Essay 2.
Do Swedish Banks Enjoy Economies of Scale or Economies of Scope?

2.1 Introduction

A number of authors argue that universal banks[1] in the long run will have difficulties to maintain their profitability in the competition with specialised institutions with leaner cost levels.[2] Specialised institutions, that have been established after deregulations, are willing to offer more competitive interest rates than the universal banks. The argument refers mainly to the ongoing change on the liability side of banks' balance sheets, where the amount of core deposits that are paid low interest rates, are dwindling in the big universal banks, compared to the amount of purchased funds (e.g. Certificates of Deposits, CDs) and large-denomination deposits, that are paid money market interest rates.

The historically low levels of deposit interest rates prior to deregulation gave banks incentives to increase the delivery capacity in their organisations and branch networks as long as the marginal revenues from additional deposits were larger than the marginal costs for raising them. In the changing market conditions after deregulations, the previously high spreads on core deposits are not there any more to carry their part of the burden of extensive branch networks. - On the other hand, universal banks have the comparative advantage of offering a full range of diversified products and a bigger and safer image.

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[1] A 'universal' bank offers a full range of diversified products. The five big Swedish banks are all universal banks with a nation-wide coverage. Together they controlled some 86% of the overall industry assets in 1996.

[2] See Shaw (1990), Whitehead (1990), Abraham and Lierman (1991), Revell (1991), Conti and Maccarinelli (1992) and Walter (1997). See also contributions in Saunders and Walter (1996).

The questions on the long-run competitive viability of universal banks is closely related to the existence of economies of scale and economies of scope. A (multi-product) bank is competitively viable only if no other set of banks with other sizes and/or product mixes could jointly produce the same product mix at lower cost (adjusted for scale).

The current structural changes in the European and Swedish banking industries also raises questions concerning the competitive viability of individual banks. Some mergers and acquisitions seem to be driven by either explicit or implicit arguments referring to the cost structure of banking. One example can be the recent rush to merge banks in Sweden, where one often heard argument is that a larger scale of the banking operations should improve cost efficiency. Another example is the spread of new service delivery technologies like, e.g., internet banking, which have very strong cost advantages compared to traditional delivery channels. A third example is the argument that domestic banks will face increased international competition within the EMU and that they should not be forced to adapt in a reactive way, but preferably adapt in a "proactive" way by merging and thus cut costs. A fourth example is that the cost structure can be an important factor in seeking explanations to why domestic banks expand into new geographical markets. Several major Swedish banks have in recent years redefined their "domestic markets" to explicitly include the entire Baltic region.

Swedish banking has been operating with an increased spread between deposit and loan interest rates, see *Figure 1*. One relevant question to be asked is whether this increased spread can be explained by increased costs or if it has some other explanation. One important factor influencing both cost structures and revenue structures, is the de-regulation of the banking industry that took place in 1985, and which has been followed by a sequence of re-regulations. In order to investigate the effects of de- and re-regulations it is necessary to know the cost structure of the industry.

The de-regulation has given an increased role to competition in prices, which in turn implies that cost efficiency becomes a more important factor. Before de-regulations, competition in prices was subordinate to competition in service quality, which, e.g., caused a rapid increase of branch networks. On the other hand, reregulation has put an emphasis on capital adequacy ratios, which has influenced capital costs in Swedish banks, the extent of which we will seek to estimate in this study.

The purpose of this study is thus to investigate the presence of economies of scope and economies of scale in the major Swedish banks.[3] To my knowledge, no scientific analysis of economies of scale or economies of scope in Swedish banks has been done before.

2.1.1 Economies of Scale

Apart from general factors like spreading fixed costs over larger volumes, etc, there are a number of specific reasons why banks might be expected to show economies of scale. Firstly, a larger bank can diversify its assets, i.e. spread risks, which should lower the overall risk and diminish financial losses. Secondly, the processing of customer information, particularly the evaluation of customer creditworthiness, is sometimes considered to vary positively with bank size, which could lead to lower credit losses. Thirdly, a bank's image and reputation should normally be positively related to its size, which would imply a higher rating and lower funding costs regarding purchased funding.

In the many empirical studies in this field, statistically significant evidence of scale economies has been scant.[4] The general conclusion seems to be that the average cost curve is relatively flat, with some evidence of scale in-efficiencies for the largest banks, with total assets of more than 10 billion USD. However, the major Swedish banks have considerably bigger balance sheets than that, see *Table 1*. It is noticeable how close the four biggest banks are in terms of lending volumes and deposit volumes.

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[3] A finding of scale economies implies that smaller firms or entering firms that operate at a small scale have cost disadvantages compared to larger firms. The presence of economies of scope implies that firms that specialize in providing certain products but not others, have a cost disadvantage.

[4] See Clark (1996), who gives a brief review of the recent literature. The most comprehensive review is in Altunbas (1994), who also covers European studies. The results on European banking are inconclusive both regarding economies of scale and economies of scope. For the latter, only very few studies are reported (Altunbas 1994, ch 5.4).

