}	0.0008	0.0046	0.1694	0.865
a_{YDL}	-0.0211	0.0068	-3.1051	0.002
a_{YDK}	-0.0059	0.0018	-3.3630	0.001
a_{YDB}	0.0097	0.0086	1.1282	0.259
a_{YDV}	0.0173	0.0057	3.0573	0.002
a_{YDT}	0.0003	0.0034	0.0794	0.937
a_{LK}	0.0117	0.0030	3.8678	0.000
a_{LB}	-0.1084	0.0029	-37.4694	0.000
a_{LV}	0.0085	0.0095	0.8857	0.376
a_{LT}	-0.0050	0.0004	-12.8595	0.000
a_{KB}	-0.0239	0.0008	-28.8756	0.000
a_{KV}	-0.0150	0.0033	-4.5908	0.000
a_{KT}	-0.0007	0.0001	-5.2919	0.000
a_{BV}	-0.0989	0.0028	-35.3000	0.000
a_{BT}	0.0053	0.0005	10.3655	0.000
a_{VT}	0.0004	0.0004	1.1608	0.246
Bank fixed effects	yes			
R^2	Cost function		0.989705	
	Share of labor		0.917889	
	Share of capital		0.827383	
	Share of nondeposit debts		0.940428	
Value function	0.348222			
Overidentifiaction test	142.771			
[P value]	[.671]			
Obs.	410			

Table A3 Cost efficiency for individual banks

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988	1989	1990
Industrial Bank of Japan	0.60	0.61	0.62	0.62	0.63	0.63	0.64	0.64	0.64	0.64	0.63	0.63	0.62	0.60	0.58	0.55
Long-Term Credit Bank of Japan	0.64	0.64	0.63	0.63	0.64	0.64	0.64	0.65	0.65	0.65	0.65	0.65	0.64	0.63	0.61	0.57
Shinsei Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Nippon Credit Bank	0.61	0.62	0.64	0.65	0.66	0.66	0.66	0.66	0.65	0.65	0.63	0.61	0.59	0.56	0.53	0.49
Aozora Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Daiichi Kangyo Bank	0.58	0.59	0.61	0.62	0.64	0.66	0.68	0.70	0.73	0.75	0.78	0.80	0.81	0.82	0.82	0.80
Mizuho Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mitsui Bank	0.67	0.70	0.73	0.76	0.79	0.82	0.84	0.86	0.88	0.89	0.89	0.88	0.87	0.84	0.80	NA
Sakura Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Fuji Bank	0.64	0.65	0.67	0.68	0.69	0.70	0.72	0.73	0.75	0.76	0.77	0.78	0.79	0.79	0.77	0.75
Mizuho Corporate Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Mitsubishi Bank	0.67	0.68	0.69	0.70	0.71	0.72	0.73	0.75	0.76	0.77	0.78	0.79	0.79	0.79	0.78	0.75
Bank of Tokyo Mitsubishi	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kyowa Bank	0.71	0.78	0.83	0.87	0.91	0.94	0.96	0.98	0.99	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	0.99	0.97
Asahi Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sanwa Bank	0.71	0.71	0.72	0.73	0.75	0.76	0.78	0.81	0.83	0.86	0.87	0.89	0.91	0.91	0.90	0.88
UFJ Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
SumitomoBank	0.70	0.71	0.72	0.73	0.74	0.76	0.77	0.79	0.81	0.83	0.85	0.86	0.86	0.86	0.84	0.81
Mitsui Sumitomo Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Daiwa Bank	0.71	0.75	0.79	0.82	0.84	0.85	0.86	0.87	0.86	0.86	0.84	0.82	0.80	0.77	0.73	0.69
Resona Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Tokai Bank	0.65	0.68	0.71	0.73	0.76	0.78	0.80	0.82	0.83	0.85	0.85	0.85	0.85	0.84	0.82	0.78
Hokkaido Takushoku Bank	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	0.99	0.98	0.96	0.93	0.90	0.85
Taiyo Kobe Bank	0.68	0.70	0.73	0.75	0.78	0.80	0.83	0.86	0.89	0.92	0.94	0.95	0.96	0.97	0.95	NA
Tokyo Bank	0.52	0.54	0.55	0.56	0.56	0.56	0.56	0.56	0.55	0.54	0.53	0.52	0.50	0.48	0.45	0.42
Saitama Bank	0.91	0.94	0.97	0.98	0.99	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	0.99	0.99	0.99	**1.00**	**1.00**	**1.00**
(Mean)	0.69	0.71	0.72	0.74	0.76	0.77	0.78	0.79	0.80	0.81	0.81	0.81	0.81	0.80	0.78	0.74

