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Scale economies, bank mergers, and electronic payments:
A spline function approach

by

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SCALE ECONOMIES, BANK MERGERS, AND ELECTRONIC PAYMENTS: A SPLINE FUNCTION APPROACH[*]

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Abstract

This paper demonstrates the importance of using a flexible cost function specification when analyzing economies of scale and estimating the cost effect of banking mergers. The inflexibility of the translog cost function is illustrated and results are compared to more flexible spline and Fourier cost functions. Using these different approaches we predict the ex ante effect on average cost from mergers over 1987-1998 using a balanced panel of 130 Norwegian banks. On average mergers are predicted to lower costs. Predictions using the Fourier or spline approach are in overall agreement with computed actual average merger-cost changes ex post. Cost effects of electronic payments are also estimated and exceed cost reductions associated with mergers.

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Keywords: Economies of scale, functional form, mergers.

1. Introduction.

The vast majority of the past growth of large banking institutions in the U.S. and Europe has been achieved through mergers and acquisitions (c.f., Rhoades (1985), for the U.S.). This method of expansion is viewed as being cheaper than de novo entry and quicker than relying on demand-determined growth. The recent removal of restrictions on nationwide branching in the U.S., the opening up of domestic and cross-border banking and financial markets in Europe, and the opportunity of moving to more cost-efficient electronic service delivery methods – with inherently more scale economies[1] – have accelerated this historical trend of merger-dependent growth.

Public statements by merging banks invariably focus on their expected cost savings, planned expansions in their service mix, and the need to have a sufficiently large presence in certain markets to compete effectively with other domestic or international players. These positive ex ante statements contrast sharply with ex post analyses that: (a) compare pre- and post-merger costs for merging banks (Rhoades (1993)); (b) assess merger-related changes in frontier cost efficiency levels or rankings (Berger (1998); Berger and Humphrey (1992)); or (c) summarize case studies of individual merging banks (Rhoades (1998)). Ex post studies of banking mergers consistently find that unit costs or efficiency levels are essentially unchanged for the average banking merger almost regardless of branch market overlap (where the expectation of cost savings is highest). While some banks experience reductions in unit cost, others experience increases. For the small subset of mergers that turn out to be "successful", however, unit costs may fall by up to 5%.[2]

Equity market event studies for Europe (Cybo-Ottone and Murgia (2000)), but not the U.S. (Hawawini and Swary (1990); Hannan and Wolken (1989)), find significantly positive abnormal equity returns associated with merger announcements. Equity event studies should reflect the potential for significant cost reductions as well as possible increases in market power and profits. Perhaps due to different mar-

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[1]See for instance Lindquist (2002), who documents increased scale economies in banking following the adoption of electronic payments technology.

[2]Reductions in total expenses, common in merger announcements, need to be adjusted for associated reductions in assets. This is why unit cost is a more useful metric.

ket structures and antitrust enforcement, the expected merger benefits have been positive for Europe. So far, when examined after the fact, this expectation has not been realized in the few ex post European studies that have been done (e.g., Carbo, Humphrey, and Fernandez (2003)).

Appearances to the contrary, a 5% reduction in unit cost from a successful merger is consistent with standard projections by banking consultants of overall cost savings in a merger corresponding to 30% to 40% of an acquired bank's operating cost. Since bank operating expenses (depending on the interest rate cycle) are around forty percent of total costs and the average acquired bank comprises around one-third of the consolidated organization, a 30% to 40% reduction in operating cost of an acquired institution translates into a 4% to 5% reduction in unit cost (e.g., $40\% \times .40 \times .33 = 5.3\%$) for the merged firm. Over half of the cost reduction achieved in a successful merger is due to reducing employment (Rhoades (1998)) while additional savings come from closing redundant branch offices. In some countries, however, public opposition to bank mergers has led management to promise that labor force reductions and branch closings will be limited, which reduces previously announced expected gains from a merger. Although a 5% reduction in unit cost (which only applies to successful mergers) may sound small, it can translate into a 23% to 35% improvement in return on assets.[3]

In this paper we first show that a more detailed analysis of *scale* effects in banking can lead to more accurate predictions regarding the potential cost effects of mergers. This is achieved by comparing the estimated scale economies from a restrictive specification like the translog to the more flexible specifications of a spline or a Fourier function. The translog specification will in most cases predict average cost as a standard U-shaped quadratic curve where scale economies are exhausted for all but relatively small or medium-sized banks. By construction a quadratic function can only have one turning point, hence the typical U-shape of a translog cost function can in many cases be considered an artifact. Nevertheless, this has been the standard functional form used in most bank cost studies. In contrast

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[3] A 5% reduction in unit cost implies that the ratio of total cost to total assets (which averages .07) will fall by .0035. Since the return on assets often ranges between around .01 to .015, a cost reduction of .0035 (if entirely reflected in a profit increase) suggests that return on assets (ROA) could rise by 35% or 23%, respectively.

to the translog, both the spline and the Fourier specifications – which both allow more than one turning point – indicate that predicted average cost is not quadratic. Indeed, instead of a typical U-shaped average cost curve, the spline and Fourier forms both show something similar to an M-shaped curve so that economies and diseconomies exist for both smaller and larger banks.[4]

In order to predict the cost effect of mergers, we match merging institutions with their pre- and post-merger bank-specific scale measures at the time they merged to determine the likely effect on cost for each merger individually and as a group. These results are reported using the translog, spline, and Fourier cost functions. On average, the translog predicts that average cost will fall by less than a fifth of one percent while the Fourier and spline functions predict a two to three percent decrease. Frequency distributions of these sets of predictions show that all three functions predict both cost increases and decreases for individual mergers, with more decreases for the spline and Fourier forms. These merger cost predictions are compared to how average cost has actually changed pre- and post-merger at acquiring banks relative to the rest of the industry. This cost change related to mergers is then contrasted with cost savings resulting from advances in payment technology which reduce back office operating costs and service delivery expenses.

The accuracy of our analysis in predicting the direction of change in average cost is on par with that of merger participants who invariably predict cost reductions but, due to unforeseen events, realize this goal only about half the time. The value of our approach lies in providing a more accurate estimate of the average effect of mergers on cost. This gives an expected value which competition authorities may use to assess the likelihood that merger cost savings announced by participants may in fact be realized. For this task, the spline and Fourier functions give more reliable results than the translog.

In what follows, section 2 outlines our use of spline and Fourier functions to more accurately determine variations in scale economies across all banks. This

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[4]This point was demonstrated on a data set of U.S. banks by McAllister and McManus (1993). Also, in a special case, Shaffer (1998) shows that estimating a translog cost function can result in a spuriously U-shaped average cost curve when data are generated from a process with declining average costs. The cost function suggested as a replacement, however, has flexibility problems of its own.

analysis is illustrated by first applying a single output model to a balanced panel of 131 Norwegian banks over 1987-1998 (12 years), giving 1,572 observations. These results are contrasted with those obtained using a translog cost function, providing a benchmark for assessing the improvement in identifying scale economy and merger cost effects. Then our single output model is expanded into a two-output model where we additionally control for the transition from paper based to electronic payments. In section 3 this two-output model is applied to predict cost effects from bank mergers. These predictions are contrasted in section 4 with estimates of the actual merger-related cost change. The purpose is to determine how accurate our ex ante merger cost predictions are relative to merger analyses which rely on ex post data. In section 5, the effect on bank expenses from the shift to lower cost electronic payments is estimated and compared to the merger cost effect. Section 6 contains a summary and conclusions.

2. Spline and Fourier Function Measures of Scale Economies.

In this section we first discuss how to best arrange the data in order to capture effects from scale economies. Then we demonstrate the importance of the choice of functional form when scale economies are to be evaluated using an econometrically estimated cost function. To facilitate a graphic illustration of this issue we use single output models. Next, however, we expand our models to contain two outputs – business loans and consumer loans – and control for the revolution in payment technology that took place during our sample period. This two-output model is the model applied in section 3 when we predict merger cost effects ex ante.

