

Bank Ownership and Efficiency

by

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Abstract

Agency issues associated with different types of firm ownership are an area of concern in many banking systems where state-owned banks operate alongside mutual and private sector institutions. This paper uses the a variety of approaches to model cost and profit inefficiencies as well as technical change for different ownership types in the German banking market. We find little evidence to suggest that privately owned banks are more efficient than their mutual and public sector counterparts. While all three bank ownership types benefit from widespread economies of scale, inefficiency measures indicate that public and mutual banks have slight cost and profit advantages over their private sector competitors.

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1. Introduction

Over the years, a considerable literature has developed on the relationship between industrial ownership and performance. Two clear messages from that literature are: (i) that ownership is important; and (ii) that it is helpful to view the issue in the context of the principal-agent framework and public choice theory. However, whilst that literature has provided considerable understanding of the effects of ownership, its primary focus is on non-financial firms. This paper shifts the focus to banks and the question of whether the ownership structure of banks influences their economic behaviour. In particular, the paper attempts to evaluate whether cost and profit inefficiencies and technical change are related to bank ownership structures. The empirical work is carried out in the context of the German banking market which has a broad mix of ownership forms - private, public and mutual.

The reasons why different ownership forms may lead to different efficiency levels have been extensively explored in the literature; and the dominant model of the effect of ownership utilises the principal agent framework and public choice theory to highlight the importance of the extent to which management is constrained by capital market discipline. The theoretical argument is straightforward: a lack of capital market discipline weakens owners' control over management, making management freer to pursue its own agenda, and giving it fewer incentives to be efficient. However, whilst extensive empirical evidence provides some support for the hypothesis that public enterprises perform less efficiently than private enterprises, it should be noted that this theoretical argument is not without its critics.¹ Also, it should be stressed that the empirical work has largely concentrated on the simple dichotomy of privately-owned and publicly-owned firms, particularly non-financial firms, and particularly in non-competitive environments.²

¹ This is part of the wider debate on the public choice model, key contributions to which are Berle and Means (1932), Manne (1965), Jensen and Meckling (1976), Fama (1980), Frech (1980), Grossman and Hart (1980) and Jensen and Fama (1983).

² There are some notable exceptions, for example, Boardman and Vining (1989) focuses on firms operating in a competitive environment and gives particular attention to mixed ownership enterprises alongside public and privately owned. Also, see Boardman and Vining for a useful summary table of empirical evidence on the relative efficiency of privately-owned and publicly-owned firms.

In turning to the banking industry, it is clear that not only is the industry highly competitive, but also that in many countries mutual ownership must be considered alongside that of public and private ownership forms. Also, there is relatively little guidance from the literature about the relative efficiency of these three ownership forms of financial firms. One way forward is to ask the more general question of why management may not be minimising their costs of production (in each of the ownership forms). This question is of course central to the well established literature on X-inefficiency (Leibenstein, 1966) and technical inefficiency (Farrell, 1957) - a literature which emphasises the role of environmental pressure which should weaken management's incentive to be efficient, whereas high levels of competition in a firm's market is a classic example of a high intensity environmental pressure which should strengthen management's incentive to be efficient.³

In the specific case of the banking industry, the separation of ownership from control is common to all three ownership forms. However, the lack of capital market discipline, common to mutual and public ownership, may indicate that management in these banks experience a lower intensity of environmental pressure and therefore may operate less efficiently than privately owned banks. This is certainly in line with the arguments presented in O'Hara (1981) and Niclos (1967), two papers which explicitly compare aspects of mutual with private ownership of financial firms. In particular, both papers argue that, relative to private ownership, management of mutual firms will, *ceteris paribus*, be less cost-efficient. However, this theoretical argument is not clear-cut. Miles (1994) develops this point at some length. Most notably, he questions the implicit assumption that the managers in privately owned banks are monitored and disciplined effectively by their shareholders whilst managers in mutual enjoy some freedom to pursue a personal agenda. He draws first, on the work of Fama (1980) to make the point that 'effective monitoring of management is not dependent on a particular corporate form (PLC as against mutual) and is not weakened by the absence of a market in which ownership rights can be traded' (p.232).⁴ He then turns to work by Jensen and Fama (1983) who argue that accountability of the managers of mutual to their owners may be

³ Other potentially important environmental pressures include: the nature of the regulatory environment; market structure; entry and exit conditions; and the bureaucratic nature of the organisation.

⁴ This argument rests on Fama's view that other forms of monitoring and disciplining management exist. For example, he argues that the labour market for managers will discourage managers from pursuing any personal agenda (and they will therefore seek to operate efficiently in the interests of their owners); and he notes the presence of professional monitors of managers on boards which serves to constrain and discipline management.

greater than that of the managers of private organisations simply because mutual claim holders can each independently exercise the right to withdraw funds when faced with evidence of managerial inefficiency. This sanction on managerial inefficiency is arguably more effective than the sale of shares on a secondary market (which leaves funds within the firm).

Miles' analysis provides a useful insight on mutual organisations and therefore provides some basis for considering the relative efficiency of three ownership forms of financial firms. For example, the argument attributed to Fama could easily be generalised to include public ownership amongst the corporate forms;⁵ and, given the centralised power of the public sector to withdraw funds if it so desires, the Jensen and Fama argument can be applied to argue that public ownership has a powerful sanction to apply to management. Importantly, it seems that the relative intensity of the environmental pressure on management in each of the corporate forms cannot be resolved on theoretical grounds. All that is clear is that the central issue relates to the linkage between managers' objectives and owners' interests.⁶ Gorton and Rosen (1995) address the issue of ownership and control for US commercial banks during the 1980s and they find that owner-managers tend to take on excessive risks when the banking industry is performing poorly. This tendency, they argue, is due to the incentives that managers face when the fraction of the bank they own is large enough for them to make outside discipline costly, but not so large as to cause their interests to be aligned with those of outside shareholders. In contrast, when the banking industry is healthy, 'entrenched' managers behave too conservatively. While the aforementioned study provides a good indication of ownership and control issues for private banks, there remains little guidance from theory on the nature of these types linkages for private, public and mutual institutions.⁷

Studies on managerial incentives in US banking have mainly focused on expense preference

⁵ Fama's reference to the role of labour market competition is certainly pertinent to the public ownership form.

⁶ This presupposes that owners' interests in all three cases requires management to be cost efficient. This may not be wide of the mark: in a privately-owned corporation, owners' interests are met through maximisation of the stock market value of the firm; in mutual, members' interests are met through minimisation of the spread between the rates offered to depositors and those charged to borrowers (Miles, 1994); and in public ownership, maximisation of social welfare again requires cost efficiency. With management required to be cost efficient, the key issue is the link between managers' objectives and owners' interests.

⁷ This echoes Miles (1994) who identifies the need for empirical evidence to address the question of whether managers of mutuals face fewer incentives to be efficient than managers in privately-owned companies. Miles presents some descriptive statistics for UK banks and mutual building societies (for example, expenses ratios, pre-tax profits and rate of return on capital) which suggest that building societies have consistently outperformed banks and, in particular, have consistently had lower costs.

behaviour in relation to market structure⁸. The expectation was that a firm in a less competitive local market may choose to take any gains from market power in the form of spending more on staff and other perquisites rather than in the form of higher profits. Berger and Hannan (1998), for instance, find strong evidence that during the 1980s US banks operating in more concentrated markets exhibit lower cost efficiency. They find that the estimated efficiency cost of concentration to be several times larger than the social loss associated with mispricing. Other studies have examined the effect of mutual versus stock ownership in the savings and loan industry (for example, Verbrugge and Goldstein, 1981; Verbrugge and Jahera 1981; and Blair and Placone, 1988) and in the life insurance industry (Fields, 1988). These studies estimate cost functions that distinguish between ownership type by including a stock versus mutual binary variable in the model specification.⁹ Recent literature, (Mester, 1989; Mester, 1993; and Cebenoyan et al., 1993) takes a more rigorous approach. Mester (1993) and Cebenoyan et al. (1993) both use the stochastic cost frontier methodology to evaluate inefficiency scores for the two ownership types. Mester finds mutual S&Ls to more efficient than stock-owned banks, although Cebenoyan et al. find no difference.