	Swedbank	Förenings-banken	S-E-Banken	Handels-banken	Nord-banken
Lending	131410	55765	156010	160451	126964
Securities	70473	24190	169107	122262	73070
Total assets	280888	89259	461749	483138	289703
Deposits	144684	66593	148350	175827	167671
Issued liabilities	86195	6155	171944	215626	65768
Equity + subordinated debt	14725	5913	33920	20420	15182

Table 1. Balance sheet data for the five major Swedish banks (Parent companies) in SEK Millions at the end of 1996. "Securities" denotes lending to credit institutions and T-bills. "Issued liabilities" denotes liabilities to credit institutions and issued securities. Source: Annual reports. Further balance sheet data are in Table 3 - Table 7.

2.1.2 Economies of Scope

A universal bank offers a diversified range of products. The economic motives behind diversification might be explained by exploration of economies of scope either through the dispersion of fixed costs over an extended range of products, or through cost complementarities among the different products:

- A more efficient information processing. If a customer's qualities are known in the bank due to his habits regarding depositing funds, this will be an advantage in evaluating, e.g., creditworthiness, which can not only lower credit losses but also lower marketing costs, i.e. through cross-selling new products to the same customer.
- A more efficient use of fixed resources such as branch networks and IT systems.
- A diversification of market risks, i.e. a lower economic risk.

- A diversification of product lines into such products that carry no, or lower, capital adequacy requirements, e.g., off-balance sheet products, thereby lowering economic costs.
- A diversification of financial risks, i.e. interest rate risk, liquidity risk and leverage risk. Financial risks are concentrated in a central treasury department where they can be diversified and optimised through, e.g., maturity matching, see Essay 3.

Economies of scope can also originate on the revenue-side, since consumer synergies can be exploited through increased revenues. In banking, customers can reduce their transaction, transportation, and search costs by utilising the same system for different products, e.g. a universal account with different attached products. See Berger, Humphrey and Pulley (1996) for a study of revenue-side economies of scope. In this study we will disregard revenue-side economies of scope.

Generally speaking, there is little evidence in the literature for the empirical existence of economies of scope in banking, see Clark (1996) and Pulley and Humphrey (1993) for reviews of recent studies.

2.2.1 Definitions and methodological issues[5]

The banking firm is assumed to decide its output and input quantities according to a given production technology and given input prices. Its short-run cost-minimisation problem can then be formulated as:

$$\text{Minimise } \mathbf{w}^{t}\,\mathbf{x}$$
$$\text{s.t. } T\,(\mathbf{q}, \mathbf{x}) = 0$$

where **x** and **w** are vectors of variable input quantities and prices, T is the production technology as specified by the transformation function $T\,(\mathbf{q}, \mathbf{x})$, and **q** is the output bundle. The optimal solution, assuming cost minimisation and competitive input markets, implicates that the profit-maximising output can be treated as exogenous, and yields the dual variable cost function:

[5] The definitions on scale and scope economies used in this section are from Baumol, Panzar and Willig (1982).

$$C = \Sigma w_j x_j = C(\mathbf{w}, \mathbf{q})$$

Product-specific economies of scope in a multi-product firm measures the relative increase in cost if the output vector **q** were produced in two groups, U and $N - U$,

$$SCOPE_U = \frac{C(\mathbf{q}_U) + C(\mathbf{q}_{N-U}) - C(\mathbf{q})}{C(\mathbf{q})}$$

where $\mathbf{q}_U$ is the output vector[6] with a zero component in place of q_i for all $i \notin U$ and $\mathbf{q}_{N-U}$ is the vector with a zero component in place of q_i for all $i \in U$, and where $SCOPE_U > 0$ (<0) when we have positive (negative) economies of scope (Baumol *et al* (1982), Definition 4B2).[7] Global economies of scope are measured consequently, and for the three-output vector employed in this study it is defines as:

$$SCOPE_G = \frac{C(q_1,0,0) + C(0,q_2,0) + C(0,0,q_3) - C(\mathbf{q})}{C(\mathbf{q})},$$

where $SCOPE_G > 0$ (<0) when we have positive (negative) economies of scope.[8]

The analogue to the concept of average cost in a single-product firm, is ray average cost in a multi-product firm. Ray average cost is the average cost of a proportionate increase in all outputs. Increasing returns to scale at **q** implies decreasing ray average costs at **q**. The de-

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[6] The cost function is written C (**q**) for convenience, where the input price vector is suppressed.

[7] Economies of scope is a special case of cost subadditivity where the output vectors of specialised firms ($\mathbf{q}_i$) are restricted to be orthogonal. A subadditive cost function means that the firm or the industry is a natural monopoly, i.e. the output bundle can be produced at a lower cost by a single firm than by any combination of smaller firms. Subadditivity is defined as $\sum_i C(\mathbf{q}_i) > C(\mathbf{q})$ where $\sum_i \mathbf{q}_i = \mathbf{q}$. It does not require the firm to be specialised.