2.1. Arranging the Data to Best Capture Scale Effects.

Scale effects have been estimated using cross-section and panel data. With panel data, it can make a difference how the data are arranged. The average cost figure below illustrates two ways of doing this when bank a (the larger of the two banks) acquires bank b, forming the new bank $a + b$.

The usual way is to create a balanced panel by backward aggregating all pre-merger data on banks a and b prior to their merger, generating point 3 in the Figure 2.1. Once the merger occurs, yielding point 4, the output level will not change by

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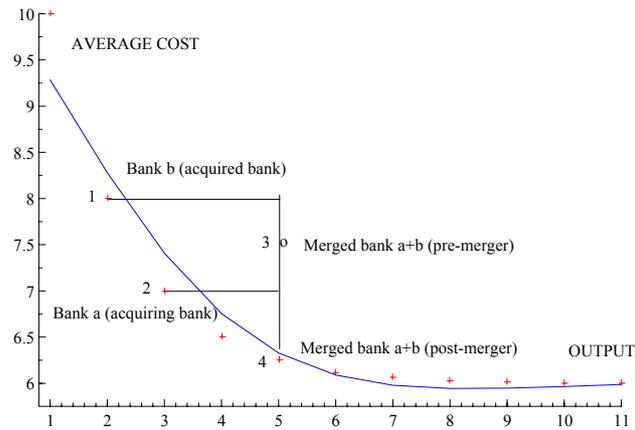
Figure 2.1:

much (since the banks have already been artificially merged) but costs may change if there are scale economies. This is a common approach and we have done it ourselves. Upon rethinking the issue, we feel a more defensible approach (and the one adopted below) would be to instead use the observed pre-merger data point 2 along with point 4. With this data arrangement, when 2 is compared to 4 in a panel regression both cost and output are allowed to change in response to the merger. The merger process is thus represented as a series of output and cost "jumps" which is how it is also viewed by the merger participants.

2.2. Approximating the Curvature of Average Cost.

A spline function is a regression-based method developed to fit a polynomial equation of a given order to a scatter plot of data points. At one extreme, the polynomial fitted can be a straight line equal to what is obtained with a simple linear regression. At the other extreme, a series of line segments would connect each point in a scatter plot. The benefit of a spline is that it can represent numerous curvatures intermediate to these two extremes at the discretion of the researcher, which is how it is applied here.

Take the case of a standard average cost (AC) curve. If AC is linear, log linear,

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or log quadratically related to output, then the appropriate cost function model to determine scale economies should itself be linear, Cobb-Douglas, or a translog model. Increased flexibility is attained if a Fourier cost function is specified, which effectively adds a series of sin and cos terms to the translog model, or if a spline function is used. Which model to use is thus determined by how much curvature exists in the underlying relationship between AC and output and how closely the curvature needs to be approximated for the task at hand.

As shown by McAllister and McManus (1993), average cost for U.S. banks is poorly represented by a translog form. More flexible representations using a Fourier form, a kernel regression, or a linear spline function showed that average cost was quite variable across banks and indicated continuing scale economies for larger institutions. Since the main benefit from a merger (if successful) is to achieve lower cost with larger size, a flexible specification of AC is important in order to accurately judge the likely cost effect of mergers by different sized institutions. Figure 2.2 illustrates that a flexible representation of average cost is important for Norwegian banks as well. The predicted average cost curves shown reflect translog, Fourier, and linear spline cost functions which relate total cost (TC) to the level of a single output (Q) which is represented by total assets. These cost functions are estimated jointly with k-1 cost shares as a SURE system. The illustrative specifications used in the figure are:

$$\text{Translog:} \quad \ln TC = \alpha_0 + \alpha_1 \ln Q + \alpha_2 1/2 (\ln Q)^2 + A + B$$

$$\text{Fourier} \quad : \quad \ln TC = \text{ Translog Cost Function}$$
$$+ \tau_1 \sin(\ln Q^*) + \tau_2 \sin(2\ln Q^*) + \tau_3 \sin(3\ln Q^*)$$
$$+ \tau_4 \cos(\ln Q^*) + \tau_5 \cos(2\ln Q^*) + \tau_6 \cos(3\ln Q^*)$$

$$\text{Linear Spline:} \quad \ln TC = \alpha_0 + \sum_{n=1}^{7} \alpha_n \ln Q_n + A + B \quad ,$$

where the cost share used in all three above estimations, according to Shephard's lemma, is:

$$S_k = \beta_k + \sum_{m=1}^{4} \beta_{k,m} \ln P_k + \delta_k \ln Q$$

and where:

$$
\begin{aligned}
A &= \sum_{k=1}^{4} \delta_k (\ln Q \ln P_k) \\
B &= \sum_{k=1}^{4} \beta_k \ln P_k + 1/2 \sum_{k=1}^{4} \sum_{m=1}^{4} \beta_{k,m} (\ln P_k \ln P_m)
\end{aligned}
$$

TC = operating cost, interest expenses on funding, and the opportunity costs of financial and physical capital;

Q = one output: the value of total assets and where Q_n is used only in the spline function (n = the number of size-classes of banks (seven) with a separate linear line segment);[5] and

$\ln Q^* = \ln Q \cdot YQ + ZQ$, where $YQ = (0.8 \cdot 2\pi)/(\max \ln Q - \min \ln Q)$, $ZQ = 0.2\pi - \min \ln Q \cdot YQ$, and $\pi = 3.141593...$, hence $\ln Q^*$ is essentially expressed in radians.[6]

$P_{k,m}$ k, m = four input prices: the weighted average interest rate paid for banks' borrowings in the money market and retail deposits, the average expense per man-hour, an index measure of prices of materials and purchased services[7], and the opportunity cost of financial capital and invested physical capital.[8]

S_k = the cost shares for the funding, labor, and materials inputs (the share for physical capital is excluded from the econometric model to avoid singularity).

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[5]In a previous estimation we only used six segments for the spline. However adding one more spline among the smaller banks results in an AC curve estimated with splines more similar to the AC curve estimated with the Fourier form.

[6]See Mitchell and Onvural (1996) and Berger and Mester (1997).

[7]As banks have outsourced much of their IT activities – especially those related to payments – materials and purchased services have a cost share of 12 % at sample mean.

[8]More specifically the four input prices are: price of funding (represented by a weighted average of the price of borrowed money – three months money market interest rate – and the average interest rate on deposits); average labor cost per manhour; price of materials and purchased services (represented by the price index of materials and services input to the financial industry from the national accounts); and a weighted average of a calculated user cost of physical capital and the required return on equity capital and subordinated debt. The latter is represented by the ten-year interest rate on government bonds plus a risk premium of 3 pct. points. The actual cost of equity capital cannot be computed for ninety per cent of the banks in our sample because their equity is not traded and/or they are mutually held institutions.
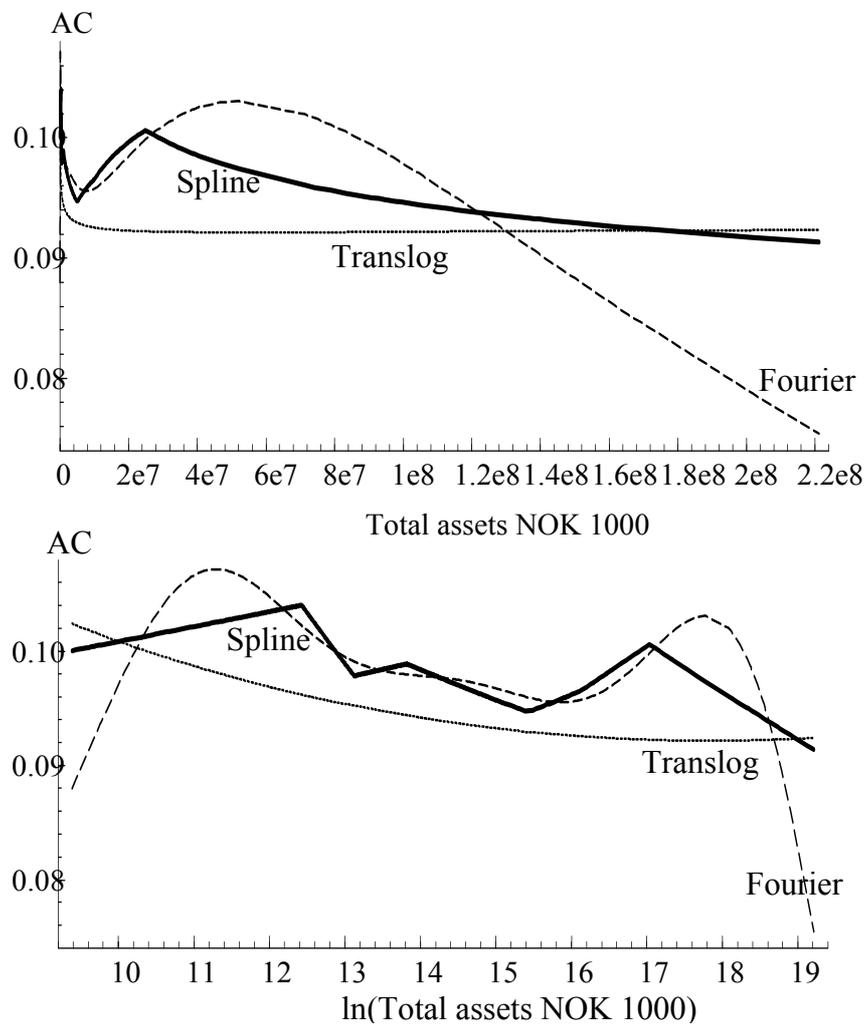
Figure 2.2: Average costs plotted against total assets for different cost function specifications, upper panel. Average costs plotted against ln of total assets, lower panel.

