INSTITUT FÜR VOLKSWIRTSCHAFTSLEHRE

der

UNIVERSITÄT AUGSBURG

Technology and Cost Efficiency in Banking

A „Thick Frontier“-Analysis of the German Banking Industry

von

Günter Lang and Peter Welzel

Beitrag Nr. 130

Februar 1995

swirtschaftliche Diskussionsreihe

Institut für Volkswirtschaftslehre
Universität Augsburg

Memminger Straße 14
86159 Augsburg
Telefon (08 21) 5 98-3 65
Telefax (08 21) 5 98-3 21

Technology and Cost Efficiency in Banking

A „Thick Frontier"-Analysis of the German Banking Industry

von

Günter Lang und Peter Welzel

Beitrag Nr. 130

Februar 1995

Technology and Cost Efficiency in Banking

A „Thick Frontier"-Analysis of the German Banking Industry

Günter Lang and Peter Welzel*
University of Augsburg
February 1995

Abstract

Using 1992 data of 1490 banks covering about 40% of German banking, we specify a multi-product translog cost function and follow the „thick frontier"-approach to control for cost inefficiency when evaluating the technology of banking. Scale economies are found to exist up to a size of about 5 billion DM of total assets, with diseconomies being caused by non-operating costs. There is hardly any evidence of economies of scope. Compared to X-inefficiency external factors play a surprisingly strong role in explaining cost differences between high-cost and low-cost banks. Smaller banks turn out to be more responsive to input prices.

* We are indebted to M. Sautter and U. Simon of McKinsey & Co., Frankfurt, and to B. Gentsch and his staff of the Genossenschaftsverband Bayern, München, who gave us access to their databases. We would also like to thank seminar participants at Dresden for their discussion on an earlier version of this paper, and seminar and conference participants at Augsburg, Chemnitz, München, Mannheim, Sion, Chania and Maastricht for their helpful comments on earlier work with part of the dataset. Financial support from the University of Augsburg is gratefully acknowledged.

Correspondence to: Dr. Günter Lang, Dr. Peter Welzel, Wirtschafts- und Sozialwissenschaftliche Fakultät, Universität Augsburg, Memminger Straße 14, D-86159 Augsburg, Phone +49-821-598-421/-930, Fax +49-821-598-954.

1 Introduction

Throughout the 1980s German banking like banking in many other countries experienced an increase in concentration which apparently continues in the 1990s. From end of 1990 until end of 1993, for example, the number of German banks decreased by 16%.[1] In the vast majority of cases market exit of formerly independent banks was not caused by bank failure, but by mergers and acquisitions. Unlike in the U.S. and in some other European countries, however, the economics of this trend towards larger banks have not been sufficiently analyzed in the case of Germany. Due to a lack of accessible micro data little is known, for example, about efficiency gains from increasing the size of a bank or from extending the range of its products, about the optimal size of a German bank, and about the extent of X-inefficiency in this part of the service sector. Both bank managers and regulators of banking, however, would need this kind of information on the „technology" of banking in order to support their business and policy decisions.

As for any other firm, a bank's motivation for increasing its size can arise from the revenue and/or the cost part of its profit equation. It appears rather unlikely, however, that the desire to create or expand market power is the main driving force behind bank mergers recently observed in Germany. Given that the nature of the banking industry in this country is still rather disperse and that local monopolies or oligopolies - if they exist - are increasingly threatened by telephone banking and discount brokerage, probably only a small number of very big banks can hope to increase their market power in an economically significant way by mergers and acquisitions. For all other banks it is predominantly the cost of banking which they try to influence by creating larger units. This view is supported by the fact that very small banks like cooperative banks in the south of Germany play a more than proportionate role in the merger activities we observe. Managers of these banks argue that their banks need to become bigger in order to exploit economies of scale and scope in banking. Research should therefore focus on the costs or - more precisely - the cost functions of German banks.

The technology and the costs of banking have been examined in numerous studies of the U.S. banking industry (see e.g. *Gilligan et al., 1984, Mester, 1987, Berger et al., 1987*; for recent surveys see *Berger et al., 1993*, and - with a focus on mergers - *Berger and Humphrey, 1992*). The majority of these studies conclude that there exists an optimal size in U.S. banking which they typically identify in the range of $ 100-300 million (cf. *Berger et al., 1987*) or around $ 500 million (cf. *McAllister and McManus*, 1993) of

---

[1] For the years of 1985 to 1989 there was a decrease of 10%.

deposits, i.e., for relatively small units. Banks exceeding this threshold can no longer improve their cost situation by internal or external growth. They may even face a cost disadvantage from their size. Recently *Berger and Humphrey (1991, 1992)* and *Bauer et al. (1993)* pointed to the considerable cost dispersion as an indicator for the existence of X-inefficiencies in banking. They showed that the cost savings from eliminating these inefficiencies clearly dominate the cost savings from adjusting to optimal size and optimal output mix (for a similar conclusion see *Ferrier and Lovell, 1990*). Taken together these results seem to imply that in the United States there is limited empirical support for a strategy of improving cost competitiveness by merging banks. The data indicate that this would work only for rather small banks, and even for these banks the cost effects of improved management of an existing bank are stronger than the cost effects of increasing the bank's size. In addition, we should be careful using measures of scale and scope economies and of optimal size derived in many of the previous studies because the authors did not control for the presence of X-inefficiency which may lead to biased estimates of those measures.[2]

Compared to the U.S. the technology of banking has been much less examined in European countries. Notable exceptions are *Sheldon (1993, 1994)* and *Sheldon and Haegler (1993)* on Swiss banking, *Berg et al. (1993)* and *Berg and Kim (1993, 1994)* on Nordic and Norwegian banking, respectively, *Kolari and Zardkoohi (1990)* and *Zardkoohi and Kolari (1994)* on Finnish banking, *Schmid (1994)* on Austrian banking, *Dietsch (1993)* on French banking, *Baldini and Landi (1990)* on Italian banking, *Rodriguez et al. (1993)* on Spanish savings banks, *Drake (1992)* on British building societies, and *Glass and McKillop (1992)* on a major Irish bank. There are also a few studies which analyze international samples such as *Vennet (1993)* on 2600 credit institutions in the EC, *Altunbas and Molyneux (1993)* on French, German, Italian and Spanish banks, and *Allen and Rai (1993)* on European, U.S. and Japanese banks. The main conclusion from these papers is that there are economies of scale which tend to disappear or even reverse to diseconomies as the banks examined become larger (for a brief survey of the results see *Altunbas and Molyneux, 1993*). As for economies of scope, the results are less clear. However, several of these studies suffer from severe limitations in the data they employ. This restricts the number of outputs they are able to consider, forces the authors to include banks which are atypical of a country's banking sector, inhibits the calculation of meaningful input prices, and in general seems to generate numerical values of scale and scope measures which often look rather unplausible.

---

[2] For a discussion of this bias which may go in either direction see *Berger and Humphrey (1991, footnote 27)*.

For the German banking sector there are currently only papers by *Altunbas and Molyneux (1993)* and *Lang and Welzel (1994a, 1994b, 1995)*. In their study of four EC banking markets the former use 1988 balance sheet and income statement data from the IBCA database for 196 German banks. They estimate a hybrid form of the multi-product translog cost function where output levels undergo a *Box-Cox* transformation. If they do not control for the number of branches, they find diseconomies of scale in all size classes of their sample. After controlling for branches part of the smaller banks and banks with total assets greater than $ 5 billion exhibit economies of scale. Evidence on economies of scope is also fairly mixed. On the whole, many of the numerical values presented by *Altunbas and Molyneux (1993)* are outside the range which would normally be considered as plausible. The paper seems to suffer considerably from the consequences of data restrictions mentioned above. The studies by *Lang and Welzel (1994a, 1994b, 1995)* are also limited, since they deal only with about 760 southern German cooperative banks. While the quality of the data appears to be good, the results cannot be representative for the German banking sector as a whole, because this segment which covers less than 20% of all German banks is characterized by low firm sizes, relatively high numbers of branches, and by volumes of loans which are often lower that the volume of deposits. Using a multi-product translog specification *Lang and Welzel* conclude that there exist moderate scale economies for all banks in the sample which are, however, clearly dominated by the X-inefficiencies observed. Furthermore, there is evidence of moderate economies of scope, in particular of cost advantages of universal as opposed to specialized banking.

Given the wave of mergers in German banking there is a clear need for more empirical knowledge on the technology of banking in Germany. In the present paper we try to close this gap by analyzing a sample of 1490 German banks for the year 1992. We apply the intermediation approach and estimate a multi-product translog cost function. In order to control for the presence of X-inefficiencies and to be able to compare the cost savings potential of better management to the cost savings potential of becoming bigger, we follow the lead of *Berger and Humphrey (1991)* and estimate a „thick cost frontier“. From this frontier measures of scale and scope economies, of X-inefficiency, and of factor substitutability are derived.

The plan of the paper is as follows: In section 2 we outline our specification and estimation method, and give a brief review of measures used to analyze the technology and efficiency of banking firms. In section 3 our data are explained. Section 4 presents our empirical results. Finally, section 5 sums up.