[8] As an additional (local) test of economies of scope, one can also utilise the pairwise cost complementarities derived by Baumol *et al.* (1982). A sufficient condition for the existence of economies of scope at output **q*** is for C(**q**) to have weak cost complementarities between *each* pair of outputs at *all* output vectors **q** up to **q***: $\partial^2 C(\hat{\mathbf{q}})/\partial \hat{q}_i \partial \hat{q}_j \leq 0; i \neq j; \forall \hat{\mathbf{q}}$ such that $\mathbf{0} \leq \hat{\mathbf{q}} \leq \mathbf{q}^*$, with strict inequality for some subset of outputs.

gree of multi-product overall scale economies defined over the entire product set is given by (Baumol *et al*, 1982):

$$SCALE_G(\mathbf{q}) = \frac{C(\mathbf{q})}{\mathbf{q}} \nabla C(\mathbf{q}) = \frac{C(\mathbf{q})}{\sum q_i C_i(\mathbf{q})}, \text{ where } C_i(\mathbf{q}) \equiv \frac{\partial C(\mathbf{q})}{\partial q_i} \text{ and}$$

$\nabla C(\mathbf{q}) \equiv (C_1(\mathbf{q}),\ldots,C_n(\mathbf{q}))$ is the gradient of C(**q**).

Returns to scale are increasing (decreasing) when $SCALE_G$ (**q**) > 1 (<1). The degree of scale economies specific to product set U is defined as:

$$SCALE_U(\mathbf{q}) = \frac{AIC_U(\mathbf{q})}{C_U(\mathbf{q})} = \frac{(C(\mathbf{q}) - C(\mathbf{q}_{N-U}))}{\mathbf{q}_U C_U(\mathbf{q})},$$

where AIC_U is the average incremental cost of product set *U*. Product-specific scale economies are increasing (decreasing) when $SCALE_U$ > 1 (<1).

There are serious methodological difficulties involved in the estimation of economies of scope. The typical approach has been to apply a translog cost function.[9] According to Berger, Hanweck, and Humphrey (1987), the traditional studies on economies of scope have "often been incomplete, potentially inappropriate, or subject to unknown extrapolation error". These problems arise because of problems inherent in the translog function, specifically its inability to admit zero values of any output in estimation or prediction, whilst zero value outputs are constitutional in the definition of scope above. There are several studies demonstrating the inability of the translog function to correctly capture the economies of scope in comparison with alternative functional forms.[10]

Published estimates of economies of scope have also varied greatly. Pulley and Braunstein (1992, p 229) state: "Since most of the published studies have used the translog or generalized translog model,

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[9] According to Pulley and Humphrey (1993), the multi-product translog cost function and its variants was the only functional form used in studies of banks. Their article comprises a methodological survey of contemporary cost studies in banking. There are only a few later studies utilising the alternative forms of cost functions proposed by Pulley and Braunstein (1992), such as the composite form, which is used in this study. Altunbas (1994) gives a full review of cost studies.

[10] See Pulley and Humphrey (1993), McKillop *et al.* (1996), and McAllister and McManus (1993).

this result is not surprising." As an alternative to the translog function, they propose a "composite" cost function, which is nested in a "general" cost function together with the translog, the generalised translog, and the separable quadratic cost functions. The composite function combines a quadratic structure for multiple outputs with a log-quadratic input price structure, which enters the cost function multiplicatively:

$$C = \left(\alpha_0 + \sum_{s=1}^{r} \rho_s D_s + \sum_{i=1}^{n} \alpha_i q_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_{ij} q_i q_j + \sum_{i=1}^{n} \sum_{k=1}^{m} \delta_{ik} q_i \ln w_k \right) * \\ * \exp \left(\sum_{k=1}^{m} \beta_k \ln w_k + \frac{1}{2} \sum_{k=1}^{m} \sum_{l=1}^{m} \beta_{kl} \ln w_k \ln w_l \right), \qquad (1)$$

where i and j are output indices for the n outputs, k and l are input indices for the m inputs, s is the index for the r banks, D is a dummy variable that allows for different banks to have individual intercepts.[11]

Symmetry requires that $\alpha_{ij} = \alpha_{ji}$ for all i and j, and $\beta_{kl} = \beta_{lk}$ for all k and l. The following homogeneity restrictions must be imposed on the cost function in order to get linear homogeneity in the input prices:

$$\sum_{k=1}^{m} \beta_k = 1; \quad \sum_{l=1}^{m} \beta_{kl} = 0, \forall k; \quad \sum_{k=1}^{m} \delta_{ik} = 0, \forall i.$$

The cost function can be estimated by ordinary least squares subject to the restrictions implied by linear homogeneity in input prices. However, according to the standard methodology utilised in most empirical studies, an increase in efficiency in the estimates of the parameters can be achieved if the cost function is estimated jointly with cost share equations, since the inclusion of the cost share equations adds no new parameters but gives additional cross-equation restric-

[11] Pulley and Braunstein (1992) also propose a logarithmic version of (1), and a joint formulation for both versions in terms of a "transform-both-sides" Box-Cox transformation. McKillop *et al.* (1996) estimate different values of the Box-Cox transformation parameter, but in the end set it equal to 1, in order to ensure a better satisfaction of regularity conditions, thus reducing their cost function to (1). Also Noulas *et al.* (1993) set their Box-Cox transformation parameter equal to 1 for the same reason while estimating a generalised translog model. Also in this study the parameter had to be set to 1 due to problems of non-convergence during estimation, see further section 2.5.

tions. Furthermore, the composite cost function, as well as the common translog cost function, creates a large number of explanatory variables even for a modest number of inputs and outputs. Therefore, multicollinearity among the explanatory variables becomes a less serious problem when the cost equation is restricted to be linearly homogeneous.