Average cost is the ratio of predicted total costs to actual total assets. All the three cost functions are estimated using four input prices. For predicting total costs, all input prices are set equal to their sample mean.

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As our main concern is to allow for greater flexibility in the local identification of scale effects, the sin and cos terms in the Fourier form and the linear segments in the spline function are applied only to the output (Q) measure.[9] The Fourier form is a globally flexible approximation since the respective sin and cos terms attached to the translog form are mutually orthogonal over the $[0, 2\pi]$ interval. In the linear spline, one line segment is specified for each of seven bank size-classes. Predicted values of AC in Figure 2.2 are obtained by evaluating each equation with the range of actual Q values in the data set (holding input prices constant at their sample mean values), exponentiating the predicted $\ln TC$ result, and dividing by Q.

As seen, the AC relationship using the spline or Fourier functions contain more curvature than is fitted by the translog specification and, in this sense, would provide a more accurate representation of scale economies facing different sized banks both pre- and post-merger. A log likelihood ratio test of the Fourier specification versus the more restrictive translog specification shows that the added trigonometric terms in the Fourier are jointly significant.[10] Econometrically this clearly points in the direction of preferring the Fourier over the translog specification. The translog function is slightly U-shaped (almost L-shaped) and predicts increasing average costs for all banks with total assets in excess of NOK 52 (6.7 Euros) billion, a large medium sized bank. The spline and the Fourier specifications give something like a M-shaped average cost curve. Importantly, both specifications indicate falling average costs for larger banks, i.e. banks with total assets in excess of NOK 25 (3.2 Euros) billion in total assets for the spline, and NOK 50 (6.4 Euros) billion for the Fourier.[11]

Accurate local identification of scale economies for merging banks is important. Aside from changes in the average price of physical inputs (if any), or the possibility of facing lower debt funding rates due to larger size, all the other cost effects of a merger will be reflected in a scale economy measure. This includes cost reductions

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[9]The specifications shown are designed to illustrate clearly the main differences between the three cost functions used.

[10]The log likelihood ratio statistic is 54.182 with degrees of freedom equal to 6, giving a p-value less than 0.001.

[11]Of a total number of 1572 observations, 167 observations have total assets larger than NOK 5.2 billion, 50 observations have total assets larger than NOK 25 billion and 34 observations have total assets in excess of NOK 50 billion.

achieved by consolidating back and front office operations (which reduces labor requirements and eliminates overlapping branch offices) as well as the cost effect from restructuring management policies and procedures (which would otherwise be captured by measured changes in average frontier cost efficiency).

2.3. Scale Economies from Different Specifications of the Cost Function, Two Outputs.

The simple spline function as well as the Fourier representation of average cost in Figure 2.2 suggest that there are important differences in scale economies across different sized banks. We now estimate these scale differences using a more comprehensively specified cost function, one with multiple outputs and inputs along with a specific indicator (not a time trend) that controls for changing banking technology. Specifically, we consider a two output cost model with consumer loans and business loans representing the banking outputs and control for concurrent changes in payment technology. The latter is represented by the aggregate ratio of electronic payment transactions to total non-cash transactions each year.[12] We use the same four input prices as in section 2.2; funding costs (borrowing and retail deposits), average labour costs per manhour, a measure of the price of materials and purchased services, and the opportunity cost of financial and physical capital.

By splitting output into loans to businesses and loans to consumers we control for the fact that:

1. consumer loans and business loans require different labor input skills; and

2. the ratio of business loans to total loans varies considerably among the banks in our data set (from just above 1% at some of the smallest banks to more than 70% among the largest banks).

With a seven-piece linear spline function for the two outputs and a standard translog specification for the remaining variables, our spline cost function model estimated jointly with $k - 1$ cost shares is:

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[12]This payment data, like that for the price of materials and purchased services, is only available by year (not also by bank) in our panel data set.

Spline Cost Function:

$$\ln TC \;=\; \alpha_0 + \sum_{i=1}^{2}\sum_{n=1}^{7}\alpha_{i,n}\ln Q_{i,n} + A' + B + \gamma_1\ln ELE + \gamma_2 1/2(\ln ELE)^2$$

$$S_k \;=\; \beta_k + \sum_{m=1}^{4}\beta_{k,m}\ln P_k + \sum_{i=1}^{2}\delta_{i,k}\ln Q_i \qquad\qquad (2.1)$$

where:

$$A' \;=\; 1/2\sum_{i\neq j}^{2}\alpha_{i,j}(\ln Q_i\ln Q_j) + \sum_{i=1}^{2}\sum_{k=1}^{4}\delta_{i,k}(\ln Q_i\ln P_k)$$

$$B \;=\; \sum_{k=1}^{4}\beta_k\ln P_k + 1/2\sum_{k=1}^{4}\sum_{m=1}^{4}\beta_{k,m}(\ln P_k\ln P_m)$$

$Q_{i,n}$ i,j = two outputs: the value of consumer loans and the value of business loans (n = the number of size-classes of banks (seven) with a separate linear spline line segment); and

ELE = the ratio of the number of electronic payments to the number of all non-cash payments per year.

Use of a piece-wise linear spline function for i outputs over n separate bank size-classes gives $i \times n$ separate relationships between cost and output. Since all of the curvature properties are obtained here, we do not specify quadratic own terms $1/2\sum\alpha_{i,i}(\ln Q_i)^2$, although in A' output is allowed to interact with itself in $1/2\sum_{i\neq j}\alpha_{i,j}(\ln Q_i\ln Q_j)$ and with input prices. While many studies find little significance in the $\sum\sum\delta_{i,k}(\ln Q_i\ln P_k)$ interactions, over the business cycle variations in funding costs relative to labor expenses can affect the mix of liabilities between retail deposits and money market or interbank funding.[13]

ELE is an explicit indicator of technology-related bank processing cost savings realized as users of payment services shift from expensive paper-based giro and check payments to much cheaper electronic giro and debit card payments. Electronic payments cost banks from one-third to one-half as much to produce and process compared with paper-based payments for the same type of transaction (Flatraaker and Robinson (1995); Wells (1996)). Over our time period, Norway has moved from having 85% of its non-cash payments in paper form to having over 75% in electronic

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[13]This interaction does not need a spline function. The resulting parameters ($\delta_{i,k}$) are equivalent to the average relationship between n linear output splines and n linear price splines for each of the $\ln Q_i\ln P_k$ combinations. The same holds for the parameter $\alpha_{i,j}$ for the $\ln Q_i\ln Q_j$ interactions.

form. As electronic bill payments and payroll disbursements are automated and debit cards substitute for cash at the point of sale (Snellman, Vesala, and Humphrey (2000)), there is less need for direct bank-to-customer interaction, allowing banks to reduce the number and size of branch offices and thus lower service delivery expenses. This rapid change of technology took place within the period covered by our sample, and controlling for it in estimating a cost function is important given the cost savings it has implied.