2 Theoretical Background

2.1 Econometric Specification

Observations on output quantities and input prices are used to estimate a multi-product cost function in the non-homothetic functional form of the translog-type (cf. *Diewert and Wales, 1987*). Total costs C of an individual bank are given as a function of three factor prices w_i, $i = 1,2,3$, five output levels $y_m, m = 1,\dots,5$, a growth variable gr and the number of branch offices br. As in *Mester (1987)* the branching variable br is treated as a technological condition of production which interacts with other exogenous variables. Omitting subscripts identifying individual banks, the translog cost function is specified as follows:

$$\begin{aligned}\ln C(w, y, br) = a_0 &+ \sum_{i=1}^{3} a_i \ln w_i + \sum_{m=1}^{5} b_m \ln y_m + \frac{1}{2}\sum_{i=1}^{3}\sum_{j=1}^{3} a_{ij} \ln w_i \ln w_j \\ &+ \sum_{i=1}^{3}\sum_{m=1}^{5} g_{im} \ln w_i \ln y_m + \frac{1}{2}\sum_{m=1}^{5}\sum_{n=1}^{5} b_{mn} \ln y_m \ln y_n + c_0 \ln br \qquad (1) \\ &+ \sum_{i=1}^{3} d_i \ln w_i \ln br + e_0\, gr + \sum_{i=1}^{3} f_i\, gr \ln w_i + u_0\end{aligned}$$

Using *Shephard's Lemma* we derive a cost share s_i for each input:

$$s_i = a_i + \sum_{j=1}^{3} a_{ij} \ln w_j + \sum_{m=1}^{5} g_{im} \ln y_m + d_i \ln br + f_i\, gr + u_i \qquad i = 1,2,3 \qquad (2)$$

For the disturbance vectors u_i, $i = 0,1,2,3$, we assume $\mathrm{E}(u_i) = 0$ and $\mathrm{E}(u_i u_i') = \sigma_i^2 \mathrm{I}$. To ensure symmetry and linear homogeneity in input prices, the following restrictions are imposed:

$$\begin{aligned}& a_{ij} = a_{ji} \quad i, j = 1,2,3 \qquad b_{mn} = b_{nm} \quad m, n = 1,\dots,5 \qquad \sum_{i=1}^{3} a_i = 1 \\ & \sum_{i=1}^{3} d_i = 0 \qquad \sum_{i=1}^{3} f_i = 0 \qquad \sum_{j=1}^{3} a_{ij} = 0 \quad i = 1,2,3 \qquad \sum_{i=1}^{3} g_{im} = 0 \quad m = 1,\dots,5\end{aligned} \qquad (3)$$

Two of the three share equations (2) can be added to the cost function (1) to build a system of „seemingly unrelated regressions equations" (SURE) (cf. *Greene, 1993, pp. 486-487*). Given that there are parameter restrictions across equations and that there can be non-zero covariances $\mathrm{E}(u_i u_j') = \sigma_{ij}^2 \mathrm{I}$ of residuals across equations, the three equations should be estimated jointly. We apply *Zellner's (1962)* iterative SURE-estimator which starts with an OLS estimation of each single equation to derive a first estimate of the unknown 3×3 matrix of the σ_{ij}'s and uses this estimate of the covariance matrix in a GLS estimation of the full system which is iterated until convergence is achieved.

2.2 Cost Inefficiency

The estimation of a multi-product translog cost function as outlined above yields a best-practice cost frontier for the banks in the sample. However, as *Berger and Humphrey (1991)* observed and will be shown to be also true in our data of the German banking sector, the banks' actual costs deviate considerably from the minimum cost as defined by the cost frontier. In particular, these deviations are much stronger than can be explained by normally distributed errors which capture luck and measurement error. This indicates the existence of cost inefficiency and calls for a modified approach that allows for efficiency differences in the estimation of the cost function.

We follow *Berger and Humphrey (1991)* and use their concept of a „thick cost frontier" to modify the estimation of the cost function.[3] In a first step we divide the sample in K size classes. We then define the ratio of total costs and total assets as a measure of the banks' average costs. This measure is used to define within each size class $k = 1, \ldots, K$ two groups of banks: group l_k which consists of the banks in the lowest cost quartile, and group h_k which consists of the banks in the highest cost quartile. Finally, for the whole sample the group l of the banks in the lowest cost quartile is defined as $l = \bigcup_{k=1}^{K} l_k$, and analogously for the group h of the banks in the highest quartile.

For groups l and h separate translog cost functions of the type specified above are estimated. Denote by $X_k^q, q = l, h$, the vector of the means of all exogenous variables in class k and quartile q. From the estimated cost function $\hat{C}^q(X_k^q), q = l, h$, we calculate estimated average costs $\hat{c}_k^q$ of class k in quartile q as the ratio of estimated total cost and total assets of the average (k, q)-bank. I.e., $\hat{c}_k^q = \hat{C}^q(X_k^q)/B_k^q$, where B_k^q denotes the mean of total assets of class k in quartile q. We then calculate

$$\Delta_k = (\hat{c}_k^h - \hat{c}_k^l)/\hat{c}_k^l, \tag{4}$$

which is a measure of the total deviation of the typical bank in the high-cost quartile h in class k from the average cost of the typical class k bank in the low-cost quartile l. Δ_k tells us how much higher average costs of class k are in quartile h compared to quartile l. Apart from bad luck, other sources such as differences in the output mix or in input prices, but also bad management can cause this deviation. *Berger and Humphrey (1991)* therefore suggested to decompose Δ_k into a part determined by external factors and an

---

[3] For a brief survey of other approaches to account for the existence of cost inefficiency see the discussion in *Berger and Humphrey (1991, pp. 119-122)*.

inefficiency residual which captures management's failure to achieve the lowest possible level of average costs.

Suppose that output mix, input prices and the number of branch offices can not or at least not in the short run be influenced by management. Denote by $\hat{c}_k^{h*} = \hat{C}^l(X_k^h)/B_k^h$ the hypothetical average costs for class k in quartile h which would hold, if this group of banks used the efficient technology of quartile l instead of their present technology. By

$$\mathrm{M}_k = (\hat{c}_k^{h*} - \hat{c}_k^l)/\hat{c}_k^l \tag{5}$$

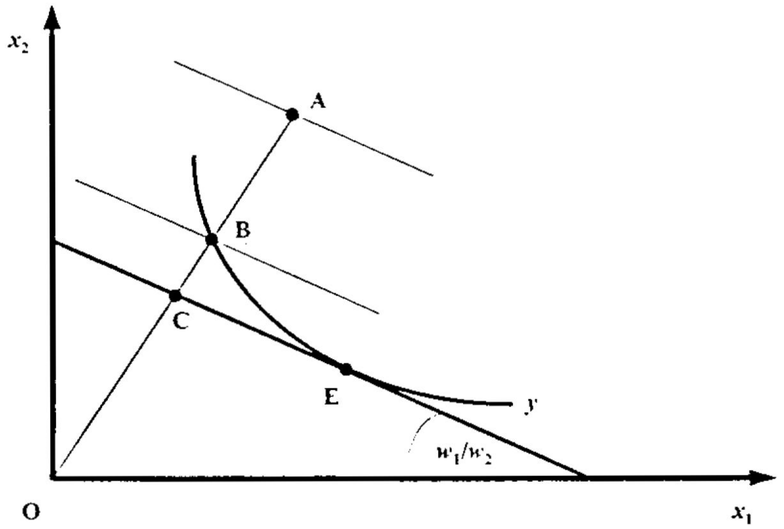
we can then measure the share of Δ_k which is caused by external factors. Finally,

$$\mathrm{X}_k = \Delta_k - \mathrm{M}_k = (\hat{c}_k^h - \hat{c}_k^{h*})/\hat{c}_k^l \tag{6}$$

defines a measure of cost inefficiency in class k. X_k is the share of the relative difference in average cost which can not be explained by output mix, factor prices, the number of branch offices, and previous growth. In the terminology of *Leibenstein (1966)* X_k can be called a bank's X-inefficiency. Figure 1 uses a simple isoquant diagram to clarify this notion of inefficiency. Suppose, there is a single-output bank using two inputs. It currently employs the input combination (x_1^A, x_2^A) to produce an output quantity of y. This production plan is X-inefficient because it is located on a higher isocost line than E which is the most efficient input combination to produce y. The ratio OA/OC is a measure of cost inefficiency.

Figure 1

X-inefficiency



A factor-oriented decomposition of X-inefficiency X_k can be calculated as

$$X_k^i = \frac{w_{i,k}^h x_{i,k}^{\mathrm{A}} \; B_k^h - w_{i,k}^h x_{i,k}^{\mathrm{E}} \; B_k^h}{X_k \, \hat{c}_k^l} . \tag{7}$$

For a given input i the numerator represents the difference between production plans A and E in factors costs relative to total assets. Notice from (6) that the denominator gives the difference in average costs which can not be explained by external factors. Together this yields factor-oriented measures of X-inefficiency that add up to one.