While the aforementioned literature has dedicated much attention to the efficiency characteristics of mutual and private banking firms none of the studies consider the effect of public ownership because such ownership is not prevalent in the United States. As Berger et al. (1993) has also noted, ‘...further research is needed quasi-government financial institutions... that provide measurable outputs in at least somewhat competitive markets.’ (p.239). The aim of the following analysis is to extend the established literature by examining the cost characteristics of private, mutual and public banks, types of ownership which are widespread in many non-US banking markets.

The structure of the paper is as follows. Section 2 outlines the cost and profit frontier methodology utilised in this paper. Data and results are discussed in Section 3; and Section 4 is the conclusion.

⁸ See Edwards (1977), Hannan (1979), Hannan and Mavinga (1980) and Smirlock and Marshall (1983).

⁹ Others such as Carter and Stover (1995) and Peristiani and Wizman (1997) have examined the rationale for mutual-to-stock conversions in the US thrift industry.

2. Methodology

This study uses a variety of approaches to model cost and profit efficiencies, as well as technical change, for different ownership types in the German banking market. Estimating efficiencies for different bank ownership forms, however, poses two main problems. First, one has to decide whether to estimate an industry cost or profit frontier including all ownership types from which efficiencies can be calculated, or alternatively, whether frontiers for each ownership type be estimated. The former allows for comparisons between ownership types relative to the industry 'best practice' cost or profit frontier, whereas the latter only permits comparison between banks of the same ownership type. Mester (1989, 1993) makes the case for estimating a separate cost function for each type of ownership, arguing that it is inappropriate to compare inefficiency scores for different ownership categories when firms in one category utilise a different technology. Mester argues that this will confound technology choice and inefficiency if different technologies are adopted. Cebenoyan et al. (1993) recognise this and test for differing underlying cost functions for firms in their sample. Since they find none, they use a single estimating equation for both mutual and stock firms. However, *if a priori*, all firms are faced with the same opportunities to combine labour, physical capital, and financial capital to produce outputs that are virtually identical, then the adoption of a technology that results in higher costs or lower profits is the result of a management choice. Presumably, managers who were monitored effectively by owners would choose the lower cost or higher profit technology. For instance, being close to the 'frontier' of a costly or lower profit technology may result in higher costs/ lower profits than being a bit further from the frontier of a more efficient technology. The Cebenoyan et al (1993) approach is also perhaps more useful for regulators in that they can compare the efficiencies of different ownership types relative to best practice in the industry, as opposed to best practice in the ownership sector. This may be important when the authorities have to consider issues relating to demutualisation and privatisation within their banking system.

The second difficulty concerns the objectives and incentives of managers who run banks with different ownership types. While market forces are expected to discipline private commercial banks to minimise costs, it is uncertain as to whether managers of mutual and public banks follow similar objectives. For instance, Fried et al (1993) argue that a traditional cost minimising approach cannot be used to evaluate the efficiency of the US credit union sector

and Lang and Welzel (1996) also state in the context of German cooperative banks, '...one can indeed ask if such (banks) can be assumed to minimise costs at a given scale' (p.1012). While Mester (1993), Cebenoyan et al. (1993) and Lang and Welzel (1996) recognise that agency problems may imply managerial objectives other than cost minimisation, they all suggest that competition between banks is likely to emphasise cost minimisation as important managerial objectives. In addition, owners of public and mutual banks do have means of sanctioning inefficient managers which is also likely to encourage management to focus on efficiency criteria especially in competitive banking markets. Cost-minimisation or profit maximisation approaches which find that mutual banks appear to lie further way from the best-practice frontier compared with similar sized private banks might also suggest that different ownership forms pursue objectives other than cost minimisation or profit maximisation.¹⁰

Our approach, therefore, follows from those of Mester (1993), Cebenoyan et al (1993) and Berger and Mester (1997) as we estimate separate cost and alternative profit frontiers for the three different ownership types: private commercial banks, public savings banks and mutual cooperative banks. We then compare these results with those derived from a sample combining all three ownership types. This allows for comparisons of scale economies, cost and profit efficiencies, and technical change between banks that have the same organisational form and also permits a comparison across ownership types.

For our definition of inputs and outputs we choose the intermediation approach as suggested by Sealey and Lindley (1977), where the inputs, labour, physical capital and deposits are used to produce earning assets. We include five outputs: mortgage loans; public sector loans; other loans; other earning assets and off-balance sheet items. Although off-balance sheet items are technically not earning assets this type of business constitutes an increasing source of income for many banks and therefore should be included when modelling banks' cost and profit inefficiencies, otherwise total output would tend to be understated. (Jagtiani and Khanthavit, 1996).

¹⁰ For example, Lang and Welzel (1995) in their study of the German banking market found that deviations from cost minimisation was more severe among cooperative banks.

Inefficiency measures are estimated using the stochastic frontier and distribution-free approaches. The stochastic frontier approach labels a bank as inefficient if its costs are higher, or profits lower, than those predicted for an efficient bank producing the same input/output combination and the difference cannot be explained by statistical noise. The cost or alternative profit frontier is obtained by estimating a cost or alternative profit function with a composite error term, the sum of a two-sided error representing random fluctuations in cost or profit and a one-sided positive error term representing inefficiency.

Ferrier and Lovell (1990) have shown that inefficiency measures for individual firms can be estimated using the stochastic frontier approach as introduced by Aigner et al. (1977), Meeusen and van den Broeck (1977) and Battese and Corra (1977). The single-equation stochastic cost model can be given as:

$$TC = TC(Q_i, P_i) + \varepsilon_i \quad (1)$$

Where TC are observed total cost, Q_i is a vector of outputs, and P_i is an input price vector.

Following Aigner et al. (1977), we assume that the error of the cost function is:

$$\varepsilon = u + v \quad (2)$$

where u and v are independently distributed. u is usually assumed to be distributed as half-normal, that is, a one-sided positive disturbance capturing the effects of inefficiency, and v is assumed to be distributed as two-sided normal with zero mean and variance σ^2 , capturing the effects of the statistical noise.

Observation-specific estimates of the cost inefficiencies, u , can be calculated by using the distribution of the inefficiency term conditional on the estimate of the composed error term, as proposed by Jondrow et al. (1982). The mean of this conditional distribution for the half-normal model is shown as:

$$E(u_i | \varepsilon_i) = \frac{\sigma\lambda}{1 + \lambda^2} \left[\frac{f(\varepsilon_i \lambda / \sigma)}{1 - F(\varepsilon_i \lambda / \sigma)} + \left(\frac{\varepsilon_i \lambda}{\sigma} \right) \right] \quad (2)$$

where $F(\cdot)$ and $f(\cdot)$ are the standard normal distribution and the standard normal density function, respectively. $E(u | \varepsilon)$ is an unbiased but inconsistent estimator of u_i , since regardless of N , the

variance of the estimator remains non-zero (see Greene, 1993; p.80-82). Jondrow et al. (1982) have shown that the ratio of the variability (standard deviation, σ) for u and v can be used to measure a banks' relative inefficiency, where $\lambda = \sigma_u/\sigma_v$, is a measure of the amount of variation stemming from inefficiency relative to noise for the sample. Estimates of this model can be computed by maximising the likelihood function directly (see Olson, Schmidt and Waldman, 1980). Previous studies modeling international bank cost inefficiencies such as, Allen and Rai (1996) and those which examine US banks, such as Kaparakis et al (1994), and Mester (1996), all use the half-normal specification to test for inefficiency differences between banking institutions¹¹. To calculate the profit inefficiencies we use the alternative profit function formulation as specified in Berger and Mester (1997). Inefficiencies are calculated in the same way as in the above cost frontier case although because we are maximizing profits (as opposed to minimizing costs) the inefficiency term, u , is subtracted from the estimated residuals.

Earlier studies (Bauer and Hancock, (1993), Berger (1993), Berger and Mester (1997)), however, have also noted that the distributional assumptions of the stochastic frontier approach are fairly arbitrary. As such, it has been suggested that if panel data are available then the distributional assumptions of the stochastic frontier approach can be relaxed and the distribution-free approach may be used. This method assumes that there is a 'core or average efficiency' for each firm over time. 'The core efficiency is distinguished from the random error (and any temporary fluctuations in efficiency) by assuming that core inefficiency is persistent over time, while random errors tend to average out over time' (Berger and Mester, 1997 p.906). To calculate the distribution-free inefficiencies the cost and alternative profit function are estimated for each period of the panel data set and the random error is assumed to average out over time so the average of a bank's residuals from all of the regressions will be an estimate of the inefficiency term¹².