The coefficients of a system of regression equations will be estimated, comprising the cost function and $(m-1)$ cost input share equations. The effects of variations across banks are reflected in the stochastic disturbance term of each equation. These disturbances are assumed to possess all properties in the classical linear regression model; in addition it is possible also to allow for the disturbances to be correlated across equations. In this way a system of seemingly unrelated regression (*SUR*) equations is generated (Parikh and Bailey, 1990), where the cost function and cost share equations are estimated as a multivariate regression system. The inclusion of the cost share equations in the estimation procedure has the effect of adding various additional degrees of freedom without adding any unrestricted regression coefficients. This yields more efficient parameter estimates than the single equation estimates obtained by using the cost function alone (Zellner, 1962).

Factor share equations for the *m* inputs are obtained by differentiating the composite cost function with respect to input prices, and using Shephard's lemma:

$$S_k = \left(\alpha_0 + \sum_{s=1}^{r} \beta_s D_s + \sum_{i=1}^{n} \alpha_i q_i + \frac{1}{2} \sum_{i=1}^{n} \sum_{j=1}^{n} \alpha_{ij} q_i q_j + \sum_{i=1}^{n} \sum_{k=1}^{m} \delta_{ik} q_i \ln w_k \right)^{-1} *$$

$$\sum_{i=1}^{n} \delta_{ik} q_i + \beta_k + \sum_{l}^{m} \beta_{kl} \ln w_l$$

where S_k is the share of factor costs for input k of total costs C. After attaching the share equations to C, the full dual system is estimated. The cost function and the input cost share equations are assumed to have additive disturbance terms. Since the input cost share equations are generated by differentiation, they do not contain the disturbance term from the cost function. Hence the disturbance terms are assumed to come from a joint normal distribution with non-zero correlation for a particular bank, but impose zero correlations across different banks. The estimated covariance matrix of disturbances required to implement the iterative seemingly unrelated regression technique (*SUR*) is singular because the disturbances on the share equation must sum to zero for each firm. One of the share equations is omitted at the estimation since the system of share equations is singular because of the adding-up constraint, $\Sigma S_k = 1$.

Pulley and Braunstein (1992) apply the composite cost function in a study of the US banking industry, and demonstrate its superiority over the other specifications.[12] The advantages of it are that the composite cost function, in comparison to cost functions which are multiplicatively separable in outputs and input prices, does not require input demands to co-vary with outputs. The composite model accordingly does not require input ratios and cost shares to be independent of output level and, consequently, it does not impose input demand elasticities with respect to each output to be equal and independent of input prices. Its log-quadratic input price structure is easily restricted to be linearly homogeneous.

For an estimated cost function to adequately represent the underlying technology, it must fulfill some "regularity conditions" (Lau, 1986): it must be concave in the input prices and monotonically non-decreasing in input prices and outputs. Concativity, (the input price regularity condition) is satisfied if the Hessian of input prices based on the parameter estimates is negative semi-definite. Monotonicity (the output regularity condition) is satisfied if the estimated cost shares are positive and marginal costs of outputs are positive. When estimating economies of scope, Noulas *et al.* (1993) contend that these regularity conditions for the cost function should hold not only at the point of estimation, but also at the points of evaluation, since scope estimates necessitate the evaluation of the estimated cost function at zero outputs, i.e. far away from the region of original estimation.

[12] Other empirical applications of the composite function are in Clark (1996) and in McKillop et al. (1996). The latter study also demonstrate the superiority of the composite cost function over three other functional forms: the translog, the generalised translog and the separable quadratic forms.

2.2.2 The Input and Output Variables and the Data

The Riksbank (the Swedish central bank) collects balance sheet data and interest rate data from all Swedish banks on a quarterly basis.[13] Data were collected from 1989:1, and the last observation used here is from 1997:2.[14] Each bank reports balance sheet stocks and interest rates for three categories of customers: Corporate customers (excluding financial corporations), households (including entrepreneurs with one-person businesses), and other customers (includes municipalities). Each customer category has the following types of accounts:

Loans:[15]	Fixed amount loans
	Credit lines
	Overnight loans (<3 days)
Deposits:	Savings deposits accounts

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[13] The data are published only as market averages for the five biggest banks. However, individual bank data have been made available for this study by the Riksbank, on the condition that the identity of individual banks must remain concealed. The order of banks discussed in section 2.2 is *not* the same as the order in *Table 1*.

[14] The data comprises only accounts denominated in the domestic currency, since there are no data collected on interest rates on foreign currency denominated balance sheet items. Foreign currency items to the largest part reflect wholesale banking activities. They typically have small spreads and low operating costs compared to the banks' other activities. Their omission gives an upward bias to the estimated cost levels from the cost data of "other operating costs". This bias is largest for S-E-Banken and Handelsbanken, see *Table 3 – Table 7* where total assets in domestic and foreign currencies are reported for each bank.