2.3 Factor Substitution and Economies of Scale and Scope

After estimating the „thick cost frontier" we apply the cost function found for the group l of the most efficient banks to all banks in the sample. Proceeding in this way we control for the existence of cost inefficiencies when we evaluate the technology of banking. Following the common practice in the literature, the measures presented below are evaluated for the average bank in each size class k.

The reactions of German banks to changes in input prices are captured by price elasticities $\varepsilon_{ij} = (\partial x_i / \partial w_j) \cdot (w_j / x_i)$, $i, j = 1,2,3$.

Scale economies can arise from improved division of labor and specialization in larger firms. In addition, there is a bank-specific reason for increasing returns to scale: Depositors face a lower risk at a larger bank. They are therefore willing to hold larger balances in their accounts which reduces the bank's costs per currency unit deposited (see *Sheldon, 1993, p. 356*).

The ray scale elasticity

$$RSCE(y) = \left. \frac{\partial \ln C(\lambda y)}{\partial \ln \lambda} \right|_{\lambda = 1} = \sum_{m=1}^{5} \frac{\partial \ln C(y)}{\partial \ln y_m} = \sum_{m=1}^{5} \frac{\partial C(y)}{\partial y_m} \frac{y_m}{C(y)} \tag{8}$$

is used to measure economies of scale. *RSCE* is the relative cost increase caused by a relative increase in outputs, where the levels of all outputs are raised proportionately. Values of *RSCE* of less than one indicate cost increases which are less than proportionate to output increases. A given output vector can then be produced at a lower cost within one big firm compared to several smaller firms with the same composition of outputs. *RSCE* can be disaggregated by the three factors of production used:

$$RSCE_i(y) = \sum_{m=1}^{5} \frac{\partial \ln x_i}{\partial \ln y_m} = \sum_{m=1}^{5} \frac{\partial^2 C(y)}{\partial w_i \, \partial y_m} \frac{y_m}{\partial C(y) \; \partial w_i} . \qquad i = 1.2.3 \tag{9}$$

$RSCE_i$ gives the percentage change in the demand for input i in response to a one percent change in all outputs. If $RSCE_i < 1$, factor i can be considered a source of scale economies. Under $RSCE_i > 1$, on the other hand, the use of input i increases more than proportionately which indicates factor-specific diseconomies of scale.

Economies of scope in banking can arise from a variety of factors (cf. *Berger et al., 1987, pp. 504-505*): (a) fixed costs, e.g., of branch offices, computer equipment, or collection of information on the financial status of customers, can be spread across several products; (b) diversification and adjustment of maturities of deposits and loans can be used to reduce the portfolio and the interest rate risks; (c) customers enjoy an advantage from being served with several products at one bank, which allows banks to extract some of this additional consumer surplus by charging higher fees for their services. Our cost function is able to capture effects of type (a). The traditional measure for economies of scope, used for example in *Mester (1987)*, gives the relative cost increase from producing a firm's output vector in two or more different firms which specialize in some of the outputs. To calculate this measure, some components of the output vector have to be set to zero which can be criticized in our framework for at least two reasons. Firstly, we can hardly find banks in the dataset and in the economy in general which are completely specialized. We can rather expect banks to differ in their degree of specialization. Evaluating the cost function in those regions of full specialization is therefore equivalent to extrapolating the estimated function far beyond the range of output vectors covered by the data. Secondly, output levels of zero which are used to measure economies of scope are in conflict with the specification of a translog cost function, since the logarithm of zero does not exist. There are a number of „solutions" for this problem in the literature (see e.g. *Mester, 1987, p. 439, Berger et al., 1987, p. 513, Pulley and Braunstein, 1992, p. 227*), but none of them is very convincing. We therefore employ a modified measure of economies of scope suggested by *Kolari and Zardkoohi (1987)*:

$$\begin{aligned} MSCOPE_T(y^B, y^A) = {} & [(C(y_T^B, y_{-T}^A) - C(y_T^A, y_{-T}^A)) + (C(y_T^A, y_{-T}^B) - C(y_T^A, y_{-T}^A)) \\ & - (C(y_T^B, y_{-T}^B) - C(y_T^A, y_{-T}^A))] \cdot [C(y_T^B, y_{-T}^B) - C(y_T^A, y_{-T}^A)]^{-1}, \quad (10) \\ & \text{where} \quad T \subset \{1, \ldots, 5\}, \quad -T = \{1, \ldots, 5\} \setminus T. \end{aligned}$$

y_T^B (y_T^A) denotes the output vector of bank B (A) in which all outputs which are not covered by the index set T are set equal to zero. Analogously, y_{-T}^B (y_{-T}^A) is the output vector of bank B (A) in which all outputs belonging to T are set equal to zero. We compare a (larger) bank B to a (smaller) bank A. If $MSCOPE_T$ is greater (less) than zero, the difference between output vectors y^B and y^A can be produced at a lower (higher) cost within a single bank as opposed to production in several specialized firms. If there are economies of scope, a bank of type A which increases only outputs in T or in $-T$ is at a cost disadvantage compared to a bank of type B or a bank of type A which increases its outputs according to the proportions suggested by the output structure of bank B. As for the index set, we report results on $T=\{m\}, m=1,\ldots,5$. We are particularly interested in the case $T=\{4\}$ which, as will be seen from the description of our data in the next section, provides information on whether or not there are economies of joint production of loans on the one hand and other services offered by the banks on the other. Therefore, $MSCOPE_4$ can be considered an indicator of the cost advantage of universal banking.

Berger et al. (1987) suggested expansion path subadditivity as yet another measure of economies of scope. Again a (larger) bank *B* and a (smaller) bank *A* are considered. Define the output of a hypothetical bank *D* as the difference $\left(y^B - y^A\right)$ of the output vectors of banks *B* and *A*. We then calculate

$$EPSUB(y^B, y^A) = \frac{C(y^A) + C(y^D) - C(y^B)}{C(y^B)} \tag{11}$$

This is the relative cost increase or decrease arising from producing bank *B*'s outputs in bank *A* and in the complementary bank *D*. Positive (negative) values of *EPSUB* indicate economies (diseconomies) of scope. Notice, however, that *EPSUB* and $MSCOPE_T$ include both economies of scope and scale.

3 Data

The empirical analysis of this paper is based on 1992 balance sheet and income statement data drawn from two sources. One is the Hoppenstedt database which covers a considerable share of all banks above a certain size, but contains only very few of the small banks. In order to get a dataset as representative for the German banking sector as possible, we added to these data the database of the Genossenschaftsverband Bayern which contains all Bavarian cooperative banks. The latter banks together make up a little less than 20% of all German banks, but are almost all comparatively small. We do not expect this selection to bias our results because (a) cooperative banks are the banks that dominate the small end of the market, and (b) due to their specific legal form cooperative banks in other parts of the country can be expected to operate like their Bavarian counterparts. For each bank additional information on the number of branch offices and of employees was given or collected.[4]

---

[4] If a bank's financial status was available both on a consolidated and a non-consolidated basis, we used the latter, i.e., the one without consolidated subsidiaries.

Table 1

Number of banks by type and size class

Size Class	Total Assets (million DM)	Credit Banks	Savings Banks	Cooperative Banks	Total Number
class 1	0 - 25	4 (29)	0 (0)	17 (78)	21 (107)
class 2	25 - 50	3 (7)	0 (0)	117 (405)	120 (412)
class 3	50 - 100	17 (25)	0 (4)	216 (726)	233 (755)
class 4	100 - 250	27 (61)	0 (37)	276 (1016)	303 (1114)
class 5	250 - 500	29 (45)	0 (130)	119 (420)	149 (595)
class 6	500 - 1000	30 (39)	56 (214)	151 (183)	240 (436)
class 7,8	1000 - 5000	64 (96)	280 (297)	76 (87)	420 (480)
class 9	> 5000	26 (34)	37 (41)	3 (3)	67 (78)
	Total number	200 (336)	373 (723)	975 (2918)	1548 (3977)

Numbers for whole banking sector given in parentheses; source: Deutsche Bundesbank, Monatsberichte

Table 1 presents detailed information on the size classes we defined, the numbers and types of banks in our data and in the German banking sector as a whole. Classes in table 1 are defined such that the numbers in our data can be compared to the numbers published by the *Deutsche Bundesbank* for the whole banking sector. For our evaluations of the technology of banking we split the class from 1000 to 5000 million DM of total assets into class 7 from 1000 to 2000 million DM and class 8 from 2000 to 5000 million DM. Our dataset contains credit, cooperative and savings banks, but we omitted four head organizations of the cooperative and thirteen of the savings sector because of their atypical functions. For similar reasons mortgage banks, building and loan associations as well as some other special banks, e.g., of the public sector, remained excluded. Finally, while contained in the Hoppenstedt database, most of the private banks could not be included in our data, because they did not report all the information we needed for our estimations. With a total of 1548 banks we cover about 40% of German banking. Given the wide dispersion both across size classes and across types of banks we feel rather confident about the representativity of our sample.