¹¹ See Bauer (1990) for an excellent review of the frontier literature and how different stochastic assumptions can be made. Cebenoyan et al. (1993), for example, use the truncated normal model. Mester (1993) in common with many (non-banking) studies uses the half-normal distribution. Stevenson (1980) and Greene (1990) have used the normal-gamma model. Altunbas and Molyneux (1994) find that efficiency estimates are relatively insensitive to different distributional assumptions when testing the half normal, truncated normal, normal-exponential and gamma efficiency distributions, as all distributions yield similar inefficiency levels for the German banking market.

¹² The approach followed is the same as outlined in Berger and Mester (1997). Given the period of our study spans 1989 – 1996 it is reasonable to assume that random errors will average out.

The next step, given the choice of inefficiency measures, relates to choosing the underlying cost and profit function specification. To estimate cost and profit inefficiencies we use the standard cost function and alternative profit function approaches as detailed in Berger and Mester (1997). Inefficiencies are derived from a cost or profit function in which total costs or total profits depend on the prices of variable inputs, outputs and a time trend.

In this paper we use the Fourier Flexible form (FF) to examine the specification which best fits the underlying cost and profit structure of German banks. The first application of the Fourier Flexible specification to banking was by Mitchell and Onvural (1996) and Berger et al (1997). Gallant (1981, 1982), as well as the aforementioned authors, have noted that the FF is the global approximation which can be shown to dominate the conventional translog form. It has been widely accepted that the global property is important in banking where scale, product mix and other inefficiencies are often heterogeneous, therefore, local approximations (such as those generated by the translog function) may provide poor approximation to the underlying true function.

The FF is a semi-nonparametric approach used to tackle the problem arising when the true functional form of the relationships are unknown. This methodology was first proposed by Gallant (1981, 1982), discussed by Elbadawi, Gallant and Souza (1983), Chalfant and Gallant (1985), Eastwood and Gallant (1991), Gallant and Souza (1991) and applied to the analysis of bank cost efficiency by Berger et al. (1994), Spong et al. (1995) and more recently by Mitchell and Onvural (1996). It has been shown (Tolstov, 1962), that a linear combination of the sine and cosine function, namely the Fourier series, can approximate any well behaved multivariate function. This is due to the mathematical behavior of the sine and cosine functions which are mutually orthogonal over the $[0, 2\pi]$ interval and function space-spanning. The FF form, therefore, provides a better approximation of the true form of the unknown function without misspecification.

To calculate the inefficiency measures, the FF form, including a standard translog and all first, second and third-order trigonometric terms, as well as a two-component error structure is estimated using a maximum likelihood procedure. This is shown as:

$$\begin{aligned}
\ln TC = & \alpha_0 + \sum_{i=1}^5 \alpha_i \ln Q_i + \sum_{i=1}^3 \beta_i \ln P_i + t_1 T + \\
& \frac{1}{2} \left[\sum_{i=1}^5 \sum_{j=1}^5 \delta_{ij} \ln Q_i \ln Q_j + \sum_{i=1}^3 \sum_{j=1}^3 \gamma_{ij} \ln P_i \ln P_j + t_1 T^2 \right] + \\
& \sum_{i=1}^3 \sum_{j=1}^5 \rho_{ij} \ln P_i \ln Q_j + \sum_{i=1}^3 \psi_{it} \ln P_i T + \sum_{i=1}^5 \theta_{it} \ln Q_j T + \\
& \sum_{i=1}^5 [a_i \cos(z_i) + b_i \sin(z_i)] + \sum_{i=1}^5 \sum_{j=1}^5 [a_{ij} \cos(z_i + z_j) + b_{ij} \sin(z_i + z_j)] + \quad (3) \\
& \sum_{i=1}^5 \sum_{j=1}^5 \sum_{k \geq j, k \neq i} [a_{ijk} \cos(z_i + z_j + z_k) + b_{ijk} \sin(z_i + z_j + z_k)] + \varepsilon
\end{aligned}$$

where

$\ln TC$ = the natural logarithm of total costs (Operating and Financial cost);

$\ln Q_i$ = the natural logarithm of bank outputs (with one added to avoid problems with taking the log of zero);

$\ln P_i$ = the natural logarithm of i th input prices (*i.e.* wage rate, interest rate and physical capital price);

T = time trend;

Z_i = the adjusted values of the log output $\ln Q_i$ such that they span the interval $[0, 2\pi]$;

$\alpha, \beta, \delta, \gamma, \theta, \Psi, \rho, a, t$ and b are coefficients to be estimated.

The alternative profit function has the same specification as the above, the only difference being that the dependent variable is replaced with profits¹³. Following Berger et al. (1997), we apply Fourier terms only for the outputs, leaving the input price effects to be defined entirely by the translog terms. The primary aim is to maintain the limited number of Fourier terms for describing the scale and inefficiency measures associated with differences in ownership and

¹³ We use net income before tax as our profits measure with the relevant adjustment to exclude negative values. This differs with Berger and Mester (1997) who use a return-on-equity profits measure. We attempted to estimate the alternative profits function with both return-on-equity and return-on-assets as the dependent variables but the results revealed unreliable parameter estimates.

bank size. Moreover, the usual input price homogeneity restrictions can be imposed on logarithmic price terms, whereas they cannot be easily imposed on the trigonometric terms¹⁴.

In addition, the scaled log-output quantities, z_i , are calculated as $z_i = \mu_i (\ln Q_i + w_Q)$, $\ln Q_i$ are unscaled log-output quantities; μ_i and w_Q are scaled factors. It should be noted that it is important to scale the data to limit the periodic sine and cosine trigonometric functions within one period of length 2π before applying the FF methodology (see Gallant 1981). The μ_i 's are chosen to make the largest observations for each scaled log-output variable close to 2π ; w_Q 's are restricted to assume the smallest values close to zero. In this study, we restricted the z_i to span between 0.001 and 6 to reduce approximation problems near the endpoints as discussed by Gallant (1981) and applied by Mitchell and Onvural (1996)¹⁵.

Since the duality theorem requires that the cost and alternative profit function must be linearly homogeneous in input prices, the following restrictions have to be imposed on the parameters of the function in equation (4):

$$\sum_{i=1}^3 \beta_i = 1 \quad \sum_{i=1}^3 \gamma_{ij} = 0 \quad \text{for all } j; \tag{4}$$

$$\sum_{i=1}^3 \rho_{ij} = 0 \quad \text{for all } j.$$

Furthermore, the second order parameters in equation (4) must be symmetric so:

¹⁴ Mitchell and Onvural (1996; p.181) did not impose restrictions on the trigonometric input price coefficients for computational reasons. Gallant (1982), however, has shown that this should not prevent an estimated FF cost equation from closely approximating the true cost function.

¹⁵ Berger et al. (1997) restricted z_i to span $[.1; 2\pi, .9; 2\pi]$, however, the use of this interval provided inconsistent results in the present study. While Mitchell and Onvural (1996) adopted a second trigonometric order in their study, we preferred to use a third trigonometric order following Berger et al. (1997). According to Gallant (1982), increasing the number of trigonometric orders, relative to sample size, reduces approximation errors. Eastwood and Gallant (1991) show that the FF cost function produces consistent and asymptotically normal parameter estimates when the number of parameters estimated is set to the number of effective observations raised to the two thirds power. However, Gallant (1981) advocates that even a limited number of trigonometric orders is sufficient to obtain global approximations. The choice of the range used by different researchers is, however, subjective and relative to the size of data set analysed.

$$\delta_{ij} = \delta_{ji} \text{ for all } i, j; \quad (5)$$

$$\gamma_{ij} = \gamma_{ji} \text{ for all } i, j.$$

The cost and alternative profit frontiers are estimated using the random effects panel data approach (as in Lang and Welzel, 1996). We use the panel data approach because technical efficiency is better studied and modeled with panels (see Baltagi and Griffin, 1988; Cornwell, Schmidt and Sickles, 1990; Kumbhakar, 1993). The random effects model is preferred over the fixed effects model because the latter is considered to be the more appropriate specification if we are focusing on a specific set of N firms. Moreover, and if N is large, a fixed effects model would also lead to a substantial loss of degrees of freedom (See Baltagi, 1995). Simar (1994) has also noted that because time-variant regressions cannot be estimated in the fixed model approach this method may yield inaccurate measures of efficiency. As such, the random effects model, appears to be the more appropriate.