Another source of bias in the cost function is the omission of off-balance sheet activities as an output, due to lack of data. This bias affects only labour costs and other operating costs, whereas funding costs are calculated net of any off-balance charges.

[15] Interest rate data on deposits started to be collected in the first quarter of 1989 by the Riksbank, which is therefore a natural starting date for this analysis. On the loan side, adversely rated credits, repurchase agreements, and internal credits within a banking group are not part of the data set, as compiled by the Riksbank. This refers both to the balance sheet data and the interest rate data. All banks are required to deduct the amount of non-performing loans and loans subject to interest concessions or interest deferments. The loan portfolio is thus reported on a net basis, i.e. after subtracting provisions for expected loan losses. Therefore, both the interest rate data and the balance sheet data used in this analysis are already corrected for the effects of non-performing credits on the remaining loan stock after deduction of losses.

Transactions deposits accounts
Other deposit accounts
Overnight deposits accounts

Out of these, the "overnight loans" and the "overnight deposits accounts" will be excluded from the subsequent analysis, since they are small in comparison to the other types (<2% of the overall balance) and also heavily biased towards two of the banks. In order to keep the number of parameters in the estimation down, also "other deposit accounts" are excluded since *i.)* they are small in comparison to the other types (ca 10%), and *ii.)* they yield interest close to the inter-bank rates, which indicates that they are large-denomination deposits carrying small operating costs. Furthermore, due to the small number of observations, it was necessary also to aggregate Loans and Credit lines, and Savings deposits and Transactions deposits. After these initial aggregations, there are the following five outputs:[16] 1. Loans to corporate customers; 2. Loans to households; 3. Deposits from corporate customers; 4. Deposits from households; 5. Securities and other earning assets.[17] However, further aggregation of the output vector is necessary, for reasons explained below.

Without exception, published bank cost studies hypothesise that there is a common technology in the banking industry, which leads to

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[16] There is a large debate among bank researchers on how to define banking inputs and outputs, see e.g. the papers and discussions in Griliches (1992). The main issue of this debate is the nature of deposits. It has sometimes been defined only as an input (the "asset" or "intermediation" approach), sometimes only as an output (the "production" approach), sometimes as either input or output (the "user cost" approach), and sometimes as both (the "value-added" approach). Based on the banking model established in Essay 3, we here adhere to the value-added approach. This is also the approach taken in recent bank cost studies like Pulley and Braunstein (1992), Pulley and Humphrey (1993) and Clark (1996). Hence the two deposit categories enter both as outputs (measured as balance sheet stock amounts) and as inputs (measured as interest cost flows in the profit and loss statement).

[17] Even though securities give rise to very low operating costs compared to other assets, they are included as a separate output for the following reasons: *i.* they constitute a considerable part of total assets, see *Table 1*. Since the entire liability side is part of the cost function as inputs, all assets should also be accounted for as outputs; *ii.* they contribute substantially to banks' earnings; *iii.* they have a critical role in managing financial risks which means that they can be expected to have some impact on economic costs, i.e. opportunity costs for equity capital.

pooling of data sets across banks. However, the hypothesis of a common technology is never tested for. In the current study there are only five banks, that differ substantially in sizes – from less than 10 per cent market share to 25 per cent market shares – as well as in cost levels – from about 1.5 to about 3.2 per cent, defined as operating costs./.total assets. These differences alone should make the common technology hypothesis questionable.[18] Furthermore, calculating a correlation matrix between all variables on a bank-by-bank basis, reveals that there are fundamental differences among the banks, particularly in correlation between output levels and costs. Specifically, there are negative correlations between the total cost and one or more of the five outputs in each bank, although this refers to different outputs in different banks, see the upper half of *Table 2*. On the other hand, correlations between input prices and costs are more conform across banks.

	TC bank 1	TC bank 2	TC bank 3	TC bank 4	TC bank 5
Corporate deposits	0,20	0,074	0,26	0,16	0,30
Corporate loans	0,46	-0,39	0,23	-0,074	0,095
Househ.deposits	-0,11	-0,063	-0,16	-0,067	0,23
Household loans	-0,036	-0,032	-0,015	0,31	0,27
Loans (q_1)	0,36	-0,31	0,16	0,27	0,24
Deposits (q_2)	-0,20	-0,14	-0,056	-0,013	0,27
Securities (q_3)	0,22	0,23	0,24	0,35	0,27
Labour costs (w_1)	-0,011	0,13	0,18	0,34	0,21
Other op costs (w_2)	0,29	0,23	0,10	0,25	-0,026
Funding costs (w_3)	0,83	0,88	0,85	0,83	0,87

Table 2. Correlation matrix for the individual banks' total costs, their outputs and individually calculated input price levels. Greyed entries diverge in sign compared to other entries in the same row and thus indicate a potential problem to use pooled data.