We follow the majority of the literature and apply the „intermediation approach" proposed by *Sealey and Lindley (1977)* which treats deposits as inputs and loans as outputs. Total costs consist of operating and interest costs, the former being defined as costs of labor and physical capital. We define inputs as labor (x_1), physical capital (x_2), and deposits (x_3). Input quantities are measured by the annual average of the number of employees, the value of fixed assets in the balance sheet, and the volume of deposits both from non-banks and banks, respectively. Factor prices for labor (w_1) and deposits (w_3) are calculated in a straightforward way by dividing nominal expenses through input quantities. For the price of physical capital we draw upon the concept of user-costs: A price w_2 of capital is generated as sum of a bank's depreciation rate and opportunity cost. The former can be inferred from the balance sheet and the income statement. As for the latter, we use the (firm-specific) interest rate for loans less the expected rise in the value of the physical capital employed. We approximate this latter expectation by the growth rate of the producer price index for investment goods in Germany. While this approximation of a price of physical capital is far from perfect, we feel confident that our approach is more reliable than what can be found in related work in the literature, where rents for office space, depreciation, spending on furniture etc. are used as proxies for the quantity of physical capital and a price is generated by dividing quantity by the volume of deposits or the number of employees (see e.g. *Mester, 1987*, *Sheldon and Haegler, 1993*). Total costs C are finally calculated as the sum over $w_i x_i$, $i = 1,2,3$.

Reflecting both the limitations of the data and the German system of universal banking, we consider loans, security holdings, and commissions as outputs. More precisely, our five outputs y_i are defined as short-term loans to non-banks (y_1), long-term loans to non-banks (y_2), interbanking assets (y_3), commissions (y_4), and a residual output (y_5). Long-term loans have a duration of at least four years. The residual output includes bonds, cash and other assets held by a bank and not covered by outputs y_1 to y_3, with bonds dominating this variable. Notice that only share holdings for portfolio purposes were included in this variable which therefore does not cover investments German banks hold in other firms.[5] Income from commissions, finally, is a consequence of the universal banking system in the German financial sector. The growth variable *gr* which we include to control for short-run disequilibrium effects is defined as the rate of growth of total assets from the previous year to the year examined. Table 2 gives information on the variables used.

---

[5] In the terminology of a German balance sheet we only included shares from the „Umlaufvermögen" but not from the „Anlagevermögen".

Table 2

Description of the variables

Variable	**Description**	**Mean Value**	**Standard-Deviation**	**Minimum**	**Maximum**
	total assets (million DM)	1845.1	12587.2	7.5	333969.5
C	total cost (million DM)	131.7	878.9	0.5	22939.7
w_1	price of labor (thousand DM/employee)	76.6	18.3	35.6	240.2
w_2	price of capital (%)	19.3	9.4	6.1	87.9
w_3	price of deposits (%)	5.9	1.1	2.1	14.5
s_1	cost share of labor (%)	22.3	5.7	1.0	85.1
s_2	cost share of capital (%)	4.5	2.1	0.03	21.4
s_3	cost share of deposits (%)	73.2	6.7	12.3	97.9
y_1	short-term loans to non-banks (million DM)	390.7	3298.1	0.02	88908.1
y_2	long-term loans to non-banks (million DM)	601.1	3061.6	0.001	83590.8
y_3	loans to banks (million DM)	304.4	3226.2	0.03	106272.5
y_4	commissions (million DM)	12.7	107.4	0.005	2978.6
y_5	bonds, cash, shares (million DM)	356.9	1685.4	0.1	37034.6
gr	growth of total assets (%)	9.8	15.4	-36.1	247.5
br	number of branch offices	20.8	62.8	1	1518

Number of banks used in estimations: 1490; year: 1992

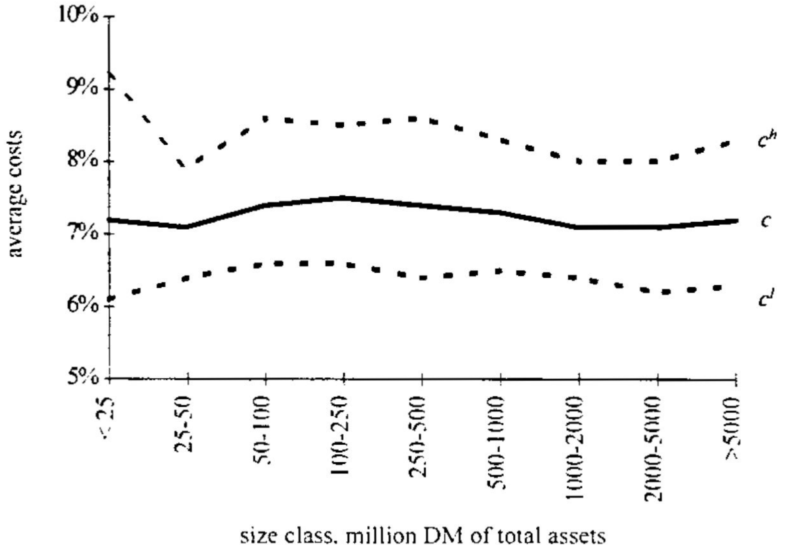
Notice that table 2 is based on the 1490 banks finally entering our estimations. Of the 1548 banks initially included in our database 58 (3.7%) had to be eliminated after defining our variables for two reasons: Some had a zero output level for at least one output, and some other had unreasonably high input prices. By excluding banks with zero outputs we avoided the problem of using replacement values in the translog specification. In the case of real capital one reason for an extremely high input price could be special depreciation rules in the five federal states of former East Germany.

4 Results

Consider first figure 2 where the means of actual average costs c_k^l and c_k^h for the most efficient quartile and the least efficient quartile, respectively, are compared to the means of average costs c_k of the full sample.

Figure 2

Dispersion of average costs



There is considerable dispersion of average costs, even within size classes, where differences in scale and scope are relatively small. Banks in group h on average enjoy a cost disadvantage of 30% relative to banks in group l. This confirms our conjecture that an estimation approach should be used which takes account of the existence of inefficiencies.

In table A-1 in the appendix we report the parameter estimates and t-statistics of the SURE system for the most efficient quartile l. The share equations of inputs 1 and 2, i.e., labor and physical capital, were used. Most parameters are highly significant. We also ran *Likelihood-Ratio* tests in order to check whether a less flexible functional form of the cost function would have been sufficient. The hypotheses of a linear-homogeneous, a homogeneous, and a homothetic cost function were all clearly rejected. The same procedure was followed for the least efficient quartile h. The qualitative properties of this second cost function were similar to the first one.

Before analyzing the underlying technology of German banks, we have to check whether our estimated function meets the theoretical requirements for a cost function. Table 3 provides information on four criteria which were examined for all 1490 banks. We find only a very limited number of violations and therefore feel encouraged to proceed with our analysis.

Table 3

Properties of the estimated cost function

Criterion	**Actual Violations**	**Potential Violations**
increasing in outputs:	122	7450
increasing in input prices:	16	4470
concave in input prices:	77	1490
negative own-price elasticity:	119	4470

We now apply the cost function estimated for quartile *I*, i.e., the „thick frontier“, to the means - based on the full sample - of the nine size classes in order to evaluate the technology of banking in Germany. Recall that this amounts to controlling for cost inefficiencies in the evaluation of technology. Consider first table 4, where price elasticities of input demands are presented.

Table 4

Estimated price elasticities of inputs

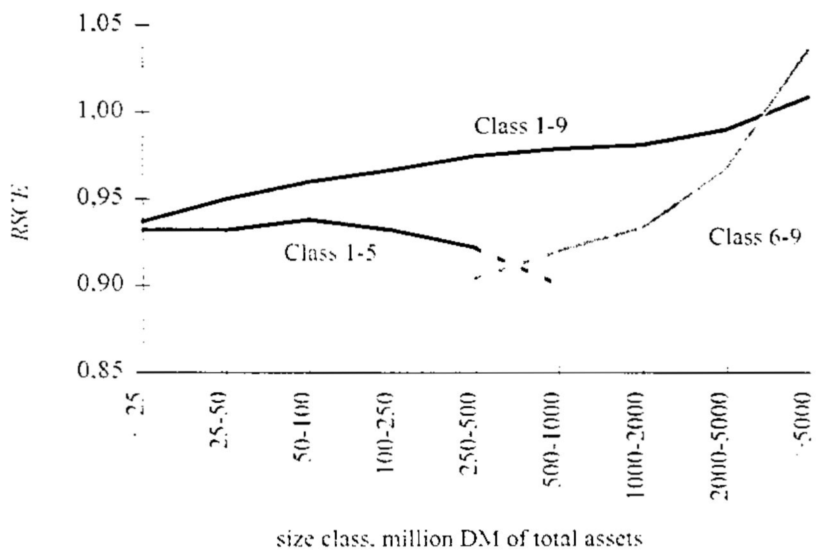
	ε_{11}	ε_{22}	ε_{33}	ε_{12}	ε_{13}	ε_{23}
class 1	-0.364	-0.686	-0.110	0.042	0.438	0.649
class 2	-0.357	-0.668	-0.097	0.048	0.381	0.418
class 3	-0.355	-0.659	-0.094	0.047	0.357	0.348
class 4	-0.348	-0.663	-0.088	0.046	0.334	0.418
class 5	-0.352	-0.671	-0.093	0.042	0.350	0.500
class 6	-0.339	-0.656	-0.079	0.036	0.294	0.473
class 7	-0.320	-0.653	-0.067	0.035	0.253	0.518
class 8	-0.322	-0.647	-0.067	0.035	0.268	0.476
class 9	-0.278	-0.602	-0.042	0.038	0.209	0.222

From table 4 we see that all factor demands are inelastic with respect to changes in input prices. Smaller banks show somewhat stronger reactions to price changes. Physical capital turns out to be the input most responsive to its own price, deposits the least responsive. As for cross-price elasticities, we find that labor and deposits, as well as physical capital and deposits are substitutes, whereas labor and physical capital are very close to being limitational. This latter result seems to reject the wide-spread notion of computer systems and automatic teller machines replacing bank employees.