Within sample scale economies are calculated as in Mester (1996) and are evaluated at the mean output and input price levels for the respective size quartiles. A measure of economies of scale (*SE*) is given by the following cost elasticity by differentiating the cost function in equation (4) with respect to output. This gives us:

$$SE = \sum_{i=1}^5 \frac{\partial \ln TC}{\partial \ln Q_i} = \sum_{i=1}^5 \alpha_i + \sum_{i=1}^5 \sum_{j=1}^5 \delta_{ij} \ln Q_j + \sum_{i=1}^3 \sum_{j=1}^5 \rho_{ij} \ln P_i + \sum_{i=1}^5 \Theta_{i\tau} T + \mu_i \sum_{i=1}^5 [-a_i \sin(Z_i) + b_i \cos(Z_i)] + 2\mu_i \sum_{i=1}^5 \sum_{j=1}^5 [-a_{ij} \sin(Z_i + Z_j) + b_i \cos(Z_i + Z_j)] \quad (6)$$

If $SE < 1$ then increasing returns to scale, implying economies of scale;

If $SE = 1$ then constant returns to scale;

If $SE > 1$ then decreasing returns to scale, implying diseconomies of scale.

Following Hunter and Timme (1991), McKillop et al. (1996) and Lang and Welzel (1996) the rate of technical progress may be inferred from changes in a firm's cost function over time. A time trend variable, T, serves as a proxy for disembodied technical change. The time-trend is a 'catch-all' variable that captures the effects of technological factors: i.e. learning by doing and

organisational changes allowing for the more efficient use of existing inputs, together with the effects of other factors, such as changing environmental regulations (see Baltagi and Griffin, 1988; Nelson, 1984). Technical progress allows the firm to produce a given output, Q , at lower levels of total cost over time, holding input prices and regulatory effects constant. In order to estimate the impact of technical change we calculate the variation in the average cost due to a given change in technology. This can be measured by the partial derivative of the estimated cost function with respect to the time trend (T) and can be shown as follows:

$$T_c = \frac{\partial \ln TC}{\partial T} = t_1 + t_{11} T + \sum_{i=1}^3 \psi_i \ln P_i + \sum_{i=1}^5 \theta_i \ln Q_i \quad (7)$$

3. Data and Results

This study uses banks' balance sheet and income statement data for a sample of German banks between 1989 and 1996, obtained from the London-based International Bank Credit Analysis Ltd's 'Bankscope' database. Table 1 shows the number and size of banks according to ownership category and Table 2 illustrates the coverage of our sample relative to the populations for each ownership type and for the whole banking sector¹⁶. The unbalanced nature of our sample was determined by the limited coverage of the database in the late 1980's and early 1990's although Table 2 shows that a substantial proportion of banking sector assets are covered. Overall, the sample consists of 1195 private commercial bank observations, 2858 public savings bank observations and 3486 mutual co-operative bank observations between 1989 and 1996.

INSERT TABLE 1 AND TABLE 2 HERE

The breakdown of banks into the three ownership types: private commercial banks, public savings banks and mutual cooperative banks, is helped by the detailed classification provided by the Deutsche Bundesbank. Our sample of private commercial banks includes (in

¹⁶Data for the whole population of German banks, as far as we are aware is not publicly available.

accordance with the Deutsche Bundesbank's classification) information relating to four groups of banks; the 'big-three' banks (Deutsche Bank, Dresdner Bank and Commerzbank), regional and other commercial banks, foreign banks and 'private' banks. The 'big-three' banks are involved in all aspects of banking, have national branch networks and provide a universal service. The regional and other commercial banks, like the 'big-three', are organised as joint-stock publicly quoted companies, partnerships limited by shares, or private limited companies. These banks concentrate on providing universal banking services in their particular regions, although some maintain networks of branches that allow them to operate on a multi-regional or national basis. The domestic assets mix of the regional banks is broadly similar to that of the 'big-three' commercial banks. Yet the regional banks have a higher reliance on wholesale funding and a relatively low retail deposit base compared to the 'big-three' banks. Foreign banks are also included in the private bank category, their business is mainly geared to wholesale activities. Finally the commercial banking sector also includes private banks which the Bundesbank classifies as banks which are organised as sole proprietorships, general partnerships, or limited partnerships. Although private banks are able to conduct the full range of banking activities they tend to specialise in investment banking, asset management and trust business.¹⁷

The savings bank sector represents the government owned institutions in our sample. Under German convention the sector is categorised into three groups: the Deutsche Kommunalbank (DGZ Bank); the regional giro banks (Landesbanken/Girozentrale); and the savings banks. DGZ Bank and the twelve Landesbanken act as clearing houses and conduct foreign payments transactions, wholesale business and other services for the savings bank sector. The Landesbanken are established under public law and are usually owned and guaranteed by their particular Land (federal government), although some may also be co-owned and co-guaranteed by the respective local savings bank association, or even by another Landesbank. Because of their specialist nature, we exclude these institutions from our sample. The savings banks are classified by the Bundesbank by their ability to offer giro transactions and savings facilities. Typically, these banks offer deposit and lending facilities to low- and middle-income customers, and undertake mortgage lending and local authority lending activities (mainly for capital investment and housing). Legal restrictions mean that the savings banks

¹⁷ At the end of 1995 Deutsche Bundesbank (1996) shows that asset share of the private banks amounted to: 9.3% for the 'Big-Three' banks; 12.8% for the 195 regional and other commercial banks; 1.4% for the 69 foreign banks and 0.7% for the 64 private banks.

may only operate within their respective state, or 'home area'. Although the larger savings banks now offer a wider range of services, their main business still tends to be concentrated in their home area, where they compete with the 'big-three' banks and regional and other commercial banks. Many operate with the mandate of implementing public policy in one form or another. The deposits of savings banks are either state or local government guaranteed.¹⁸ The guarantor accepts statutory liability for the obligations of the bank under the concept of *Gewahrtragerhaftung* (guarantor liability) which is defined under public law. Under *Gewahrtragerhaftung*, a holder of defaulted obligations first makes claims against the assets of the bank, and any unfulfilled claims must be satisfied by the guarantor. (Although not included in our sample, there are also several so-called free savings banks (*Freie Sparkassen*) which do not have access to public support).¹⁹ According to Revell (1989) savings banks have historically pursued to four main strategic objectives: to foster savings among the general population; to develop to economy of the locality or area; to carry out social works in that locality; and to operate in the best interest of their members. However, given increasing competition in German banking market there has been a recent trend for the sector to become cost and profit efficient institutions (see IEF 1998).

The mutual sector in our sample is represented by the cooperative banks. Like the savings banks, the cooperative banks following the same strategic objectives and are organised around a three-tier structure which includes: the Deutsche Genossenschaftsbank (DG Bank); regional credit cooperatives; and local urban and agricultural credit cooperatives. The DG Bank, established as a corporation under public law acts as the central bank for the regional cooperative banks. It operates as a universal bank. There are five regional cooperative banks

¹⁸ It should be noted that three deposit insurance schemes are administered by the banking associations of the these major bank types: savings banks; co-operative banks and commercial banks. The deposit protection schemes-operated by the savings banks and co-operative banks are designed to avert member institutions insolvency, thus indirectly guaranteeing all creditors. Savings banks, as noted above, also enjoy the backing of municipal governments that own them. Only the commercial banks' deposit protection scheme is aimed directly at deposits. For commercial banks the scheme provides virtually full protection for all undivided customer deposits: "deposits at more than two-thirds of all branches of private sector banks are fully protected up to a ceiling of around DM30 million per depositor. This high level of coverage, adopted in 1976 was meant to ensure that commercial banks would be able to compete against banks that were owned by the public sector" (Financial Times, 1996; p.29). Given the level of deposit insurance coverage, the risk taking prospects of banks for moral hazard reasons, is expected to be similar. There are other reasons of course why the why the risk profile of banks may vary—especially given differential management styles, however, we assume these do not systematically vary between the different ownership groups and therefore do not control for risk in over cost and profit efficiency models (see Mester 1996 for an expositions of how risk and quality facts can influence cost efficiency estimates).