Note that the variable ELE only varies across time not across banks. As all banks in Norway are connected to the same clearing system for retail payments, ELE represents a common change in technology affecting all banks. Econometrically this implies that to the individual bank this variable can be considered as exogenous.

In order to assess the usefulness of our spline function model, the scale economy, payment technology, and merger cost effects from the spline function are compared with similar results from translog and Fourier specifications estimated jointly with the cost shares:

Translog Cost Function:

$$
\begin{aligned}
\ln TC &= \alpha_0 + \sum_{i=1}^{2} \alpha_i \ln Q_i + 1/2 \sum_{i=1}^{2} \alpha_{i,i} (\ln Q_i)^2 + A' + B + \gamma_1 \ln ELE + \gamma_2 1/2 (\ln ELE)^2 \\
S_k &= \beta_k + \sum_{m=1}^{4} \beta_{k,m} \ln P_k + \sum_{i=1}^{2} \delta_{i,k} \ln Q_i
\end{aligned}
\tag{2.2}
$$

Fourier Cost Function:[14]

$$
\begin{aligned}
\ln TC &= \text{Translog Cost Function} \\
&+ \sum_{i=1}^{2} (\tau_{1i} \sin(\ln Q_i^*) + \tau_{2i} \sin(2\ln Q_i^*) + \tau_{3i} \sin(3\ln Q_i^*)) \\
&+ \sum_{i=1}^{2} (\tau_{4i} \cos(\ln Q_i^*) + \tau_{5i} \cos(2\ln Q_i^*) + \tau_{6i} \cos(3\ln Q_i^*)) \\
&+ \tau_7 \sin(\ln Q_i^* + \ln Q_j^*) + \tau_8 \cos(\ln Q_i^* + \ln Q_j^*) \\
&+ \tau_9 \sin(2\ln Q_i^* + \ln Q_j^*) + \tau_{10} \cos(2\ln Q_i^* + \ln Q_j^*) \\
&+ \tau_{11} \sin(\ln Q_i^* + 2\ln Q_j^*) + \tau_{12} \cos(\ln Q_i^* + 2\ln Q_j^*) \\
S_k &= \beta_k + \sum_{m=1}^{4} \beta_{k,m} \ln P_k + \sum_{i=1}^{2} \delta_{i,k} \ln Q_i
\end{aligned}
\tag{2.3}
$$

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[14] The terms $\ln Q_i^*$ and $\ln Q_j^*$ are computed as defined earlier in section 2.2

From the estimation of the three cost function specifications (2.1) to (2.3) the scale elasticities, or the elasticities of total cost w.r.t. total loans (consumer loans plus business loans), can be calculated as:

$$E_{TC} = \sum_{i=1}^{2} E_{i,TC} \qquad ,$$

where $E_{i,TC}$ is the elasticity of total cost w.r.t. output i. The scale elasticities E_{TC} for seven different sub-samples according to bank size[15] are reported in Table 2.1 as sample means.[16]

Table 2.1: Elasticities of total costs to total loans

Size class	Total assets, NOK billions	Translog	Fourier	Spline	N
1	$0 - 0.25$	0.92	0.93	0.93	255
2	$0.25 - 0.5$	0.94	0.92	0.91	458
3	$0.5 - 1.0$	0.95	0.96	0.96	403
4	$1.0 - 5.0$	0.96	0.97	0.95	265
5	$5.0 - 10.0$	1.00	1.04	1.10	55
6	$10.0 - 25.0$	1.01	1.05	0.97	62
7	$25.0 -$	1.04	0.94	0.92	50
Total sample		0.95	0.95	0.94	1548

In estimating the scale elasticities in Table 2.1, we have controlled for (a) cost changes associated with the increased use of electronic payments (by specifying the ratio of electronic to total non-cash transactions) and (b) heterogeneity between business and consumer loans (by specifying two separate outputs). These scale elasticities show a similar pattern as that represented by the curves in Figure 2.2 using only one output (total assets) and not separately controlling for changes in payment technology. With the two-output (business and consumer loans) translog specification and controlling for changes in payments technology, scale economies are seen to be fully realized for almost all banks with an asset size of only NOK 10 (1.3 Euros) billion or larger. In section 2.2 where we used a single output (total assets –

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[15] These seven size classes are based on the value of total assets and correpond to the seven segments used in estimating the spline function illustratde in Figure 2.2.

[16] Two banks from our original sample of 131 banks did not report loans by borrower categories. Hence when estimating models with two outputs we are left with 129 banks and a total of 1548 observations.

rather than two loan categories), scale economies were fully realized for banks with an asset size five times larger (NOK 50 billion) in the translog specification. This difference reflects the fact that among banks with total assets larger than NOK 10 billion, loans – a labor intensive asset – constitute a smaller fraction of a bank's assets the larger is the bank.

As in section 2.2 a log likelihood ratio test of the Fourier specification versus the more restricted translog specification indicated that the added trigonometric terms in the Fourier are jointly significant.[17] Thus, econometrically the Fourier specification is clearly preferable over the translog.[18] Both the Fourier and the spline specifications show economies of scale for many smaller banks, some diseconomies for medium-sized institutions, and (quite differently from the translog) scale economies for larger banks.

Output specific cost elasticities as well as marginal costs for business and consumer loans are shown in Table 2.2. On average over the whole sample, expanding business loans by 10% generates a 2.3% rise in associated total costs while a 10% expansion in consumer loans generates a 7.1% rise (first two columns in Table 2.2). This differential cost effect refers only to the different slopes of the implied business and consumer loan average cost curves – not to their level. Over the whole sample, for each extra NOK 100 of business loans extended NOK 16 goes to cover the marginal interest, capital, and operating expenses while a similar extension of consumer loans generates NOK 12 of extra expenses (last two columns in Table 2.2). Business loans usually involve more screening and monitoring than do consumer loans, and hence are more costly on the margin.

The approximate M-shaped average cost curve seen for the Fourier and spline functions in Figure 2.2 is also seen when the spline function is estimated with two loan outputs in Figure 2.3.[19] The figure plots the different predicted average costs

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[17]The log likelihood ratio statistics is 56.122 with 18 degrees of freedom, giving a p-value less than 0.001.

[18]Since the spline and the translog are not nested, we cannot test the spline versus the translog using a log-likelihood ratio test. Instead we have to use a non-nested test procedure like the J-test. However, as frequently can happen with the J-test, it was inconclusive. It was even inconclusive between the Fourier and the translog, indicating the test has low power. In addition we calculated the Akaike information criterion, which (although it has no firm basis in statistical theory) indicated that the spline is more informative than the translog.