Based on these correlations, we should expect problems in estimating a five-output, three-input model with pooled data. On the other

[18] It is important to note that there is an underlying assumption of a single cost structure not only between banks, but also within each output category. E.g., different types of loans typically differ in loan sizes and costs incurred per SEK lent. A smaller bank with smaller average loan sizes might have higher costs per SEK lent.

hand, aggregating the outputs into one loan category and one deposit category shows more stable correlations across banks, see the lower half of *Table 2*, and thus conforms better with the common technology hypothesis. This aggregation also comes naturally when the issue is testing for economies of scope between loans and deposits. The final output vector qi thus comprises: *q1*: Loans; *q2*: Deposits; *q3*: Securities.

Regarding costs for inputs, banks typically report their operating costs aggregated over all outputs in annual and quarterly reports.[19] On the other hand, specifications are given regarding how big are labour costs, costs for premises, and other operating costs, including loan losses. Based on the available quarterly data, the input price vector w_k hence comprises the following three inputs: Labour costs; Other operating costs; and Weighted Average Cost of Funds, including interest costs and equity capital opportunity costs.

A. *Labour costs* (w_1) are calculated as total staff costs per the average number of full time employees during the quarter. Since only staff costs but not the number of employees is reported in the quarterly reports, I have smoothed the latter from the figure on yearly average number of employees given in the annual reports. It is likely that the average number of full-time employees would change in a smooth fashion over time given internal frictions and labour market frictions. This is also evidenced by the yearly figures, which change smoothly over time in each bank.

B. *Other operating costs* (w_2) comprises all operating costs except staff costs: Rents, marketing costs, depreciation allowances and write-down of tangible and intangible fixed assets, IT costs, etc. They are calculated as reported in quarterly reports, per the sum of loans and deposits.[20] An additional component of other operat-

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[19] All the five big "banks" in Sweden analysed here constitute a parent company which is part of a bank group. All data used here are from the parent company, which embodies the traditional core banking operations. The bank group in each of the five banks comprises, among other things, the parent holding company, a mortgage loan company, a leasing company, a card company, etc. For the years 1989-1991 there were tertiary reports instead of quarterly reports. Quarterly data for bank operating costs have been constructed as weighted averages of the tertiary data.

[20] Most bank cost studies relate other costs to the book value of the amount of fixed assets. This is problematic not only because book values might not always

ing costs is the calculated level of expected credit risk, or the "normal" level of lending losses, i.e. the average rate that the bank includes in its pricing decisions on loans. This is further discussed in the following section.

C. *Weighted Average Cost of Funds (WACF or w_3)*, comprising:[21]

1. *Deposit interest costs* are aggregated from the reported *savings deposit interest costs* and *transactions deposits interest costs*. Each bank reports the current interest rate in percent on each account on the last day of each quarter. Thereafter, the interest rates are weighted according to the balance on each account.[22]

2. *Interest for purchased funds*. These comprise yield paid on certificates of deposits and other short-term funding costs. The Stockholm interbank interest rate (STIBOR) is used.

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reflect the "true" activity-related economic levels due to accounting rules, but also since fixed assets might be owned by the parent holding company or some property company within the banking group (this seems to be the case in several Swedish banks). In order to facilitate comparisons across banks, I therefore choose to relate other costs to the sum of the outputs.

[21] Data on most balance sheet items are from Statistics Sweden, *Bankerna* (for the commercial banks) and *Kreditmarknaden I* (for aggregated savings banks and aggregated cooperative banks), for March 1989 - September 1993 and from *Bankernas tillgångar och skulder* (K18SM), for December 1993 - December 1995. From March 1996 there is no printed source for these data, but they are available on magnetic media (*TSDB*). These are all monthly statistics, although only quarterly data could be used in this study since quarterly data had to be used for operating costs and interest rates. Deposit volumes are from the Riksbank data set. The official data have been complemented by figures from annual reports as noted under the tables for each of the banks, see *Table 3 – Table 7*. This refers specifically to data on equity and other liabilities. These are commingled in the SCB reports for the period 89:1 – 93:3, so that untaxed reserves are reported as other liabilities, and reported as part of equity only from 94:1. The data on the level of, and interest paid for, "other liabilities" is generally unreliable in the official statistics since they are not cleared of repurchase agreements. When available, I have instead used the yearly averages, as disclosed in banks' annual reports, "footnote 1". Further details on the balance sheet data are found in the comments accompanying each of the tables in *Table 3 – Table 7*.

[22] For the period 89:1 – 92:3 the different categories of deposit interest rates were recorded as a quarterly average of paid out and credited interest, minus withdrawal fees, divided with the sum of deposits in the Riksbank data set. The change of method from 92:4 appears to be uncritical.

3. *Interest for other liabilities.* Other liabilities are bank giro orders, tax liabilities, securities settlement proceeds, cashier's cheques, and "other other" liabilities.[23]
4. *Long-term funding interest costs.* These comprise interest on bonds and on subordinated debt. The interest used for all banks is the monthly interest rate for 5-year Caisse bonds reported in the Statistical yearbook from the Riksbank.[24]
5. *Equity capital opportunity cost.* One necessary input in banking is equity capital. Thus, economic costs includes not only the explicit costs of inputs needed to produce the outputs, but also the implicit cost, or opportunity cost, of investment capital. The riskiness of the banking business as such is reflected in risk premia of the different debt and equity funding instruments issued by banks. This is further discussed in section 2.2.4.