¹⁹ The 624 savings banks are an important force in German retail banking accounting for 20 percent of banking sector assets and 31.8 percent of non-bank deposits at the end of 1995.

which act as regional clearing houses for the local credit cooperatives as well as providing them with other banking services. Given their specialist nature these two types of cooperative bank are excluded from our sample. The local cooperative banks are known as the Volksbanken (people's banks), and operate in towns and cities; the agricultural credit cooperatives are known as Raiffeisbanken, and operate in rural districts.²⁰ As noted by Lang and Welzel (1996) within the co-operative bank sector “a self-imposed principle of regional demarcation holds, implying very little competition within this sector” (p.1011).

Table 3 reports the definition, mean and standard deviation of the input and output variables used in the cost and alternative profit frontier estimations for each bank ownership type, as well as for the whole banking sector sample, for 1996. Parameter estimates are available from the authors on request²¹.

INSERT TABLE 3 HERE

Table 4 shows scale economies, inefficiencies and technical change estimates obtained from the sample of private commercial banks²². The results indicate widespread economies across different size groups averaging around 9 percent using the stochastic frontier method and around 6 percent using the distribution-free approach. It is also noticeable that the larger commercial banks reveal greater economies than their smaller counterparts, suggesting a steepening cost frontier. This is particularly the case for the stochastic cost frontier estimations where off-balance sheet items are included as outputs. While the difference in scale economy estimates is not so marked in the case of the distribution-free results it does at least suggest that the inclusion of off-balance sheet items as an output term has the effect of increasing

²⁰ There are also cooperative banks that undertake business for particular professions, known as Berufsständische Genossenschaftsbanken. The 2591 cooperative banks accounted for 11.7 percent of banking sector assets, 13.1 percent of non-bank lending and 20.4 percent of non-bank deposits at the end of 1995.

²¹ Although the specification test reject the translog as the preferred functional form stochastic frontier and distribution free efficiency estimates from the pooled model including OBS items yields similar efficiency ranking for both functional forms. Various structural tests were undertaken to test for data poolability and heteroscedasticity. The White (1980) test could not reject the hypothesis of homoscedasticity at the one percent level of significance for the majority of years. Chow's (1960) test confirmed that the data could be pooled across years and also across ownership types. The results of these tests and descriptive statistics for 1989 to 1996 are available from the authors on request.

²² To evaluate whether scale economy, inefficiency and technical change measures differ significantly across bank size and years we used the Kruskal-Wallis (1952) to test for difference between sample medians. In virtually all cases we reject the null hypothesis that median scale, inefficiency and technical change values were

realisable economies for the biggest private commercial banks. Cost inefficiency measures appear to vary less across time and bank sizes compared with scale economies, averaging around 21 percent, that is, if all commercial banks operated on the efficient frontier they could produce the same level of output with 79 percent of current inputs. In addition, the various model specifications reveal similar results and there appears to be no major differences in cost efficiency across different sizes of banks. Profit efficiencies are, on average, around 23 percent with some evidence that the biggest banks are more efficient than their smaller counterparts, although these differences are small. The extents of the impact of technical change on bank costs appear to be strongly influenced by the inclusion of off-balance sheet outputs in the model. Technical change estimates derived from both the stochastic cost frontier and distribution-free methods including off-balance sheet items suggest that technical progress has reduced the annual cost of production by about 5 percent, with banks up to \$10 billion in assets size benefiting most. If off-balance sheet items are excluded from the estimation technical progress results in an annual cost reduction averaging around 10 percent, with the largest banks being the main beneficiaries. This finding perhaps reflects the high technology cost associated with undertaking off-balance sheet business.

INSERT TABLE 4 HERE

Results for the public savings bank sector are shown in Table 5 and the scale economy results show again that the distribution-free method tends to yield lower overall scale economy estimates than the stochastic cost frontier approach. Depending on the model specification used, overall scale economies vary between 5 and 9 percent. However, in contrast to the private commercial banks, scale economies tend to decline with size when off-balance sheet activity is taken into account. The cost and profit inefficiency measures show that the sector has efficiency scores of around 16 percent with some evidence that the largest savings banks are less cost and profit efficient than their smaller counterparts. These differences again tend to be small. Technical progress appears to have had a relatively small impact on the public savings banks, reducing total costs by under 3.5 percent per annum between 1989 and 1996.

INSERT TABLE 5 HERE

equal. The same tests were used for all the different bank ownership types as well as the estimates derived from

The results for the mutual cooperative banks shown in Table 6 reveal economies of scale for virtually all the different size groups, the distribution-free method giving slightly smaller scale economies estimates of around 6 percent compared with 8 percent for the stochastic frontier method. However, the stochastic frontier estimates suggest that economies decrease with size compared with the distribution-free results that suggest the opposite. The cost inefficiency measures appear to be lower for the mutual co-operative banks compared with the private commercial and public savings banks, possibly reflecting the greater homogeneity of the co-operative banking sector. For the models including off-balance sheet items, overall cost inefficiencies range between 10 and 12.5 percent. Profit efficiencies for the sector average around 15 percent, although the different model specifications suggest different results – the stochastic frontier alternative profit efficiencies suggest the largest banks are by far the most inefficient, whereas the distribution-free estimates suggest they are the most profit efficient. As in the case for the other two ownership types, technical progress has made a positive contribution by reducing the cost of production for the sector as a whole. Within the sector, the largest cooperative banks (over \$25 billion assets) appear to have benefited more from technical progress than the smaller mutuals.

INSERT TABLE 6 HERE

The preceding analysis indicates that all sectors appear to exhibit substantial economies of scale, there is a greater level of cost and profit inefficiency within the private sector, compared with the public and mutual sectors, and technical progress has contributed to cost reduction in each ownership type. There also appears to be less ambiguity in the various scale economy estimates for larger private commercial banks in that all the four model specifications suggest increasing scale economies with size. The results also illustrate how different methodological approaches can yield conflicting results, and this is particularly noticeable when one compares the results for different size categories of banks.

From the above, however, a comparison between the different ownership types, is problematic because estimates are derived from sector specific cost and profit frontiers. For example, while we find that public savings banks are relatively efficient compared to each other, this tells us little about their relative efficiency compared with other ownership forms in the

German banking market. The problem is further compounded by the fact that the three bank ownership types have different underlying cost and profit frontiers and therefore technologies. Either researchers have to stop at this point and be content with comparing the efficiencies of banks which have the same ownership and cost or profit characteristics, or alternatively, cost/profit characteristics for the different ownership types can be derived from an industry frontier (obtained by pooling the data for the three ownership types) and these results can then be compared with the sector specific estimates. Despite the limitations associated with such an approach, reconciling the two sets of results provides additional information as to the relative efficiencies of different bank ownership types within the German banking market. This may be more interest from a public policy point of view, especially if regulators are wishing to consider privatisation or de-mutualisation policies.

Table 7 shows the scale economies, inefficiencies and technical progress results for the three ownership types derived from the pooled sample. The scale economy results are broadly the same as those obtained from the sectoral estimates in that they are found to be widespread across different ownership types and size categories. The results also confirm the advantages of size. At the very least these findings indicate that the government owned banks do not appear to have a major size related cost disadvantage compared to their private sector counterparts.

INSERT TABLE 7 HERE

The inefficiency measures also reveal that public savings banks and mutual co-operative banks are relatively more cost and profit efficient than their private sector competitors. This confirms the findings from the earlier sectoral estimates and is possibly a reflection of their lower funding costs compared with the commercial banks (see Table 3). Saving and co-operative banks rely primarily on retail and small business customers that are perhaps less interest-rate sensitive than the depositors at commercial banks which are more corporate and wholesale orientated. However, this explanation does not preclude the possibility that small German banks are exercising local monopoly power and/or pricing uncompetitively for moral hazard reasons.²³ There is also little evidence to suggest that efficiency in the German banking

²³ De Bandt and Davis (1998) using the Rosse-Panzar competitive conditions test, find some evidence that small German banks operate as local monopolies. As noted in footnote 18 moral hazard reasons for different bank performance may not be so strong given that deposit insurance is substantial and comprehensive across the banking sector.

market is related to bank size. Technical progress seems to have had a similar impact on reducing costs for all types of banks. The extent of this cost reduction varies according to the methodological approach taken and there is some evidence that larger banks benefit more from technical advances.