[19]The fitted Fourier form with two loan outputs is similar to the spline and is thus not shown.
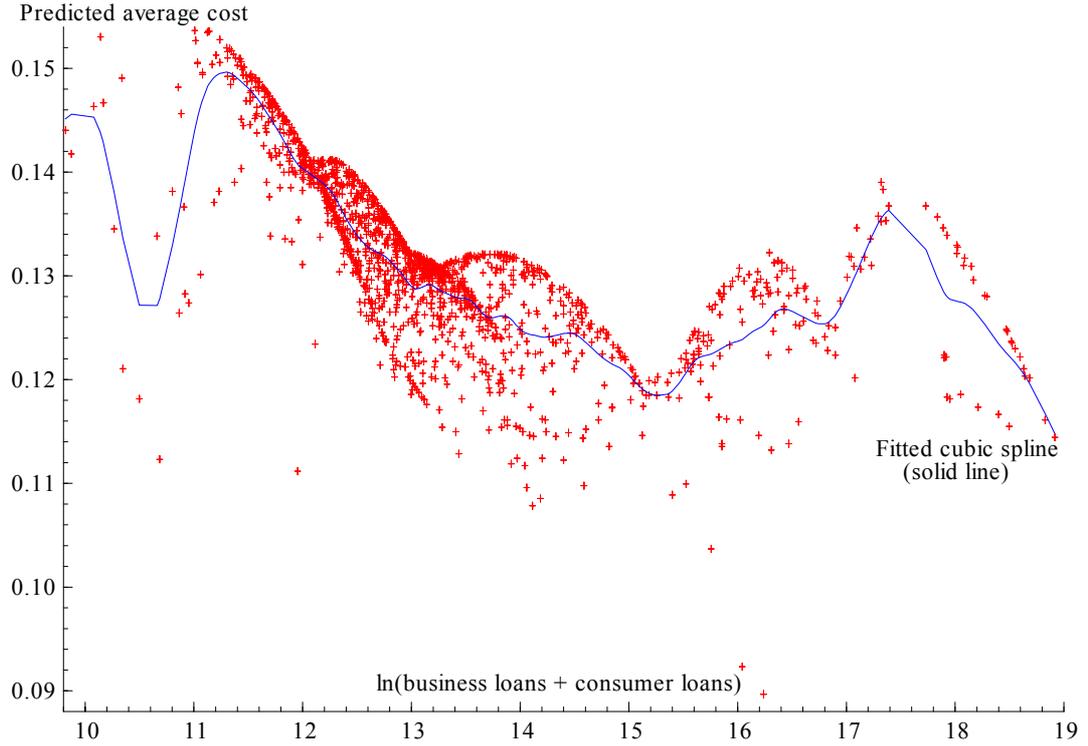
Figure 2.3: Points : Predicted average costs for the two-output spline cost function, using sample mean values of input prices and ELE, plotted against log of loans. Solid line: a fitted cubic spline for the points.

Table 2.2: Output-Specific Cost Elasticities and Marginal costs, Business and Consumer Loans

Total assets,	Cost elasticities		Marginal costs	
NOK billions	Business	Consumer	Business	Consumer
$0 - 0.25$	0.16	0.77	0.188	0.140
$0.25 - 0.5$	0.21	0.70	0.157	0.114
$0.5 - 1.0$	0.22	0.75	0.158	0.111
$1.0 - 5.0$	0.25	0.70	0.151	0.105
$5.0 - 10.0$	0.38	0.72	0.143	0.157
$10.0 - 25.0$	0.29	0.67	0.103	0.114
$25.0 -$	0.55	0.37	0.146	0.102
Total sample	0.23	0.71	0.158	0.117

Marginal costs are millions of NOK in increased total costs per millions of NOK in increased lending. In calculating the elasticities and marginal costs all four input prices and the ratio of electronic payments are set at their actual values. Only results from the spline specification are shown. The Fourier specification gives similar results.

16

against the log of business plus consumer loan values (on the X-axis).[20] The solid line shown in the figure is a cubic spline fitted to these predicted values. As seen, the result is similar to a M-shaped average cost curve. For the small banks with loans between NOK 40 millions and NOK 100 millions (those with the log of loans between 10.6 and 11.25), the solid line rises showing initial diseconomies of scale. The reason for these initial diseconomies is two-fold. First, as noted above, business loans cost more to produce than the same value of consumer loans. Second, as these small banks become larger, they start to issue more business loans. The shift toward producing more of the more expensive business loans generates the initial scale diseconomies seen in the figure. But as these banks become larger still, greater scale economies of business loans start to dominate. The later "humps" in average cost shown in the figure are associated with high marginal costs for consumer loans for the medium sized banks, banks with loans larger than NOK 5 billions. Finally, the reduction in average cost seen for the very largest banks is the direct result of significantly smaller marginal costs of consumer loans for these large institutions, as shown in Table 2.2. This indicates that the smaller banks and in particular the larger banks have been able to extend consumer loans at low costs.[21]

Notice also that the marginal cost of business lending is higher for the largest banks, almost as large as it is for small banks. The higher costs associated with larger banks can be due to more complex monitoring and screening of the larger firms that typically borrow at larger banks. Furthermore, the large corporate customers of large banks usually purchase related financial services such as foreign exchange, short-term investments, and financial derivatives from their banks. These services require physical inputs that are reported as higher total costs in our model, but we can not specify these additional services as outputs due to a lack of data.

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[20] All input prices and the share of electronic payments are held constant at their mean values.

[21] One explanation of this pattern in consumer lending is that small and fairly local banks have good information about their consumer borrowers and need not spend a lot of resources on screening and monitoring these loans. Once banks reach a medium size and encompass regions rather than communities, these local information advantages are reduced as loan requirements become more standardized and less personal. Hence they have to spend more resources on screening and monitoring the consumer loans they make. Although very large nationwide banks also have the same information disadvantage, they are geographically much more diversified and can to some degree substitute diversification for intensive monitoring. Furthermore, most of the monitoring and screening of consumer loans can be done through these banks' IT-systems, systems associated with large 'fixed' costs making them more attractive to larger banks than to smaller banks.

While scale economies exist, scope economies do not. Indeed, separate production of consumer and business loans appears to have marginally lower costs than does joint production. The average scope economy value with the Fourier form was -0.01 while it was -0.12 with the translog.[22] Thus the joint production we observe in practice is more likely due to revenue benefits than cost reductions. In any case, few merging banks actually changed their composition of business and consumer loans pre- to post-merger and so even if scope economies were positive (indicating lower costs) the effect would have been small.[23]

In the next section parameter estimates from the three cost function specifications (2.1) to (2.3) are used to give ex ante predictions of the cost savings from 26 bank mergers that actually occurred in our data set between 1988 and 1997.[24] As our scale estimates are independent of back office cost reductions associated with changes in payment technology – by the term controlling for this technological change – so (appropriately) are our predicted cost effects from mergers.

3. Predicting Merger Cost Effects Ex Ante.

When banks a and b merge into bank $a + b$ in year t, by bank a acquiring bank b in that year, the data we use for year t will contain the balance sheet items, cost, and income statements of the new larger bank, bank $a + b$. For year $t - 1$ and all previous years the reported data contains separate information for bank a and bank b as they were prior to their merger. In order to predict ex ante the cost effects of this merger we artificially merge banks a and b in only year $t - 1$ in a

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[22] The form of the spline function makes it very difficult to derive a scope measure and one is not presented. In functional notation, our scope calculation was: $SCOPE = [C(0.9 * Q_1, 0.1 * Q_2) + C(0.1 * Q_1, 0.9 * Q_2) - C(Q_1, Q_2)] / C(Q_1, Q_2)$ where $Q_1(Q_2)$ = business (consumer) loans and $C(\cdot)$ is the estimated cost function evaluated with output levels as shown but with all input prices and the share of electronic payments held constant at their mean values. As is now known, determining scope economies from a logarithmic cost function should not be done with complete or almost complete specialization in production. Hence our use of 0.9 and 0.1 points of evaluation rather 1.0 and 0.0 or 0.99 and 0.01). Other more subtle biases also exist, c.f. Pulley and Humphrey (1993).

[23] For the 26 merging banks, the average ratio of business to total loans was .36 and the average percentage point change in this ratio pre- to post-merger was .011 (with a standard deviation of .036).

[24] Our data covers 1987-1998 but we need at least one observation both one year prior to a merger and one year after a merger to calculate and contrast our predicted and actual change in merger-related average cost. This eliminates some mergers that occurred in 1987.

separate data set. We then compare the predicted average cost from each of the three cost functions for a bank with output levels the size of bank a in year $t-1$ to the predicted average cost of bank a but using the sum of output for bank a and bank b in year $t-1$.