Next we evaluate the „thick frontier“ to determine whether or not there are economies of scale and scope in the German banking industry. Figure 3 provides condensed information on the measure *RSCE* of scale economies based on table A-2 in the appendix. From the line labelled „Class 1-9“ we see that economies of scale diminish with increasing size and that banks in the largest class already face moderate diseconomies. Our data therefore indicate an L- or slightly U-shaped average cost curve with an optimal size of a German bank somewhere in the range of 2 to 5 billion DM of total assets. This is considerably higher than the threshold usually identified with U.S. data, which is probably mainly due to differences in the regulatory environment. At the same time our optimal size is lower than the range of $ 3 to $ 10 billion total assets found in *Vennet's (1993)* study of 2600 European credit institutions.

Figure 3

RSCE for full and split samples



Notice that for the purpose of calculating *RSCE* we excluded the „Big Three“ of German banking, i.e., Deutsche Bank, Dresdner Bank, and Commerzbank, from class 9 and evaluated them individually. In our view this makes sense because of the fact that their presence shifts the means of the data in class 9 far to the right. From the second column in table A-2 in the appendix which exhibits *RSCE* based on the „thick frontier“ $\hat{C}^{l}$ we find that Deutsche Bank, Dresdner Bank, and Commerzbank hold *RSCE* values of 1.024, 1.030, and 1.031, respectively. It is interesting to observe that Deutsche Bank despite being by far the biggest bank faces diseconomies which are a little smaller than the ones of numbers two and three in the market.[6]

---

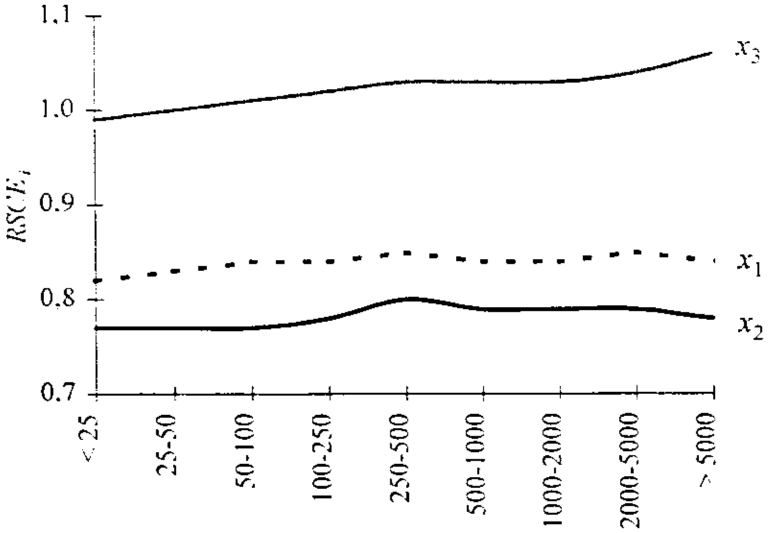
[6] Input prices for labor and physical capital are significantly higher at Deutsche Bank compared to Dresdner Bank and Commerzbank, whereas its price of deposits is slightly lower. Apparently the market leader managed to compensate for some of its diseconomies of scale by finding a better output mix or a more efficient number of branch offices

Recently *McAllister and McManus (1993)* pointed out that the optimal size identified in banking studies typically is rather sensitive to the range of size classes covered by the sample. They show that the point of reversal from economies to diseconomies of scale shifts to the right as additional classes of bigger banks are added. To check the robustness of our findings we split our data in two parts. The results are represented in figure 3 by the curves labelled „Class 1-5“ and „Class 6-9“, respectively, and by column 3 of table A-2 in the appendix. As can be seen, the optimal size turns out to be robust against this change. There are, however, stronger economies for smaller banks and stronger diseconomies for banks beyond the threshold, i.e., the average cost curve surely is U-shaped now. Notice finally, that as a point of reference we included column 4 in table A-2 in the appendix which gives *RSCE* based on a conventional cost function estimated for all 1490 banks in the sample. The results which show values of *RSCE* below one for all size classes confirm the need to control for inefficiencies when calculating this measure of scale economies.

We then disaggregated scale economies into factor-specific components $RSCE_i$. Figure 4 shows the elasticities of input demands with respect to changes in output.

Figure 4

Output elasticity of input demand

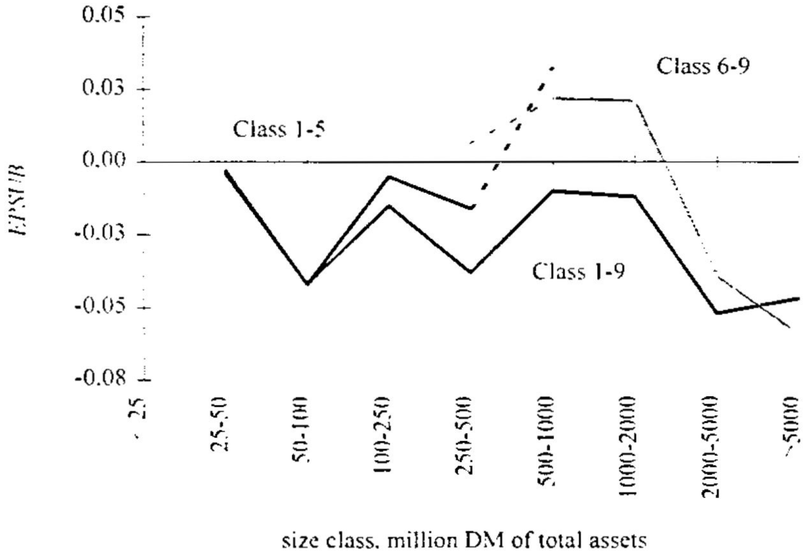


Our results indicate that labor (x_1) and physical capital (x_2) increase less than proportionately, if a bank increases its size. This holds for all size classes in the sample, implying that German banks do indeed benefit from economies of scale as far as their operating costs are concerned. Deposits (x_3), on the other hand, have an output elasticity above one for all but the very smallest banks which points at the existence of diseconomies of scale for non-operating costs in German banking.[7] Given the heavy weight of the interest costs of deposits in our cost function, this can be considered responsible for our general result of values of RSCE near or above one.

As for economies of scope, the curves for *EPSUB* in figure 5 were drawn in analogy to figure 3. Somewhat surprisingly, *EPSUB* from the full sample points to the presence of moderate diseconomies. However, *EPSUB* is less robust with respect to a split in the sample, and the data might indicate that medium-sized banks enjoy economies of scope, whereas small and large banks suffer from diseconomies. Notice from table A-3 in the appendix which gives the details on *EPSUB* that among the „Big Three", Deutsche Bank and Dresdner Bank face relatively strong diseconomies of scope, whereas splitting Commerzbank into specialized banks would yield only moderate gains.

Figure 5

EPSUB for full and split sample



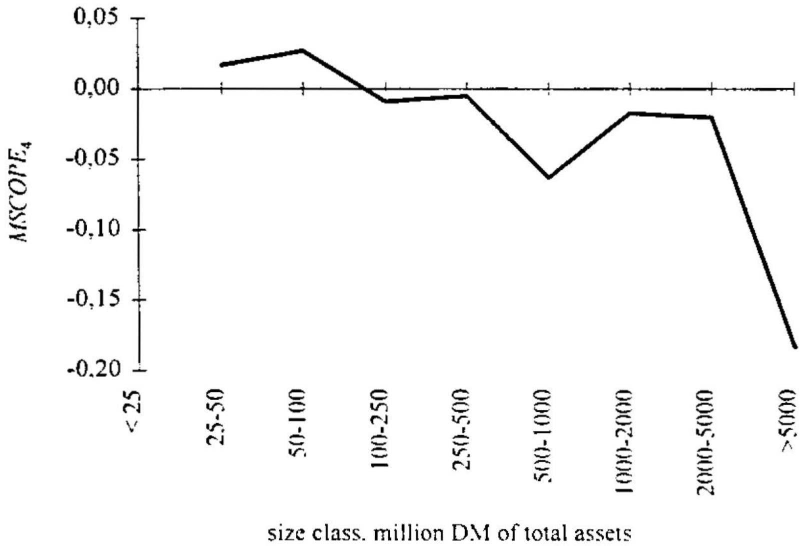
The values for $MSCOPE_T$, $T = \{m\}, m = 1,\ldots,5$, calculated for the full sample under the efficient technology $\hat{C}^I$ and given in table A-4 in the appendix also support the presence of diseconomies rather than economies of scope. In addition, consider figure 6 for some information on the economics of universal banking. $MSCOPE_4$ indicates that only relatively small banks enjoy economies of scope from producing loan outputs y_1, y_2, y_3 and y_5 jointly with the commissions earned on other services. Cost effects as covered by this study therefore are not supportive to the presumed advantages of universal banking.