Together, the interest costs and the opportunity cost of capital are calculated as a weighted average cost of funds (w_3), where the interest paid on each type of funding is weighted according to its weight in total funding:

[23] When available, the reported figures are daily averages, i.e. annual averages of each item day-by-day as disclosed in the respective annual reports' "footnote 1". In this case the same amount is shown in *Table 3 – Table 7* for each quarter in the year. Also the interest paid is reported in "footnote 1" of each bank's annual report, so that the average interest rate can be calculated. Only when these daily averages are not available due to varying reporting practices, the quarterly figures have been taken from the above mentioned official statistics from SCB (these are rather erratic and have thus been deemed of lower quality than the annual reports' daily averages). From 1995, other liabilities also include sold, but not delivered securities and derivatives. The latter is the largest item, in general. In 1996 a major change was undertaken in the accounting principles, as given by the Financial Supervisory Authority, and the daily averages are since then reported only by Nordbanken and Swedbank.

[24] There are no consistent data series reported on other maturities than the 5-year bonds. There are secondary market interest rates on individual bonds and debentures reported from the Stockholm Bond Exchange (SOX), but the differentials between different issuers and different loan id's are very small, typically less than 0.1 percentage points, which is negligible in this context. For this reason, and also because of methodological difficulties to compile consistent bank data series from the different SOX bond prices, these data have not been used.

$$WACF = \sum \frac{D_i}{TF} r_{D_i} + \sum \frac{SF}{TF} r_{SF} + \sum \frac{LF}{TF} r_{LF} + \sum \frac{OL}{TF} r_{OL} + \frac{EC.alloc}{TF} r_{EC}$$

where D_i is deposit of type *i*, *TF* is total funds, *SF* is short-term purchased funds, *LF* is long-term funds (bonds and subordinated debt), *OL* is other liabilities, *EC.alloc* is the equity capital allocated to domestic, on-balance sheet operations, and r_{index} are the respective interest rates paid on the different types of funding, as specified above. *WACF* is thus unique for each bank. The method to calculate the weighted average cost of funds is the same as in Clark (1996) and is a prevailing management method in banking, see, e.g., Matten (1996) or Hempel *et al.* (1999, ch 8).[25]

2.2.3 The expected loan losses as an operating cost

Credit risk manifested as loan losses is a normal feature of banking. In reference to the internal cost accounting in banks, this means that there is an expected level of losses which is priced into the loan products, and/or other products, cf. Matten (1996). This risk level is unique for each bank, and for each loan product marketed. Analytically it forms part of the operating costs for loans, since it has nothing to do with the amount of equity that the bank holds. Expected losses are thus separated from unexpected losses, i.e. the *mean* of the bank's operating costs is influenced through expected losses, whereas the *variance* of the bank's costs is influenced by the unexpected losses and is covered by the amount of equity held.[26]

A specific problem with the accounting of the operating cost of loan losses occurs in periods of banking crisis, due to the deteriorating

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[25] *WACF* is conceptually the same as the the more well-known concept weighted average cost of capital (*WACC*, see, e.g., Copeland and Weston (1992)), i.e. the weighted average of the debt and equity costs of capital, although I prefer to use *WACF* in the banking context, since deposits should not be conceptually mixed with capital.

[26] From an accounting point of view, actual and possible lending losses are charged to operating profit. Recoveries reduce these losses. Provisions for lending losses are reported as a reserve for possible lending losses. Withdrawals are made from the reserve for possible lending losses when receivables are sold at a loss or permanently written down, or upon recovery of losses.

quality of the loan portfolio, such as in Sweden 1990/91 - 1993.[27] The question is in which way such a banking crisis will influence the cost structure of the bank, specifically regarding what distinctions must be made between operating costs and equity costs. This question is addressed in three parts: loan losses before the crisis, loan losses during the crisis, and loan losses after containment of the crisis.

The expected level of loan losses before the crisis. The inherent riskiness of the banking business as such is something that is reflected in the equity costs. Therefore, if the banking crisis arrives "unannounced", like the Swedish banking crisis, there is no reason that banks *ex ante* should raise their expected operating cost of loan losses and consequently raise their prices on loans and other products. The only data available to calculate the level of expected loan losses are the actual *ex post* losses. Therefore, as an approximate estimate, the average level of loan losses as a percentage of loan assets in the years before the crisis (1982 - 1989) have been calculated and are included as part of other operating costs. This level will henceforth be called the "normalised expected loan losses". It is unique for each bank, but assumed constant the sampling period.

The expected level of loan losses during the crisis. During the banking crisis there is some uncertainty regarding the scale and scope of the crisis and thus the expected credit risk level in the existing stock of loans increases. On the other hand, the existing loan agreements are not readily renegotiable and variable interest rate loans are linked to money market interest rates, which are unlikely to reflect credit risks. Instead of renegotiating existing agreements, banks can cancel them and offer new loan facilities only to low-risk customers. This seems to have been the practice of Swedish banks, which were actively cancelling previous loan committments during the crisis, due to a rising level of prudence, thus creating a "credit crunch".[28] Banks

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[27] The issue of when the banking crisis started and ended is cumbersome, see Pettersson (1993). Although loan losses increased heavily from 1990:4, the stock market clearly did not realise that there was a banking crisis until mid 1991, since it was only then that the bank stock market index (AFBA) dissociated itself from the general stock market index (AFGX). The end of the banking crisis can be set to the end of 1993, when AFBA returned to the pre-crisis levels. Banks also started to report positive net incomes from early 1994.