4. Conclusions

This paper highlights the difficulties associated with evaluating efficiencies for banks with different ownership forms. In particular, we investigate scale economies, inefficiencies and technical progress for a sample of private, mutual and publicly owned banks in the German market. Typically, the traditional cost efficiency literature has focused on investigating banks of similar size or/and ownership type on the grounds that heterogeneity within the banking industry precludes meaningful comparisons because of differences in underlying cost frontiers and technologies. While the established literature mainly provides insights into the cost characteristics of similar types of banks we suggest that this approach is unhelpful in evaluating agency problems and other issues associated with different ownership forms. The traditional approach is also of limited use for bank regulators in many jurisdictions who need to consider the potential impact of deregulation, including privatisation and de-mutualisation, on restructuring their banking markets. This is an area of concern in many non-US banking markets where publicly-owned banks operate alongside mutual and private institutions.

To compare the cost and profit characteristics of different bank ownership forms we use a variety of models to evaluate cost and profit efficiencies as well as the impact of technical progress for private commercial, public savings and mutual cooperative banks operating in the German banking market between 1989 and 1996. First, we estimate cost and alternative profit frontiers for the three different ownership types and then compare results with those derived from a pooled (industry) cost frontier. The former reveal cost and profit characteristics specific to individual ownership types whereas the latter allow for comparisons across the groups. This provides additional information on cost and profit characteristics across ownership types and places the sectoral results in the context of overall banking system efficiency.

In general, we find little to suggest that privately owned banks are more efficient than their mutual and public sector counterparts in the German banking market. Private, public and

mutual banks all appear to benefit from widespread economies of scale. In each ownership type the larger banks tend to realise greater economies. Inefficiency measures indicate that all sizes of public and mutual banks have slight cost and profit advantages over their private commercial banking counterparts which can possibly be explained by their lower cost of funds. Technical progress also appears to have made an important contribution to cost reduction in the German banking system although its influence varies considerably according to different model specifications. Overall, our results do not indicate agency problems for non-private banks operating within the German banking market.

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Table 1 Number and size of banks according to ownership category

<i>Number of Banks</i>								
	0 – 499	500-999	1,000-4,999	5,000-9,999	10,000-24,999	25,000-49,999	> 50,000	All
Private Commercial banks	464	244	315	57	43	25	47	1195
Public Saving banks	793	826	1,107	89	43	0	0	2,858
Mutual Cooperative banks	2,879	369	199	16	18	5	0	3,486
Banking Sector	4,136	1,439	1,621	162	104	30	47	7,539
	1989	1990	1991	1992	1993	1994	1995	1996
Private Commercial banks	57	67	90	144	199	223	217	198
Public Saving banks	51	53	68	223	603	653	625	582
Mutual Cooperative banks	17	20	28	165	603	948	974	731
Banking Sector	125	140	186	532	1,405	1,824	1,816	1,511
<i>Average Total Assets (USD mil)</i>								
	0 - 499	500-999	1,000-4,999	5,000-9,999	10,000-24,999	25,000-49,999	> 50,000	All
Private Commercial banks	217	704	2,262	7,055	16,729	35,326	173,490	10,417
Public Saving banks	317	746	2,060	6,513	15,042	-	-	1,531
Mutual Cooperative banks	213	679	1,652	7,157	18,911	28,348	-	471
Banking Sector	233	722	2,049	6,768	16,201	34,163	173,490	2,460

Table 2 Sample size as a percentage of ownership type and banking sector population¹

Year	Private Commercial Banks	Public Saving Banks	Mutual Cooperative Banks	All Banks
1989	66.0	28.5	39.7	55.2
1990	76.1	36.5	52.2	51.7
1991	69.2	36.8	50.8	48.3
1992	66.5	63.4	57.3	57.3
1993	76.5	77.4	74.2	75.9
1994	85.1	84.7	79.8	82.0
1995	87.2	86.2	83.3	85.0
1996	86.4	85.2	81.3	83.9

¹Percentages calculated according to total assets shares.

Table 3 Descriptive statistics of the outputs, inputs, dependent variables and total assets used in the model

Private Commercial Banks (Number of Observations: 1,195)					
Variable	Definition	Mean	StDev	Min	Max
TC	total cost (USD mil)	711.7	2662.7	1.6	26718.6
Π	total profit (USD mil)	85.9	331.9	-5.3	4430.2
P1	price of labour (USD mil) (total personnel expenses/total asset)	0.0143	0.0104	0.0010	0.0805
P2	price of funds (%) (total interest expenses/total funds)	0.0643	0.0357	0.0103	0.6342
P3	price of physical capital (%) (total depreciation and other capital expenses/total fixed assets)	0.4528	0.1698	0.0952	0.9606
Q1	the dollar value of total aggregate mortgage loans (USD mil)	1692.9	7697.9	0.5	76115.6
Q2	the dollar value of total aggregate public loans (USD mil)	1313.5	5848.4	0.5	50551.3
Q3	the dollar value of total aggregate other loans (USD mil)	3307.1	13331.7	0.5	180361.7
Q4	the dollar value of total aggregate securities (USD mil)	3646.4	13608.2	0.5	168846.3
Q5	the dollar value of the off-balance sheet activities (nominal values) (USD mil)	1469.8	6715.9	0.5	77640.1
TA	total assets (USD mil)	10417.0	39595.0	12.0	447305.0
Public Savings Banks (Number of Observations: 2,858)					
Variable	Definition	Mean	StDev	Min	Max
TC	total cost (USD mil)	96.3	138.8	3.8	1408.6
Π	total profit (USD mil)	18.8	26.9	-15.9	352.6
P1	price of labour (USD mil) (total personnel expenses/total asset)	0.0138	0.0025	0.0024	0.0485
P2	price of funds (%) (total interest expenses/total funds)	0.0464	0.0093	0.0192	0.1453
P3	price of physical capital (%) (total depreciation and other capital expenses/total fixed assets)	0.4699	0.1506	0.1220	0.9645
Q1	the dollar value of total aggregate mortgage loans (USD mil)	364.1	813.5	0.6	14256.7
Q2	the dollar value of total aggregate public loans (USD mil)	68.0	140.8	0.5	2887.0
Q3	the dollar value of total aggregate other loans (USD mil)	514.5	818.4	13.6	9888.4
Q4	the dollar value of total aggregate securities (USD mil)	524.4	689.3	23.8	6418.4
Q5	the dollar value of the off-balance sheet activities (nominal values) (USD mil)	97.5	225.6	0.6	4907.2
TA	total assets (USD mil)	1531.0	2213.0	54.0	22439.0
Mutual Cooperative Banks (Number of Observations: 3,486)					
Variable	Definition	Mean	StDev	Min	Max
TC	total cost (USD mil)	30.5	93.9	1.6	1706.2
Π	total profit (USD mil)	5.1	13.0	-9.2	329.9
P1	price of labour (USD mil) (total personnel expenses/total asset)	0.0162	0.0047	0.0018	0.0625
P2	price of funds (%) (total interest expenses/total funds)	0.0464	0.0082	0.0211	0.0972
P3	price of physical capital (%) (total depreciation and other capital expenses/total fixed assets)	0.4550	0.1454	0.1000	0.9375
Q1	the dollar value of total aggregate mortgage loans (USD mil)	63.8	127.7	0.5	2439.6
Q2	the dollar value of total aggregate public loans (USD mil)	11.4	126.6	0.5	3990.4
Q3	the dollar value of total aggregate other loans (USD mil)	177.0	383.8	0.6	7781.9
Q4	the dollar value of total aggregate securities (USD mil)	199.6	1139.8	2.8	26492.8
Q5	the dollar value of the off-balance sheet activities (nominal values) (USD mil)	33.0	94.8	0.5	1940.8
TA	total assets (USD mil)	471.0	1599.0	11.0	31461.0
Banking Sector (Number of Observations: 7,539)					
Variable	Definition	Mean	StDev	Min	Max
TC	total cost (USD mil)	164.1	1095.3	1.6	26718.6
Π	total profit (USD mil)	23.2	136.7	-15.9	4430.2
P1	price of labour (USD mil) (total personnel expenses/total asset)	0.0150	0.0056	0.0010	0.0805
P2	price of funds (%) (total interest expenses/total funds)	0.0493	0.0176	0.0103	0.6342
P3	price of physical capital (%) (total depreciation and other capital expenses/total fixed assets)	0.4603	0.1516	0.0952	0.9645
Q1	the dollar value of total aggregate mortgage loans (USD mil)	437.6	3166.3	0.5	76115.6
Q2	the dollar value of total aggregate public loans (USD mil)	240.6	2385.0	0.5	50551.3
Q3	the dollar value of total aggregate other loans (USD mil)	804.4	5465.9	0.5	180361.7
Q4	the dollar value of total aggregate securities (USD mil)	872.7	5638.4	0.5	168846.3
Q5	the dollar value of the off-balance sheet activities (nominal values) (USD mil)	286.7	2735.3	0.5	77640.1
TA	total assets (USD mil)	2460.0	16288.0	11.0	447305.0

Note: Time trend, T , which covers between 1989 and 1996, is also included in all the models.