More formally, this cost comparison can be stated as follows: Let $f(\cdot)$ be the symbol of an estimated mapping of input prices, outputs, and the payment technology control variable ELE to the total cost of a bank the size of bank a alone in year $t-1$ and then to the size of bank a and bank b as if they had merged into bank $a+b$ in year $t-1$. Using this estimated mapping the predicted average costs are:

$$
\begin{aligned}
AC_{a,t-1} &= \frac{f\left(Q_{1,a,,t-1}, Q_{2,a,t-1}, \mathbf{P}_{a,t-1}, ELE_{t-1}\right)}{Q_{1,a,,t-1} + Q_{2,a,t-1}} \\
AC_{a+b,t-1} &= \frac{f\left(Q_{1,a,,t-1} + Q_{1,b,,t-1}, Q_{2,a,t-1} + Q_{2,b,t-1}, \mathbf{P}_{a,t-1}, ELE_{t-1}\right)}{\left(Q_{1,a,,t-1} + Q_{1,b,,t-1}\right) + \left(Q_{2,a,t-1} + Q_{2,b,,t-1}\right)} \quad .
\end{aligned}
$$

The percent change in average cost predicted to be associated with the scale effect of a merger is:

$$
PCAC = (AC_{a+b,t-1} - AC_{a,t-1})/AC_{a,t-1} \cdot 100 \tag{3.1}
$$

where $Q_{i,h,t-1}$, $i = 1,2$, $h = a,b$, is the the quantity of output i of bank h in year $t-1$, and $\mathbf{P}_{a,t-1}$ is the vector of input prices of bank a in year $t-1$. Hence $AC_{a,t-1}$ is the predicted average cost of bank a before the merger, and $AC_{a+b,t-1}$ is the predicted average cost of bank a assuming it–one year ahead of the actual merger–had reached the *joint size* of the two merging banks. In calculating both $AC_{a,t-1}$ and $AC_{a+b,t-1}$ we use the input price vector $\mathbf{P}_{a,t-1}$ and so disregard any effect on input prices from the merger due to increased market power or change in funding composition. Thus what we consider here is a pure economies of scale effect. $PCAC$ is calculated using each of the three cost function specifications, translog, Fourier, and spline. Negative values predict a reduction in average cost while positive values predict a rise.

Our data set contains usable data on 26 (out of 33) bank mergers that occurred over 1987-1998.[25] For these 26 mergers we calculate the predicted percent change in average cost for all merging banks as a group due to scale effects ($PCAC$) as described in equation (3.1). Our average results are reported in Table 3.1.[26]

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[25] As seven mergers occurred in the first year of the data set (1987), we are unable to predict

Table 3.1: Predicted cost effect from mergers (PCAC)

	Translog	Fourier	Spline
Pct. change AC ($PCAC$) $(AC_{a+b} - AC_a)/AC_a$	-0.16%	-2.06%	-3.09%
No. AC increase (+)	16	11	7
No. AC decrease (-)	10	15	19
Pct. change total cost	28.8%	26.3%	25.0%
Pct. change total loans	29.0%	29.0%	29.0%
Marginal scale economy	.99	.91	.86

The predicted percent change in weighted average cost (AC) due to scale effects from all 26 mergers together is shown in the first row (calculated from $(AC_{a+b,t-1} - AC_{a,t-1})/AC_{a,t-1}$. The number of negative (positive) changes indicate the number of bank mergers that are predicted to reduce (increase) average cost. Percent changes in total cost and total business and consumer loans refer to the sum of all 26 mergers. Dividing the former by the latter gives a marginal scale economy value that refers to the predicted overall merger effect.

As may be expected from the earlier almost L-shaped average cost curve in Figure 2.2 and scale economy values reported in Table 2.1 for the translog specification, only a slight reduction in average cost (-.16%) is predicted as a weighted average for all mergers in Table 3.1.[27] Out of 26 mergers, 10 are predicted to lower average cost. As the predicted change in total cost (28.8%) is slightly lower than the change in total business and consumer loans (29.0%), the scale economy effect of these mergers as a group is .99. On balance, use of the translog form suggests that mergers in Norway would yield something close to constant average cost with little benefit or cost for users of banking services.

In contrast, both the Fourier and spline functions suggest that mergers would generate larger reductions in average cost for all mergers together. The predicted reductions range from -2.06% (Fourier) to -3.09% (spline) with corresponding scale

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their cost effect one year prior to their merger.

[26]To reflect the different predicted total cost (TC) and output levels (Q) among merging banks, the weighted average cost in Table 3.1 is computed from a ratio of averages: $\frac{(\sum_{r=1}^{26} TC_{a+b,t-1,r}/\sum_{r=1}^{26} Q_{a+b,t-1,r}) - (\sum_{r=1}^{26} TC_{a,t-1,r}/\sum_{r=1}^{26} Q_{a,t-1,r})}{(\sum_{r=1}^{26} TC_{a,t-1,r}/\sum_{r=1}^{26} Q_{a,t-1,r})}$ where r refers to the merger number. A simple average of 26 average cost values (an average of ratios as in $\sum_{r=1}^{26}[(AC_{a+b,t-1,r} - AC_{a,t-1,r})/AC_{a,t-1,r}]/26$) would weight all merging banks equally even though their impact on industry cost is different.

[27]A simple average of the predicted percent changes in average cost for the 26 mergers suggests that these costs would rise (not fall) by 0.27% using the translog form.

Table 3.2: Predicted cost effect for 26 individual mergers

Pct. change total loans	0-10%	10-20%	20-50%	50-100%	>100%
	10	8	4	3	1

Percent	Frequency:		
	Translog	Fourier	Spline
6 to 11		1	
2 to 6	2	2	2
1 to 2	2	3	1
0 to 1	12	5	4
0 to -1	9	11	9
-1 to -2	1	2	5
-2 to -6			3
-6 to -11		2	2

economies of .91 and .86, respectively.[28] Here from 15 to 19 mergers are expected to reduce cost compared to only 10 with the translog. On balance, use of either the Fourier or the spline function predicts that mergers in Norway could benefit users of banking services.[29]

In large countries (such as the U.S.) the average banking merger increased the size of the acquiring bank by 50% or more (Berger and Humphrey (1992)). Thus the acquired bank accounts for one-third or more of the consolidated institution. Table 3.2 shows the size distribution of acquired banks in Norway in terms of their pre-merger expected change in loan output.[30] Fully 18 of the 26 mergers were comparatively small and were not expected to increase the size of the acquiring bank by more than 20%. Only 4 mergers increased the size of the acquiring bank by 50% or more. With so many relatively small mergers we would also expect that the predicted impact on individual banks' average cost would also be relatively small. The frequency distribution of the predicted percent change in average cost

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[28]Using simple averages suggests that average cost would rise by a miniscule 0.02% with the Fourier form but fall by 1.07% with the spline.

[29]Of course, lower average costs would be passed on to businesses and consumers only if the market is competitive. If so, users of banking services could expect to see marginally lower prices after a lag or to experience a smaller rise over time than would otherwise occur.

[30]This is from $[(Q_{1,a}+Q_{1,b}+Q_{2,a}+Q_{2,b})/(Q_{1,a}+Q_{2,a})]-1$ and represents the percent change in loan output expected from the merger if nothing else changes. The usual situation with a merger, however, is that a few borrowers switch banks while others may not have their loans renewed so the simple sum in the numerator here may overstate somewhat the actual change in loan output.

shown in Table 3.2 confirms this result. Indeed, out of 26 mergers, 21 (translog), 16 (Fourier), and 13 (spline) are predicted to change average cost–either up or down–by less than 1%. As small mergers will likely have relatively small effects on banking costs, our focus will be on the few bank mergers that are large for this is where the greatest impact on the banking industry and potentially on their customers will be.

4. Estimating Merger Cost Effects Ex Post.

One difficulty in estimating the actual cost effect of mergers lies in separating the effect of the merger from possible concurrent cost changes affecting the banking industry as a whole. Such concurrent changes include (cost push) effects from changes in interest rates and wages, effects from the shift to electronic payments, and (demand pull) effects due to changes in the business cycle that may affect productivity and alter costs per unit of output over longer periods of time. We approach this three ways, although each method has its own problems.

4.1. Comparing Pre- and Post-Merger Cost Effects for Individual Mergers.

We first look at how average cost at a merging bank has changed one year prior to and one year after their merger, excluding the merger year itself. Use of such a short period should minimize cost changes unrelated to mergers. The percent change in average cost for the merging bank is then compared to the percent change in average cost for the banking industry as a whole over the same three years. If average cost at a merging bank falls by 5% (say during a period when interest rates are falling) while average cost for the industry as a whole falls by 3% then it is presumed that actual average cost at the merging bank experienced a net reduction of 2% (actually, two percentage points). The assumption is that changes in costs experienced by the industry will also be experienced to an equal degree by the merging bank.