---

[7] The „Big Three" banks which are again excluded from class 9 have higher output elasticities than the typical class 9 bank in the diagram.

Figure 6

$MSCOPE_4$ for full sample



Our results are compatible with *Berger and Humphrey (1991)* who find diseconomies of scope for banks above $ 200 million of total assets.[8] Taken at face value, this result raises the question why banks do not react to the underlying economics of banking and turn from universal into specialized banks. When trying to answer this question we should on the one hand notice that universal banking embodies an element of diversification, i.e., of lowering risk, which is not measured in our data. On the other hand there is evidence of German banks not actually splitting up into independent firms but setting up specialized subsidiaries e.g. for capital management or discount brokerage which is in line with our findings of diseconomies of joint production. Furthermore, in their moves to cover additional financial services such as mortgage loans or insurance, the majority of German banks relied on buying existing specialized firms or starting partnerships with them instead of setting up these operations within the bank. While this policy is clearly influenced by the desire to use existing „brand names", it could also reflect the banks' awareness of the cost disadvantages of joint production.

Let us turn to the issue of cost inefficiency. Table 5 presents the measure Δ_k of the deviation in predicted average costs between quartile h and l in class k, and the decompostion of this deviation into component M_k determined by external factors and the X-inefficiency residual X_k. On the whole external factors seem to be more important for the cost disadvantages of the least efficient quartile than management error. This differs

---

[8] Notice, however, that when analyzing the group of Bavarian cooperative banks separately as in *Lang and Welzel (1995)* the evidence is much more favorable to economies of scope.

from other findings in the literature such as in *Berger and Humphrey (1991)* or *Lang and Welzel (1995)*. What is even more unpleasant, is the fact that X-inefficiency has a negative sign for the banks in class 6 or higher. While such negative signs can also be found in *Berger and Humphrey (1991, p. 132)*, we find them rather disturbing.

Table 5

Cost deviation Δ_k, and decomposition of Δ_k

	Δ_k (%)	M_k (%)	X_k (%)
class 1	37.9	21.3	16.6
class 2	28.4	11.6	16.8
class 3	31.0	18.5	12.5
class 4	27.2	15.6	11.6
class 5	27.9	20.3	7.6
class 6	34.8	36.1	-1.3
class 7	28.5	29.5	-1.1
class 8	30.2	38.1	-8.0
class 9	31.6	53.7	-22.1

Consider finally the factor-oriented decomposition of X_k given in table 6, where we restrict out attention to classes 1-5 which had meaningful values of X-inefficiency in the previous table.

Table 6

Factor-oriented decomposition of X_k

	X^1 (%)	X^2 (%)	X^3 (%)
class 1	60.3	22.1	17.6
class 2	58.5	21.3	20.1
class 3	45.9	20.0	34.1
class 4	47.8	18.3	33.9
class 5	32.3	17.9	49.8

As expected, labor is the - almost - dominant source of X_k. This is in line with previous findings in the literature. Note, however, the shift in relative weight from labor to deposits as size increases.

5 Conclusions

Based on a dataset with 1992 data of 1490 banks covering about 40% of the German banking industry we estimated a cost function of the multi-product translog type. By running estimations for the lowest and highest average cost quartiles separately, we followed the „thick frontier" approach developed by *Berger and Humphrey (1991)* which allows to control for the presence of cost inefficiencies in the evaluation of the technology of banking. As expected, we found factor demands to be inelastic with respect to changes of input prices. Labor and deposits as well as physical capital and deposits are substitutes in banking, whereas labor and physical capital are nearly limitational, indicating that increased computerization of banking so far posed no threat to employment. Smaller banks turned out to be more responsive to input prices.

As for cost advantages from size, the bad news for big German banks is that from a cost perspective the optimal size is located at a volume of total assets somewhere between 2000 and 5000 million DM. Banks surpassing this threshold can be expected to suffer from diseconomies of scale. However, there is also good news. When we disaggregated scale economies by input factors, we found deposits to be the source of diseconomies among larger banks. While output elasticities of labor and physical capital are below one for all size classes, deposits tend to increase more than proportionately with the size of a bank. This implies that even the biggest German banks enjoy economies of scale as far as their operating costs are concerned, whereas on the side of non-operating costs there are diseconomies which increase with size.

There is hardly any evidence of economies of scope. On the contrary, most of our results point in the direction of diseconomies from joint production of the five outputs considered. This is also true for a rough test of the cost advantage from of universal banking, when joint production of loans on the one hand and investment-oriented services on the other is analyzed. When we finally examined the deviation of costs between the most efficient and the least efficient quartile in the sample, we found the role of external factors in explaining this deviation surprisingly strong compared to the role of management-related X-inefficiency. It should be noted, though, that the cost disadvantage from X-inefficiency, if it is found to exist, dominates the potential cost savings from economies of scale. Considering the three input factors, the inefficient use of labor seems to carry most weight in the explanation of cost inefficiency.

What additional steps could or should be taken? One way to go would be to further improve the representativity of the sample by adding still more of the smaller banks in order to better replicate the size structure of the German banking industry. Extending the data to a panel is another - major - step which would allow to check the robustness of our findings over time and to examine technical progress in banking. We also intend to analyze - actual or hypothetical - mergers. This should be of particular interest, since merger activity, while motivating our present analysis of banking technology, is not really examined in the approach we used.

6 Appendix

Convergence was achieved after four iterations. All calculations were run with Gauss 386-i VM, Version 3.2.4 on a PC with an Intel 486 processor. In table A-1 *, **, and *** are used to denote significance at the 10%, 5%, and 1% level, respectively.

Table A-1

SURE estimation for group *I* (lowest cost quartile), 367 observations

Parameter	Estimate	*t*-statistic	Parameter	Estimate	*t*-statistic
Translog:					
a_0	1.84702589	21.246 ***	g_{33}	0.01768495	6.598 ***
a_1	0.39275563	27.497 ***	g_{34}	-0.04054795	-12.380 ***
a_2	0.03835123	5.075 ***	g_{35}	0.04041581	10.727 ***
a_3	0.56889313	34.120 ***	b_{11}	0.01673997	3.258 ***
b_1	0.14257380	7.758 ***	b_{12}	-0.00624790	-1.668 *
b_2	0.35540512	16.153 ***	b_{13}	0.00024481	0.041
b_3	0.28008520	8.822 ***	b_{14}	0.00921749	2.075 **
b_4	0.10826882	4.398 ***	b_{15}	-0.01129627	-1.948 *
b_5	0.11116076	2.660 ***	b_{22}	0.08024975	13.592 ***
a_{11}	0.09736875	9.980 ***	b_{23}	-0.05797599	-10.993 ***
a_{12}	0.01289297	3.694 ***	b_{24}	-0.00325721	-0.658
a_{13}	-0.11026171	-11.331 ***	b_{25}	-0.03261114	-5.764 ***
a_{22}	0.01296053	5.392 ***	b_{33}	0.11524323	20.530 ***
a_{23}	-0.02585349	-6.838 ***	b_{34}	0.00232388	0.324
a_{33}	0.13611520	12.495 ***	b_{35}	-0.05944646	-9.657 ***
g_{11}	-0.02506768	-10.069 ***	b_{44}	0.02041485	3.305 ***
g_{12}	0.00311025	1.067	b_{45}	-0.01955717	-2.317 **
g_{13}	-0.01374349	-5.969 ***	b_{55}	0.13292252	10.733 ***
g_{14}	0.04004772	14.214 ***	c_0	0.03232937	5.591 ***
g_{15}	-0.03426920	-10.601 ***	d_1	0.02760399	9.983 ***
g_{21}	-0.00031791	-0.230	d_2	0.00972501	6.507 ***
g_{22}	0.00168912	1.058	d_3	-0.03732901	-11.654 ***
g_{23}	-0.00394145	-3.087 ***	e_0	0.01459034	0.654
g_{24}	0.00050023	0.322	f_1	-0.04965426	-5.290 ***
g_{25}	-0.00614661	-3.434 ***	f_2	-0.00528175	-1.020
g_{31}	0.02538558	8.759 ***	f_3	0.05493601	5.071 ***
g_{32}	-0.00479937	-1.417			
$\overline{R}^2$	0.997		*SSR*	2.732	