Table 4 Scale economies, X-inefficiency and technical progress using various econometric models, German private commercial banks 1989-1996.

Scale Economies									
Stochastic Frontier Method									
	0 – 499	500 - 999	1,000 - 4,999	5,000 – 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
OBS included	0.981	0.918	0.870	0.895	0.813	0.788	0.696	0.913	
OBS excluded	0.934	0.911	0.900	0.902	0.899	0.909	0.912	0.916	
Distribution-Free Method									
OBS included	0.974	0.946	0.917	0.926	0.880	0.866	0.860	0.941	
OBS excluded	0.963	0.939	0.917	0.911	0.877	0.860	0.843	0.933	
Cost X-inefficiency									
Stochastic Frontier Method ^a									
	0 – 499	500 - 999	1,000 - 4,999	5,000 – 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
OBS included	0.222	0.220	0.229	0.277	0.218	0.265	0.183	0.225	
OBS excluded	0.215	0.217	0.207	0.247	0.189	0.266	0.204	0.215	
Distribution-Free Method									
OBS included	0.206	0.218	0.218	0.234	0.189	0.258	0.212	0.214	
OBS excluded	0.209	0.219	0.208	0.253	0.188	0.229	0.214	0.213	
Profit X-inefficiency									
Stochastic Frontier Method									
	0 – 499	500 - 999	1,000 - 4,999	5,000 – 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
OBS included	0.252	0.221	0.213	0.222	0.266	0.187	0.203	0.231	
OBS excluded	0.241	0.214	0.215	0.226	0.249	0.179	0.220	0.226	
Distribution-Free Method									
OBS included	0.238	0.228	0.226	0.212	0.267	0.218	0.224	0.231	
OBS excluded	0.233	0.228	0.232	0.206	0.267	0.223	0.240	0.232	
Technical Progress									
Stochastic Frontier Method									
	0 - 499	500 - 999	1,000 - 4,999	5,000 – 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
OBS included	-0.051	-0.054	-0.053	-0.055	-0.045	-0.026	-0.016	-0.050	
OBS excluded	-0.093	-0.098	-0.102	-0.106	-0.106	-0.116	-0.109	-0.099	
Distribution-Free Method									
OBS included	-0.046	-0.048	-0.049	-0.051	-0.043	-0.034	-0.022	-0.046	
OBS excluded	-0.104	-0.108	-0.113	-0.121	-0.121	-0.134	-0.132	-0.110	

Note: ^a The stochastic frontier approach uses the half-normal distribution. In both the cost and profit estimates the residuals has the correct skew (rightward for cost, leftward for profit) and therefore can be meaningfully interpreted. As in Berger and Mester (1997), to be consistent with the distribution-free approach, the stochastic frontier efficiency were calculated by comparing firms to the best observed expected value of $\ln u$ so that the best practice firm has an efficiency of 1.

b) Data – year estimates available from the authors on request.

Table 5 Scale economies, X-inefficiency and technical progress using various econometric models, German public savings banks 1989-1996.

Scale Economies							
Stochastic Frontier Method							
	0 – 499	500 – 999	1,000 - 4,999	5,000 – 9,999	> 10,000	All	
OBS included	0.923	0.923	0.926	0.958	1.004	0.926	
OBS excluded	0.919	0.916	0.912	0.892	0.884	0.914	
Distribution-Free Method							
OBS included	0.933	0.947	0.954	0.952	0.955	0.946	
OBS excluded	0.939	0.932	0.925	0.913	0.911	0.930	
Cost X-inefficiency							
Stochastic Frontier Method ^a							
	0 – 499	500 – 999	1,000 - 4,999	5,000 – 9,999	> 10,000	All	
OBS included	0.143	0.146	0.152	0.157	0.177	0.148	
OBS excluded	0.143	0.158	0.157	0.141	0.134	0.153	
Distribution-Free Method							
OBS included	0.148	0.150	0.148	0.148	0.148	0.149	
OBS excluded	0.159	0.158	0.159	0.159	0.166	0.159	
Profit X-inefficiency							
Stochastic Frontier Method							
	0 – 499	500 - 999	1,000 - 4,999	5,000 – 9,999	> 10,000	All	
OBS included	0.163	0.169	0.169	0.191	0.175	0.168	
OBS excluded	0.155	0.163	0.161	0.185	0.162	0.161	
Distribution-Free Method							
OBS included	0.164	0.165	0.163	0.165	0.165	0.164	
OBS excluded	0.168	0.168	0.167	0.165	0.165	0.167	
Technical Progress							
Stochastic Frontier Method							
	0 – 499	500 - 999	1,000 - 4,999	5,000 – 9,999	> 10,000	All	
OBS included	-0.016	-0.014	-0.015	-0.017	-0.019	-0.015	
OBS excluded	-0.006	-0.005	-0.005	-0.005	-0.003	-0.005	
Distribution-Free Method							
OBS included	-0.012	-0.012	-0.013	-0.014	-0.016	-0.012	
OBS excluded	-0.028	-0.034	-0.037	-0.040	-0.042	-0.034	

Note: ^a The stochastic frontier approach uses the half-normal distribution. In both the cost and profit estimates the residuals has the correct skew (rightward for cost, leftward for profit) and therefore can be meaningfully interpreted. As in Berger and Mester (1997), to be consistent with the distribution-free approach, the stochastic frontier efficiency were calculated by comparing firms to the best observed expected value of $\ln u$ so that the best practice firm has an efficiency of 1.

b) Data – year estimates available from the authors on request.

Table 6 Scale economies, X-inefficiency and technical progress using various econometric models, German mutual cooperative banks 1989-1996.

Scale Economies								
Stochastic Frontier Method								
	0 - 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	> 25,000	All	
OBS included	0.929	0.878	0.880	0.983	0.960	1.037	0.921	
OBS excluded	0.915	0.908	0.906	0.916	0.907	0.954	0.914	
Distribution-Free Method								
OBS included	0.946	0.918	0.894	0.896	0.827	0.833	0.939	
OBS excluded	0.934	0.911	0.892	0.888	0.853	0.858	0.929	
Cost X-inefficiency								
Stochastic Frontier Method ^a								
	0 - 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	> 25,000	All	
OBS included	0.098	0.103	0.105	0.124	0.105	0.072	0.099	
OBS excluded	0.110	0.114	0.115	0.129	0.138	0.052	0.111	
Distribution-Free Method								
OBS included	0.125	0.125	0.125	0.125	0.123	0.124	0.125	
OBS excluded	0.148	0.149	0.148	0.138	0.160	0.165	0.148	
Profit X-inefficiency								
Stochastic Frontier Method								
	0 - 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	> 25,000	All	
OBS included	0.141	0.127	0.134	0.240	0.145	0.258	0.140	
OBS excluded	0.156	0.144	0.149	0.188	0.130	0.211	0.155	
Distribution-Free Method								
OBS included	0.154	0.155	0.149	0.176	0.169	0.145	0.154	
OBS excluded	0.164	0.163	0.162	0.190	0.159	0.133	0.164	
Technical Progress								
Stochastic Frontier Method								
	0 - 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	> 25,000	All	
OBS included	-0.054	-0.049	-0.050	-0.057	-0.073	-0.085	-0.053	
OBS excluded	-0.012	-0.010	-0.014	-0.030	-0.017	-0.030	-0.012	
Distribution-Free Method								
OBS included	-0.039	-0.038	-0.041	-0.052	-0.059	-0.067	-0.040	
OBS excluded	-0.032	-0.031	-0.035	-0.049	-0.038	-0.049	-0.032	

Note: ^a The stochastic frontier approach uses the half-normal distribution. In both the cost and profit estimates the residuals has the correct skew (rightward for cost, leftward for profit) and therefore can be meaningfully interpreted. As in Berger and Mester (1997), to be consistent with the distribution-free approach, the stochastic frontier efficiency were calculated by comparing firms to the best observed expected value of $\ln u$ so that the best practice firm has an efficiency of 1.

b) Data – year estimates available from the authors on request.