	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005	(mean)
Industrial Bank of Japan	0.62	0.58	0.59	0.59	0.58	0.57	0.57	0.56	0.56	0.55	0.56	NA	NA	NA	NA	0.60
Long-Term Credit Bank of Japan	0.64	0.60	0.60	0.59	0.57	0.55	0.52	NA	NA	NA	NA	NA	NA	NA	NA	0.62
Shinsei Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.95	0.61	0.61	0.61	0.70
Nippon Credit Bank	0.53	0.49	0.48	0.46	0.44	0.42	0.41	NA	NA	NA	NA	NA	NA	NA	NA	0.57
Aozora Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.69	**1.00**	0.65	0.65	0.65	0.73
Daiichi Kangyo Bank	0.92	0.89	0.92	0.93	0.92	0.91	0.90	0.88	0.85	0.81	0.79	NA	NA	NA	NA	0.78
Mizuho Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.50	0.50	0.50	0.50
Mitsui Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.82
Sakura Bank	**1.00**	0.97	0.99	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	**1.00**	NA	NA	NA	NA	NA	1.00
Fuji Bank	0.85	0.82	0.85	0.85	0.85	0.85	0.85	0.85	0.84	0.82	0.83	NA	NA	NA	NA	0.77
Mizuho Corporate Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	**1.00**	**1.00**	**1.00**	1.00
Mitsubishi Bank	0.86	0.84	0.87	0.89	0.91	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.77
Bank of Tokyo Mitsubishi	NA	NA	NA	NA	NA	NA	0.71	0.69	0.67	0.66	0.67	0.93	0.59	0.57	NA	0.69
Kyowa Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.93
Asahi Bank	NA	**1.00**	**1.00**	0.99	0.97	0.96	0.95	0.95	0.96	0.96	**1.00**	NA	NA	NA	NA	0.97
Sanwa Bank	**1.00**	0.96	0.98	0.98	0.97	0.95	0.93	0.90	0.86	0.81	NA	NA	NA	NA	NA	0.86
UFJ Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.82	0.53	0.53	NA	0.63
SumitomoBank	0.92	0.88	0.89	0.88	0.86	0.84	0.81	0.77	0.73	0.69	NA	NA	NA	NA	NA	0.80
Mitsui Sumitomo Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.61	0.61	0.61	0.61
Daiwa Bank	0.76	0.72	0.73	0.72	0.72	0.73	0.74	0.76	0.79	0.82	0.89	NA	NA	NA	NA	0.79
Resona Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.65	0.65	0.65	0.65
Tokai Bank	0.87	0.83	0.84	0.84	0.83	0.82	0.81	0.80	0.78	0.77	NA	NA	NA	NA	NA	0.80
Hokkaido Takushoku Bank	0.94	0.88	0.88	0.86	0.84	0.82	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.95
Taiyo Kobe Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.85
Tokyo Bank	0.46	0.44	0.44	0.43	0.42	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.50
Saitama Bank	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	0.99
(Mean)	0.80	0.78	0.79	0.79	0.78	0.79	0.77	0.82	0.80	0.79	0.77	0.93	0.64	0.64	0.67	0.77