Table A-1 (continued)

Share1:			Share2:		
a_1	0.39275563	27.497 ***	a_2	0.03835123	5.075 ***
a_{11}	0.09736875	9.980 ***	a_{21}	0.01289297	3.694 ***
a_{12}	0.01289297	3.694 ***	a_{22}	0.01296053	5.392 ***
a_{13}	-0.11026171	-11.331 ***	a_{23}	-0.02585349	-6.838 ***
g_{11}	-0.02506768	-10.069 ***	g_{21}	-0.00031791	-0.230
g_{12}	0.00311025	1.067	g_{22}	0.00168912	1.058
g_{13}	-0.01374349	-5.969 ***	g_{23}	-0.00394145	-3.087 ***
g_{14}	0.04004772	14.214 ***	g_{24}	0.00050023	0.322
g_{15}	-0.03426920	-10.601 ***	g_{25}	-0.00614661	-3.434 ***
d_1	0.02760399	9.983 ***	d_2	0.00972501	6.507 ***
f_1	-0.04965426	-5.290 ***	f_2	-0.00528175	-1.020
$\overline{R}^2$	0.712		$\overline{R}^2$	0.277	
SSR	0.456		SSR	0.140	

Table A-2

RSCE based on thick and split thick frontier. and on conventional cost function

	Thick Cost Frontier	*Split Thick Cost Frontier*	*Conventional Cost Function*
class 1	0.937	0.932	0.942
class 2	0.950	0.932	0.950
class 3	0.960	0.938	0.949
class 4	0.967	0.932	0.949
class 5	0.975	0.922	0.948
class 6	0.979	0.920	0.951
class 7	0.981	0.933	0.956
class 8	0.990	0.967	0.955
class 9	1.009	1.036	0.958
Commerzbank	1.031	1.133	0.955
Dresdner Bank	1.030	1.137	0.952
Deutsche Bank	1.024	1.137	0.943

Table A-3

EPSUB based on thick and split thick frontier, and on conventional cost function

	Thick Cost Frontier	*Split Thick Cost Frontier*	*Conventional Cost Function*
class 1	-	-	-
class 2	-0.003	-0.004	-0.010
class 3	-0.042	-0.042	-0.041
class 4	-0.015	-0.005	-0.013
class 5	-0.038	-0.016	-0.028
class 6	-0.010	0.022	-0.003
class 7	-0.012	0.021	0.005
class 8	-0.052	-0.039	-0.035
class 9	-0.047	-0.059	-0.030
Commerzbank	-0.015	-0.037	0.000
Dresdner Bank	-0.092	-0.141	-0.062
Deutsche Bank	-0.071	-0.167	-0.045

Table A-4

$MSCOPE_T$ based on thick frontier

	$MSCOPE_1$	$MSCOPE_2$	$MSCOPE_3$	$MSCOPE_4$	$MSCOPE_5$
class 1	-	-	-	-	-
class 2	-0.016	-0.039	0.021	0.017	0.008
class 3	-0.006	-0.011	0.045	0.027	0.048
class 4	-0.054	-0.072	0.019	-0.009	-0.014
class 5	-0.031	-0.036	0.042	-0.005	0.026
class 6	-0.083	-0.101	-0.032	-0.063	-0.042
class 7	-0.041	-0.075	0.006	-0.017	-0.044
class 8	-0.051	-0.035	0.035	-0.020	0.009
class 9	-0.277	-0.124	-0.088	-0.183	-0.022

7 References

Allen, L., Rai, A. (1993). Global Financial Intermediation: Universal versus Specialized Banking, paper presented at the 20th Annual Meeting of the European Finance Association. Copenhagen Business School, August 26-28, published in section II-D of the proceedings.

Altunbas, Y., Molyneux, P. (1993). A Comparative Analysis of Scope and Scale Economies in EC Banking Markets, unpublished manuscript, University College of North Wales.

Baldini, D., Landi, A. (1990), Economie di Scala e Complementarieta' di Costa nell'Industria Bancaria Italiana, L'Industria, n° 1, 25-45.

Bauer, P.W., Berger, A.N., Humphrey, D.B. (1993), Efficiency and Productivity Growth in U.S. Banking, in: *Fried, H.O., Lovell, C.A.K., Schmidt, S.S. (eds)*, The Measurement of Productive Efficiency: Techniques and Applications, Oxford: Oxford University Press, 386-413.

Berg, S.A., Førsund, F.R., Hjalmarsson, L., Suominen, M. (1993), Banking Efficiency in the Nordic Countries, Journal of Banking and Finance 17, 371-388.

Berg, S.A., Kim, M. (1993), Banks as Multioutput Oligopolies: An Empirical Evaluation of the Retail and Corporate Banking Markets, paper presented at the 1993 E.A.R.I.E. Conference in Tel Aviv, September 4-7.[PW20]

Berg, S.A. and M. Kim, 1994, Oligopolistic Interdependence and the Structure of Production in Banking: An Empirical Evaluation, Journal of Money, Credit, and Banking 26, 309-322.

Berger, A.N., Hanweck, G.A., Humphrey, D.B. (1987), Competitive Viability in Banking. Scale, Scope, and Product Mix Economies, Journal of Monetary Economics 20, 501-520.

Berger, A.N., Humphrey, D.B. (1991), The Dominance of Inefficiencies over Scale and Product Mix Economies in Banking, Journal of Monetary Economics 28, 117-148.

Berger, A.N., Humphrey, D.B. (1992), Megamergers in Banking and the Use of Cost Efficiency as an Antitrust Defense, Antitrust Bulletin 37, 541-600.

Berger, A.N., Hunter, W.C., Timme, S.G. (1993), The Efficiency of Financial Institutions: A Review and Preview of Research Past, Present, and Future, Journal of Banking and Finance 17, 221-249.

Dietsch, M. (1993), Economies of Scale and Scope in the French Commercial Banking Industry (to be published in: Journal of Productivity Analysis)

Diewert, W.E., Wales, T.J. (1987), Flexible Functional Forms and Global Curvature Conditions, Econometrica 55, 43-68.

Drake, L. (1992), Economies of Scale and Scope in UK building Societies: An Application of the Translog Multiproduct Cost Function, Loughborough University of Technology Economic Research Paper n° 92/10.

Ferrier, G.D., Lovell, C.A.K. (1990), Measuring Cost Efficiency in Banking. Econometric and Linear Programming Evidence, Journal of Econometrics 46, 229-245.

Gilligan, Th.W., Smirlock, M.C., Marshall, W. (1984), Scale and Scope Economies in the Multi-Product Banking Firm, Journal of Monetary Economics 13, 393-405.

Glass, J.C., McKillop, D.G. (1992), An Empirical Analysis of Scale and Scope Economies and Technical Change in an Irish Multiproduct Banking Firm, Journal of Banking and Finance 16, 423-437.

Greene, W.H. (1993), Econometric Analysis, 2nd ed., New York: Macmillan.

Kolari, J., Zardkoohi, A. (1987), Bank Costs, Structure, and Performance, Lexington.

Kolari, J. Zardkoohi, A. (1990), Economies of Scale and Scope in Thrift Institutions: The Case of Finnish Cooperative and Savings Banks, Scandinavian Journal of Economics 92, 437-451.

Lang, G., Welzel, P. (1994a), Skalenerträge und Verbundvorteile im Bankensektor. Empirische Bestimmung für die bayerischen Genossenschaftsbanken, ifo Studien 40, 155-177.

Lang, G., Welzel, P. (1994b), Efficiency and Technical Progress in Banking: Empirical Results for a Panel of German Co-operative Banks, Volkswirtschaftliche Diskussionsreihe, Beitrag Nr. 117, Institut für Volkswirtschaftslehre der Universität Augsburg.

Lang, G., Welzel, P. (1995), Strukturschwäche oder X-Ineffizienz? Cost-Frontier-Analyse der bayerischen Genossenschaftsbanken (to be published in: Kredit und Kapital).

Leibenstein, H. (1966), Allocative Efficiency Versus „X-Efficiency", American Economic Review 56, 392-415.

McAllister, P.H., McManus, D. (1993), Resolving the Scale Efficiency Puzzle in Banking, Journal of Banking and Finance 17, 389-405.

Mester, L.J. (1987), A Multiproduct Cost Study of Savings and Loans, Journal of Finance 42, 423-445.

Pulley, L.B., Braunstein, Y.M. (1992), A Composite Cost Function for Multiproduct Firms with an Application to Economies of Scope in Banking, Review of Economics and Statistics 74, 221-230.

Rodriguez, J.R.O., Alvarez, A.A., Gomez, P.P. (1993), Scale and Scope Economies in Banking: A Study of Savings Banks in Spain, mimeo, Universidad De La Laguna, Tenerife.

Schmid, F.A. (1994), Technical Efficiency and Returns to Scale in Austrian Commercial Banking: 1987-1991 (to be published in: Empirica).

Sealey, C.W. jr., Lindley, J.T. (1977), Inputs, Outputs, and a Theory of Production and Cost at Depository Financial Institutions, Journal of Finance 32, 1251-1266.