Table 7 Scale economies, X-inefficiency and technical progress using various econometric models, derived from the all bank sample 1989-1996.

A. Stochastic Frontier Method/OBS included									
Scale Economies									
	0 – 499	500-999	1,000-4,999	5,000-9,999	10,000-24,999	25,000-49,999	> 50,000	All	
Private Com. Banks	0.912	0.906	0.924	1.001	0.974	0.945	0.921	0.921	
Public Saving Banks	0.917	0.909	0.902	0.893	0.891	--	--	0.908	
Mutual Coop. Banks	0.910	0.898	0.887	0.871	0.843	0.924	--	0.907	
Banking Sector	0.911	0.906	0.905	0.929	0.923	0.941	0.921	0.910	
Cost X-inefficiency									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
Private Com. Banks	0.192	0.229	0.256	0.235	0.246	0.286	0.149	0.220	
Public Saving Banks	0.153	0.159	0.161	0.193	0.197	--	--	0.160	
Mutual Coop. Banks	0.144	0.148	0.139	0.158	0.214	0.134	--	0.144	
Banking Sector	0.151	0.168	0.177	0.204	0.221	0.261	0.149	0.162	
Profit X-inefficiency									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
Private Com. Banks	0.255	0.247	0.200	0.307	0.314	0.215	0.210	0.241	
Public Saving Banks	0.188	0.188	0.192	0.182	0.237	--	--	0.190	
Mutual Coop. Banks	0.216	0.215	0.244	0.279	0.213	0.246	--	0.218	
Banking Sector	0.215	0.205	0.200	0.236	0.269	0.220	0.210	0.211	
Technical Progress									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
Private Com. Banks	-0.045	-0.050	-0.053	-0.056	-0.052	-0.047	-0.043	-0.049	
Public Saving Banks	-0.040	-0.039	-0.040	-0.040	-0.040	--	--	-0.040	
Mutual Coop. Banks	-0.044	-0.046	-0.046	-0.047	-0.059	-0.061	--	-0.044	
Banking Sector	-0.043	-0.043	-0.043	-0.046	-0.048	-0.050	-0.043	-0.043	
B. Stochastic Frontier Method/OBS excluded									
Scale Economies									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
Private Com. Banks	0.956	0.940	0.925	0.962	0.874	0.798	0.695	0.927	
Public Saving Banks	0.902	0.870	0.835	0.795	0.768	--	--	0.862	
Mutual Coop. Banks	0.916	0.869	0.846	0.825	0.818	0.885	--	0.907	
Banking Sector	0.918	0.882	0.854	0.856	0.821	0.813	0.695	0.893	
Cost X-inefficiency									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
Private Com. Banks	0.234	0.272	0.313	0.297	0.287	0.256	0.173	0.265	
Public Saving Banks	0.175	0.176	0.176	0.179	0.174	--	--	0.176	
Mutual Coop. Banks	0.167	0.174	0.170	0.179	0.338	0.106	--	0.169	
Banking Sector	0.176	0.192	0.202	0.221	0.242	0.231	0.173	0.187	
Profit X-inefficiency									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
Private Com. Banks	0.239	0.212	0.185	0.275	0.242	0.200	0.212	0.219	
Public Saving Banks	0.169	0.167	0.171	0.177	0.220	--	--	0.170	
Mutual Coop. Banks	0.200	0.185	0.210	0.218	0.150	0.211	--	0.199	
Banking Sector	0.198	0.179	0.179	0.215	0.223	0.202	0.212	0.191	
Technical Progress									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
Private Com. Banks	-0.102	-0.124	-0.140	-0.155	-0.161	-0.164	-0.164	-0.125	
Public Saving Banks	-0.095	-0.103	-0.110	-0.116	-0.119	--	--	-0.104	
Mutual Coop. Banks	-0.090	-0.102	-0.111	-0.129	-0.171	-0.200	--	-0.093	
Banking Sector	-0.092	-0.106	-0.116	-0.131	-0.143	-0.170	-0.164	-0.102	

Table 7 Scale economies, X-inefficiency and technical progress using various econometric models, derived from the all bank sample 1989-1996.

A. Distribution-Free Method/ OBS included									
Scale Economies									
	0 – 499	500-999	1,000-4,999	5,000-9,999	10,000-24,999	25,000-49,999	> 50,000	All	
Private Com. Banks	0.894	0.871	0.846	0.883	0.807	0.762	0.760	0.864	
Public Saving Banks	0.921	0.898	0.882	0.890	0.879	--	--	0.898	
Mutual Coop. Banks	0.933	0.935	0.931	0.874	0.853	0.799	--	0.932	
Banking Sector	0.926	0.903	0.881	0.886	0.844	0.768	0.760	0.908	
Cost X-inefficiency									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
Private Com. Banks	0.138	0.149	0.145	0.143	0.131	0.163	0.127	0.142	
Public Saving Banks	0.133	0.132	0.133	0.139	0.136	--	--	0.133	
Mutual Coop. Banks	0.131	0.134	0.133	0.130	0.130	0.126	--	0.131	
Banking Sector	0.132	0.136	0.135	0.140	0.133	0.157	0.127	0.134	
Profit X-inefficiency									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
Private Com. Banks	0.224	0.217	0.219	0.230	0.219	0.219	0.219	0.221	
Public Saving Banks	0.219	0.219	0.219	0.219	0.218	--	--	0.219	
Mutual Coop. Banks	0.219	0.218	0.219	0.214	0.214	0.234	--	0.219	
Banking Sector	0.219	0.218	0.219	0.222	0.218	0.222	0.219	0.219	
Technical Progress									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 - 49,999	> 50,000	All	
Private Com. Banks	-0.018	-0.022	-0.027	-0.031	-0.034	-0.037	-0.041	-0.024	
Public Saving Banks	-0.025	-0.026	-0.029	-0.031	-0.033	--	--	-0.027	
Mutual Coop. Banks	-0.022	-0.026	-0.029	-0.029	-0.044	-0.044	--	-0.023	
Banking Sector	-0.022	-0.026	-0.029	-0.031	-0.034	-0.038	-0.041	-0.025	
B. Distribution-Free Method/ OBS excluded									
Scale Economies									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 – 49,999	> 50,000	All	
Private Com. Banks	0.948	0.911	0.887	0.901	0.841	0.771	0.690	0.903	
Public Saving Banks	0.907	0.875	0.842	0.809	0.790	--	--	0.868	
Mutual Coop. Banks	0.928	0.884	0.860	0.828	0.808	0.829	--	0.918	
Banking Sector	0.926	0.883	0.853	0.844	0.815	0.781	0.690	0.897	
Cost X-inefficiency									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 – 49,999	> 50,000	All	
Private Com. Banks	0.149	0.163	0.156	0.168	0.145	0.160	0.147	0.154	
Public Saving Banks	0.140	0.138	0.136	0.130	0.127	--	--	0.137	
Mutual Coop. Banks	0.138	0.143	0.141	0.134	0.179	0.159	--	0.139	
Banking Sector	0.140	0.144	0.141	0.144	0.141	0.160	0.147	0.141	
Profit X-inefficiency									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 – 49,999	> 50,000	All	
Private Com. Banks	0.204	0.199	0.198	0.194	0.216	0.201	0.206	0.201	
Public Saving Banks	0.205	0.210	0.212	0.221	0.241	--	--	0.210	
Mutual Coop. Banks	0.211	0.206	0.210	0.221	0.178	0.180	--	0.210	
Banking Sector	0.209	0.207	0.209	0.211	0.223	0.198	0.206	0.209	
Technical Progress									
	0 – 499	500 - 999	1,000 - 4,999	5,000 - 9,999	10,000 - 24,999	25,000 – 49,999	> 50,000	All	
Private Com. Banks	-0.099	-0.101	-0.104	-0.107	-0.109	-0.127	-0.111	-0.103	
Public Saving Banks	-0.107	-0.115	-0.115	-0.119	-0.105	--	--	-0.113	
Mutual Coop. Banks	-0.102	-0.098	-0.104	-0.112	-0.096	-0.122	--	-0.102	
Banking Sector	-0.103	-0.108	-0.112	-0.114	-0.106	-0.126	-0.111	-0.106	