This procedure has been applied to each merger over the 8 different years that these mergers occurred. The frequency distribution of the estimated actual change in average cost is shown in Table 4.1, along with the frequency distributions of the predicted changes from the translog, Fourier and spline functions.[31] While the

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[31] As the range of the actual changes is larger than the range for the predicted changes, the

Table 4.1: Actual and predicted cost effects for 26 individual mergers

		Frequency:		
Percent	Actual	Translog	Fourier	Spline
15 to 20	1			
10 to 15	2			
5 to 10	4		1	
0 to 5	6	16	10	7
0 to -5	9	10	13	17
-5 to -10	3		2	1
-10 to -15	1			1
-15 to -20				

general presumption is that a merger will lower average cost or, at a minimum leave it unchanged, our estimated changes in actual average cost showed an equal split: rising in 13 cases and falling in 13. As well, there is considerably more dispersion in the estimated changes in actual average cost than in any of our scale effect prediction models.[32]

As seen, few of our predicted and actual merger-related changes in average cost are very large. This is because most mergers did not generate large changes in business and consumer loans. The extent of this skewed distribution is illustrated by the fact that the single largest merger (where loan output expanded by 126%) accounts for half of the merger-related change in the total value of business and consumer loans. Indeed, the three largest mergers (in absolute not percentage terms) account for three-quarters of total merger-related loan growth. In Table 4.2, we compare the predicted and actual changes in average cost from the six largest mergers, which collectively account for 87% of the merger-related change in loan output.[33]

Merger announcements, and materials presented to competition authorities in

intervals have been expanded to make the comparison clearer.

[32]Since it is possible that merger transition or adjustment expenses may have unduly affected this outcome, we re-ran the analysis computing the actual change in average cost pre- and post-merger using two years prior to and two years after the merger (again excluding the merger year) instead of using just a single year. Although this could not be done for 4 banks, for the remaining 22 the changes were minor and had little effect on the distribution shown in Table 4.1.

[33]This is close to the so-called "20-80 rule" where 20% of a sample often contributes 80% of a change associated with it. In our case, the largest six mergers comprise 23% of the sample and 87% of the change in loan output.

their defense, naturally emphasize the positive aspects expected to be associated with a merger. These concern expected cost savings, planned expansions in service mix, and the need to become larger to better serve domestic markets and/or address international competition. The estimated actual change in merger-related average cost (Table 4.2) indicates that five out of the six largest mergers apparently experienced a cost reduction. As the largest single merger accounts for half of all the merger-related changes in output, it is clear that the net effect of all six mergers was to reduce cost. Although these actual cost reductions may look small, recall (from the introduction) that a 5% decrease in unit cost, if passed on entirely to profits, can generate a 23% to 35% improvement in return on assets.

In terms of sign, the ability of the three cost functions to accurately predict the direction of change in average cost is as follows: 2 correct sign predictions out of 6 for the translog, 2 out of 6 for the Fourier, and 3 out of 6 for the spline.[34] Why not 6 correct predictions out of 6? Indeed, this would be nice but unlikely. As seen in Table 4.1, even the merging banks, which to our knowledge invariably predict that average cost will fall due to their merger, get it wrong half the time. This fact is well-known to banking consultants and has been elaborated on in a recent case study (Rhoades (1998)). In this application, our cost functions do no better for individual mergers. Unexpected events occur and throw off predictions. Drawing on the experience of banking mergers in other countries, unexpected outcomes – due to poor planning, back office integration difficulties, and a poor fit of management cultures – are common and make predictions regarding individual mergers difficult. We now look at the expected or average outcome of mergers relative to the actual average change in costs.

4.2. Comparing Average Pre- and Post-Merger Cost Effects.

The average predicted percent change in merger-related average cost for the three cost functions was shown at the top of Table 3.1 and were -0.16% (translog), -2.06%

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[34]We have not determined confidence intervals for our predictions and instead only contrast point estimates. This is consistent with how estimates of cost effects are announced by merger participants. If confidence intervals were to be formed, the difference between these announced estimates and what banks typically achieve would make for a large interval.

Table 4.2: Actual and predicted percent changes in average cost from the 6 largest mergers

Rank of loan change	Pct. change total loans	Actual	Percent Translog	change AC: Fourier	Spline
1	126%	-4.4%	1.3%	-6.8%	-10.8%
2	80	-4.0	3.7	-7.8	-8.7
3	13	15.6	2.2	-1.1	-1.7
4	98	-8.8	1.1	6.6	0.2
5	17	-0.5	-0.1	0.1	1.1
6	49	-1.6	0.8	4.6	-2.2

(Fourier), and -3.09% (spline).[35]   These predicted values are now compared with the pre- to post-merger change in actual average cost for all 26 merging banks as a weighted average, cf. equation (3.1).   In order to minimize the possible effect of merger adjustment costs, we used (i) pre-merger average costs for the 26 merging banks and (ii) pre-merger average costs for the entire banking industry for *each year* that data existed before each merger.   Similarly, post-merger average costs were computed for the 26 mergers and (separately) for the entire industry for all years after each merger.[36]   Largely due to lowered interest rates and cost reductions associated with the shift to electronic payments, average cost at all merging banks as a group fell by 43.6% pre- to post-merger while average cost at all banks fell by 40.8%.   Thus the net change in costs at all 26 merging banks for all years pre-merger to all years post-merger was -2.81%.[37]   This is the overall expected cost effect from Norwegian banking mergers and it agrees fairly well with the average predicted effect from either the Fourier or the spline functions.   Computing the change in actual cost over this longer period should reduce the influence (if any) of temporary merger

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[35] As noted above, this change was derived by comparing (i) the predicted average cost using the output level and prices of the acquiring bank (bank a) one year prior to its merger with (ii) the predicted average cost using the output level of acquiring and acquired bank (bank $a + b$) also one year prior to the merger.   Only the level of loan output is changed here as the input prices are those of the acquiring bank.   The cost effect associated with the on-going shift to electronic payments relates to the year prior to the merger.

[36] In all cases here, the year of the merger was excluded.

[37] This net decline (-43.57% minus -40.76%) is really a percentage point reduction and relates to average cost computed as a weighted average.   If we had used a simple average of individual average cost ratios–one for each merging bank as well as one for each bank in the industry–the net cost change for merging banks would have been -2.41% (from -40.54% minus -38.13%).

transition expenses and thus may represent an estimate closer to an "equilibrium" cost change.[38]

An alternative way to estimate the average effect of all mergers would be to specify a merger dummy variable (M) which is zero prior to a merger and 1.0 in the merger year and thereafter. If a second merger occurs for the same bank over 1987-1998, the dummy becomes 2.0 in the year the second merger occurs and thereafter, and so on if there is a third merger for the same bank.[39] Intercept and output slope dummy variables, $\theta M + \sum \theta_i M \ln Q_i$, are added to each of the three cost functions (2.1) to (2.3) and all were reestimated. The cost effect using this approach suggests that average costs have fallen, ranging from -2.13% to -8.15%. The dummy variable approach suggests that, on average, mergers have reduced banking costs but this estimate is larger than the average computed above (-2.81%).[40]

5. Cost Reductions from Greater Use of Electronic Payments.

It is not common to find that banking mergers in a country have lowered costs. Most merger studies, especially those in the U.S., have found on average that unit costs are unchanged, neither rising or falling significantly. This contrasts with results from still other studies which find that technical change – invariably indexed by a time dummy – contributes to lowering banking costs. During the 1960s and 1970s, technical change was focused on automating internal bank deposit and loan accounting procedures. During the 1980s and 1990s, technical change – in Europe generally and Norway in particular – is associated with a strong shift to lower cost electronic payments. An electronic payment using a debit card, a giro, or

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[38]However, it also means that there will be more external (e.g., interest rate, business cycle, electronic payment) influences affecting the costs of merging banks and the entire industry that may not be the same for each group.

[39]Out of 26 mergers, four banks had 2 mergers each while two banks had 3 mergers. The remaining 12 merger events were single mergers.