Sheldon, G. (1993), Skalenerträge, Verbundvorteile und Ineffizienz im Schweizer Bankgewerbe, Ifo-Studien 38, 351-379.

Sheldon, G. (1994), Nichtparametrische Messung des technischen Fortschritts im Schweizer Bankensektor, Schweizerische Zeitschrift für Volkswirtschaft und Statistik 130, 691-707.

Sheldon, G., Haegler, U. (1993), Economies of Scale and Scope and Inefficiencies in Swiss Banking, in: *Blattner, N., Genberg, H., Swoboda, A. (eds)*, Banking in Switzerland, Heidelberg: Springer-Verlag, 103-134.

Vennet, R.V. (1993), Cost Characteristics of Credit Institutions in the EC, paper presented at the 20th Annual Meeting of the European Finance Association, Copenhagen Business School, August 26-28, published in section II-D of the proceedings.

Zardkoohi, A., Kolari, J. (1994), Branch Office Economies of Scale and Scope: Evidence from Savings Banks in Finland, Journal of Banking and Finance 18, 421-432.

Zellner, A. (1962), An Efficient Method of Estimating Seemingly Unrelated Regressions and Tests of Aggregation Bias, Journal of the American Statistical Association 57, 500-509.

JEL classification: G21, L89

Keywords: banking, translog cost function, economies of scale, economies of scope, X-inefficiency

Beiträge in der Volkswirtschaftlichen Diskussionsreihe seit 1993

Im Jahr 1993 erschienen:

Beitrag Nr. 83:	Manfred Stadler	Innovation, Growth, and Unemployment. A Dynamic Model of Creative Destruction
Beitrag Nr. 84:	Alfred Greiner Horst Hanusch	Cyclic Product Innovation or: A Simple Model of the Product Life Cycle
Beitrag Nr. 85:	Peter Welzel	Zur zeitlichen Kausalität von öffentlichen Einnahmen und Ausgaben. Empirische Ergebnisse für Bund, Länder und Gemeinden in der Bundesrepublik Deutschland
Beitrag Nr. 86:	Gebhard Flaig Manfred Stadler	Dynamische Spillovers und Heterogenität im Innovationsprozeß. Eine mikroökonometrische Analyse
Beitrag Nr. 87:	Manfred Stadler	Die Modellierung des Innovationsprozesses. Ein integrativer Mikro-Makro-Ansatz
Beitrag Nr. 88:	Christian Boucke Uwe Cantner Horst Hanusch	Networks as a Technology Policy Device - The Case of the "Wissenschaftsstadt Ulm"
Beitrag Nr. 89:	Alfred Greiner Friedrich Kugler	A Note on Competition Among Techniques in the Presence of Increasing Returns to Scale
Beitrag Nr. 90:	Fritz Rahmeyer	Konzepte privater und staatlicher Innovationsförderung
Beitrag Nr. 91:	Peter Welzel	Causality and Sustainability of Federal Fiscal Policy in the United States
Beitrag Nr. 92:	Friedrich Kugler Horst Hanusch	Stock Market Dynamics: A Psycho-Economic Approach to Speculative Bubbles
Beitrag Nr. 93:	Günter Lang	Neuordnung der energierechtlichen Rahmenbedingungen und Kommunalisierung der Elektrizitätsversorgung
Beitrag Nr. 94:	Alfred Greiner	A Note on the Boundedness of the Variables in Two-Sector Models of Optimal Economic Growth with Learning by Doing
Beitrag Nr. 95:	Karl Morasch	Mehr Wettbewerb durch strategische Allianzen?
Beitrag Nr. 96:	Thomas Kuhn	Finanzausgleich im vereinten Deutschland: Desintegration durch regressive Effekte
Beitrag Nr. 97:	Thomas Kuhn	Zentralität und Effizienz der regionalen Güterallokation
Beitrag Nr. 98:	Wolfgang Becker	Universitärer Wissenstransfer und seine Bedeutung als regionaler Wirtschafts- bzw. Standortfaktor am Beispiel der Universität Augsburg
Beitrag Nr. 99:	Ekkehard von Knorring	Das Umweltproblem als externer Effekt? - Kritische Fragen zu einem Paradigma -
Beitrag Nr. 100:	Ekkehard von Knorring	Systemanalytischer Traktat zur Umweltproblematik - Reinhard Blum zum 60. Geburtstag -
Beitrag Nr. 101:	Gebhard Flaig Manfred Stadler	On the Dynamics of Product and Process Innovations. A Bivariate Random Effects Probit Model
Beitrag Nr. 102:	Gebhard Flaig Horst Rottmann	Dynamische Interaktionen zwischen Innovationsplanung und -realisation

Beitrag Nr. 103:	Thomas Kuhn Andrea Maurer	Ökonomische Theorie der Zeit
Beitrag Nr. 104:	Alfred Greiner Horst Hanusch	Schumpeter's Circular Flow, Learning by Doing, and Cyclical Growth
Beitrag Nr. 105:	Uwe Cantner Thomas Kuhn	A Note on Technical Progress in Regulated Firms
Beitrag Nr. 106:	Jean Bernard Uwe Cantner Georg Westermann	Technological Leadership and Variety. A Data Envelopment Analysis for the French Machinery Industry
Beitrag Nr. 107:	Horst Hanusch Marcus Ruf	Technologische Förderung durch Staatsaufträge. Das Beispiel Informationstechnik

Im Jahr 1994 erschienen:

Beitrag Nr. 108:	Manfred Stadler	Geographical Spillovers and Regional Quality Ladders
Beitrag Nr. 109:	Günter Lang Peter Welzel	Skalenerträge und Verbundvorteile im Bankensektor. Empirische Bestimmung für die bayerischen Genossenschaftsbanken
Beitrag Nr. 110:	Peter Welzel	Strategic Trade Policy with Internationally Owned Firms
Beitrag Nr. 111:	Wolfgang Becker	Lebensstilbezogene Wohnungspolitik - Milieuschutzsatzungen zur Sicherung preiswerten Wohnraumes
Beitrag Nr. 112:	Alfred Greiner Horst Hanusch	Endogenous Growth Cycles - Arrow´s Learning by Doing
Beitrag Nr. 113:	Hans Jürgen Ramser Manfred Stadler	Kreditmärkte und Innovationsaktivität
Beitrag Nr. 114:	Uwe Cantner Horst Hanusch Georg Westermann	Die DEA-Effizienz öffentlicher Stromversorger. Ein Beitrag zur Deregulierungsdiskussion
Beitrag Nr. 115:	Uwe Cantner Thomas Kuhn	Optimal Regulation of Technical Progress in Natural Monopolies with Incomplete Information
Beitrag Nr. 116:	Horst Rottmann	Neo-Schumpeter-Hypothesen und Spillovers im Innovationsprozeß - Eine empirische Untersuchung
Beitrag Nr. 117:	Günter Lang Peter Welzel	Efficiency and Technical Progress in Banking. Empirical Results for a Panel of German Co-operative Banks
Beitrag Nr. 118:	Günter Lang Peter Welzel	Strukturschwäche oder X-Ineffizienz? Cost-Frontier-Analyse der bayerischen Genossenschaftsbanken
Beitrag Nr. 119:	Friedrich Kugler Horst Hanusch	Preisbildung und interaktive Erwartungsaggregation
Beitrag Nr. 120:	Uwe Cantner Horst Hanusch Georg Westermann	Detecting Technological Performances and Variety. An Empirical Approach to Technological Efficiency and Dynamics
Beitrag Nr. 121:	Jean Bernard Uwe Cantner Horst Hanusch	Technology and Efficiency Patterns. A Comparative Study on Selected Sectors from the French and German Industry
Beitrag Nr. 122:	Gebhard Flaig	Die Modellierung des Einkommens- und Zinsrisikos in der Konsumfunktion: Ein empirischer Test verschiedener ARCH-M-Modelle
Beitrag Nr. 123:	Jörg Althammer Simone Wenzler	Intrafamiliale Zeitallokation, Haushaltsproduktion und Frauenerwerbstätigkeit

Beitrag Nr. 124:	Günter Lang	Price-Cap-Regulierung. Ein Fortschritt in der Tarifpolitik?
Beitrag Nr. 125:	Manfred Stadler	Spieltheoretische Konzepte in der Markt- und Preistheorie. Fortschritt oder Irrweg?
Beitrag Nr. 126:	Horst Hanusch	Die neue Qualität wirtschaftlichen Wachstums
Beitrag Nr. 127:	Wolfgang Becker	Zur Methodik der Wirkungsanalyse von Maßnahmen der Verkehrsaufklärung

Bisher im Jahr 1995 erschienen:

Beitrag Nr. 128:	Ekkehard von Knorring	Quantifizierung des Umweltproblems durch Monetarisierung?
Beitrag Nr. 129:	Axel Olaf Kern	Die "optimale" Unternehmensgröße in der deutschen privaten Krankenversicherung - eine empirische Untersuchung mit Hilfe der "Survivor-Analyse"