[40]We also experimented by specifying only three separate dummy intercept variables $\theta_p M_p$ ($p = 1, 2, 3$) for the first, second, or third consecutive mergers experienced in different years by some banks. The purpose was to see if we could possibly identify a "learning curve" where the reduction in average costs increased as the same bank undertook more than one merger. This was tried two ways but no learning effect was evident. In one case, M_1 contained zero elements pre-merger and 1.0 for the merger year and all years thereafter for the first merger. The same procedure was followed for M_2 and M_3 for second and third mergers, respectively. In a second case, elements in each M_p vector were 1.0 in the year the merger occurred and zero both pre- and post-merger otherwise.

an automated clearing house (ACH) credit or debit transfer can reduce a bank's payment cost per transaction by from one-half to two-thirds depending on how the instrument is used (for point-of-sale, bill payment, or disbursement) and whether or not users are separately notified prior to the (bill payment) transaction. This is because an electronic payment only costs a bank from one-third to one-half of what a corresponding paper-based non-cash payment would cost (Flatraaker and Robinson (1995); Humphrey, Kim, and Vale (2001)).

The share of the volume of electronic payment transactions in all non-cash payments in Norway (ELE) is a direct indicator of how rapidly payments have shifted to electronics. Electronic payments are often more convenient to use and, as well, banks charge a higher per transaction price for paper-based instruments (checks and paper giro payments). As payment data for each bank over time are not separately available, ELE refers to the share of electronic payments for all banks in each year. This variable enters each of the three cost functions as $\gamma_1 \ln ELE + \gamma_2 1/2 (\ln ELE)^2$ and was estimated earlier.[41]

The share of electronic payments rose from 15.6% of all non-cash payments in 1987 to 74.1% in 1998. These shares are shown for selected years in Table 5.1. To determine the change in average cost associated with the shift to electronic payments for the banking industry as a whole, we computed two values of predicted average cost. This applied to all banks (a weighted average) for each year over 1987-1998 using each of the previously estimated cost functions. One computed average cost for 1988, for example, uses the value of the share of electronic payments in 1988, along with loan output levels and input prices for 1988. Average cost is then recomputed with the only change being that the share of electronic payments for 1987 substitutes for that of 1988. As $ELE_t > ELE_{t-1}$ for all t, there is a steady shift to electronics each year. If the first computation using the 1988 value of ELE is less than the second computation using the (lower) 1987 ELE value, then costs are deemed to have fallen as a result of the shift to electronic payments. The results are reported in Table 5.1.[42]

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[41] Thus the earlier scale economy results and merger cost effects are independent of the cost effects associated with the on-going shift to electronic payments.

[42] Our results here were virtually identical for the translog, Fourier, and spline cost functions. The spine results are reported in the table. Since ELE steadily increases over time, this variable

While the share of electronic payments increases in each year, average cost does not always fall. As seen in Table 5.1, average cost for the banking system apparently rose by 5.4% in 1988 with greater electronic payments but fell in almost all other years. On average, for the industry as a whole unit costs are estimated to have fallen by 1.3% per year with the shift to electronic payments, or by 13% over the whole period.[43] In terms of industry impact, this cost reduction exceeds that for all 26 mergers. Thus policies that encourage electronic payments provide benefits that exceed those associated with mergers.

Table 5.1: Yearly change in average cost from shift to electronic payments

Year	Pct. share of electronic payments	Pct. change average cost
1988	18.8%	5.4%
1990	30.3	0.5
1992	43.1	-3.0
1994	54.0	-2.1
1996	63.3	-3.2
1998	74.1	-3.5
Average	44.9	-1.3

Negative (positive) values indicate that predicted average cost fell (rose) as a result of the change in the share of electronic payments one year to the next.

6. Summary and Conclusions.

Along with market competition, the effect of banking mergers on unit cost determines whether mergers are in the public interest. Merger participants predict the effect their merger will have on costs by careful, but often optimistic, analysis of proprietary internal data, yielding an estimate of labor and capital resources saved by combining operations. Banking consultants have developed "checklists" of where to look for merger cost savings and have a good idea about the values that can be saved in a successful merger. They also know that fewer than half of all mergers

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may also be reflecting other (unspecified and unknown) changes in costs.

[43] The reduction in total costs from the shift to electronic payments only really affects operating expenses. As operating expenses are approximately one-fourth of total costs, this implies that the change in payment technology has reduced bank operating cost by about 50%.

– due to poor planning, poor execution, management conflict, or other problems – do not experience significant cost reductions. Academics point to (selected) studies of bank scale economies which show that scale economies exist and suggest that expected merger cost savings may be similar to the average scale effect estimated. Our goal is to demonstrate an improved way to estimate bank scale economies and to develop more accurate predictions of expected merger cost effects.

Following the work of McAllister and McManus (1993), we demonstrate the importance of using a cost function specification that is more flexible than the translog form when estimating scale economies. Both a linear spline and a Fourier cost function provide a more accurate representation of how average cost varies by size of bank than does the translog form and thus improves the accuracy of predictions of the cost effect of mergers.[44] Using a balanced panel of 131 Norwegian banks over 12 years (1987-1998), the translog form effectively yields an L-shaped average cost curve while the linear spline and Fourier forms give an M-shaped curve. Instead of translog-determined scale economies for only smaller banks and constant average costs for only larger institutions, the spline and Fourier models show economies and diseconomies for both smaller and larger institutions. This occurs when total assets are used as a single measure of banking output as well as a two-output case using business and consumer loans. Although business loans have a higher marginal cost than consumer loans, they also have greater scale economies and thus a greater potential for unit cost reductions from a merger.

Using three cost functions, we computed the predicted change in average cost for each of 26 mergers. When bank a (the larger bank) acquires bank b to form the merged bank $a + b$, the predicted change in average cost equals the predicted average cost of a bank the size of bank a one year prior to its merger minus the predicted average cost of a bank the size of bank $a + b$ also one year prior to the merger. For all mergers together, the translog prediction is for average cost to fall slightly by -0.16% while larger cost reductions are predicted with the Fourier (-2.06%) and spline (-3.09%) models. The overall change in actual average cost for all years pre-merger to all years post-merger for our 26 merger events was -2.81%.

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[44]However, if one is only interested in the mean scale effect and not concerned with how costs vary with size, then any one of these three forms may be used since they all give almost identical mean scale economy values.

In contrast with other studies, bank mergers in Norway have – on average – resulted in lower costs.

In the U.S., the average acquired bank is half the size of the acquiring institution. In Norway, the average merger is smaller: in 18 of 26 mergers the acquired bank is less than one-fifth the size of the acquiring institution. Indeed, the distribution is quite skewed. One merger accounts for half of the total change in the value of loan output from mergers while the six largest mergers account for 87% of this change. For these six mergers, the accuracy of the direction of the our predicted change in average cost is less than one-half with the Fourier or spline functions. This sounds like a poor showing until it is compared to the accuracy of merger participants themselves. Merger participants almost always predict that their merger will reduce cost but ex post analyses typically find that this occurs in half or less than half of the cases. Overall, our ex ante cost predictions for individual mergers are about as good (or poor) as those of merger participants themselves. There is greater agreement when the average of predicted ex ante cost effects (-3.09% for the spline) are compared with the average of ex post changes (-2.81%). Thus the estimated expected value of the cost effect from a merger can play a useful role in assessing the likelihood that cost saving estimates by merger participants may be realized in a probabilistic sense. In this area, the spline and Fourier functions give more reliable results than the translog.

We also estimated how bank average cost has been affected by the on-going shift from expensive paper-based payment instruments (checks, paper giro transactions) to lower cost electronic payment substitutes (debit cards, electronic giro payments). This switch from paper to electronic payments has been substantial. The share of electronic payments in all non-cash transactions rose from 16% in 1987 to 74% in 1998. This shift is associated with a mean yearly reduction in all bank average cost of 1.3%, or -13% for the industry over our 12 year period. This cost reduction exceeds that for all 26 mergers and, in terms of consumer and bank benefits, policies that encourage electronic payments are preferred over those associated with mergers.

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