[28] See Larsson and Sjögren (1995, ch 6) and Sveriges Riksbank, *Quarterly Review* 1993:2.

could therefore be expected to be even more prudent during the crisis in providing loans, and to grant new loans only to "risk-free" customers. This is a practice which is likely to be supported by supervisory authorities. For this reason, the calculated normalised expected loan losses is defined as the cost of expected credit risks on individual loan facilities also during the crisis and included as a part of other operating costs. The increase in the perceived riskiness of the banking business *per se* during the crisis, as reflected in persistingly increased risk premia on debt or equity issued by banks, is defined as part of equity costs, see section 2.2.4.

The expected level of loan losses after containment of the crisis. Once the depth of the crisis is established and the risks connected with the crisis are contained, accrued losses are to be regarded as sunk costs and are written off from the equity capital. The level of prudence in granting new loans should *a priori* be higher than before the crisis, for which reason the normalised level of expected loan losses is defined as the relevant norm to include in the operating costs. Inasmuch as the riskiness inherent in the banking business as such has risen, it will, again, be reflected in rising equity costs.

2.2.4 Risk premia for doing banking as an equity cost

Opportunity costs for equity capital are important to include in the cost function not only because they are an integral part of the economic theory on optimal resource allocation within firms. They are important also because of their inherent feature of reflecting varying risks between banks, and over time. Specifically, they take away a possible source of bias as far as asset portfolios, mainly loans, are concerned, since heterogeneities in loan quality between banks will be reflected in the stock market valuations of bank shares. Banks can easily lower their production costs by more risk-taking behaviour, such as quickly expanding their loan portfolio without increasing monitoring, etc. What appears to be improved production cost efficiency should then be offset by an increase in risk, that increases economic costs. These considerations have not only theoretical relevance, but are moreover of specific relevance to this study, which also covers years during which a profound credit-risk related banking crisis took place. Finally, opportunity costs of equity are comparable in size compared to other major funding cost components, see *Fig 5*.

The financial markets and the banks' owners will require compensation for the inherent riskiness of the banking business itself, covering various financial risks and non-financial risks. There are several ways of estimating risk premia implemented in the literature on bank cost structures. [29] In a *CAPM* setting, which is an asset pricing model, the way to measure the risk premium for investors in bank equity, r, would be to evaluate a total opportunity cost of equity capital in percentage terms, $r_f + \overline{\beta}_i(r_M - r_f)$, where $\overline{\beta}_i$ is the stock market beta for the bank's stock, r_f is the risk-free market return of the same duration as the bank's stock and r_M is the return to the aggregate market portfolio of stocks.

Here we will apply a *long*-term perspective, assuming that investors in bank equity consider the long-term equity risk premium to be the relevant measure, and applying the method proposed by Ibbotson and Sinquefield (1989, ch 9) to estimate the cost of capital with the Sharpe-Lintner *CAPM* model.[30] The method involves using a long-term government bond yield as r_f and then calculating the (arithmetic mean of the) excess of total equity returns over r_f as the long-horizon equity risk premium.

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[29] The only empirical bank researcher to date to include the opportunity cost for deploying equity capital in the cost specification is Clark (1996), who applies the *CAPM* model in a study of US banking. An alternative approach is used by McAllister and McManus (1993), who calculate a hypothetical cost of equity capital and add that to production costs. The hypothetical capital requirement is set as a function of the estimated mean and variance of the bank's portfolio of assets so as to achieve a fixed *z*-score of 3, and an (arbitrarily chosen level of) expected return on equity of 15%. However, there are several logical drawbacks with their method, as pointed out by Clark (1996). This method is also not feasible for a small sample study like the current one.

[30] The *CAPM* was originally formulated to measure the *short*-term opportunity cost of capital. However, there are profound problems to estimate the short-term risk premia empirically, and the estimates are not stable, see Fama and French (1997), who apply different variants of asset pricing models to estimate industry costs of equity in US industries, including the banking sector. They find that even while treating industry betas as constants (which they are not), the estimation error of the market premium ($r_M - r_f$) in itself produces standard errors of around three percentage units per year, implying that two-standard-error bounds are from around zero to more than 10 percent for the *CAPM* cost of equity estimates for individual US industries. Furthermore, estimates of the cost of equity for individual firms would be even less precise.

The first step is to specify the equity risk premium for Swedish stocks. Levonian (1994) estimates that the duration for US bank stocks is somewhere between 10 and 23 years, and then uses the 10-year treasury bond yield as the risk-free rate, r_f. I will here use the equity risk premium estimated by Frennberg and Hansson (1990), who calculate the Stockholm stock market return as an average over the period 1919-1990 (for the Affärsvärlden general index, AFGX), which gives a long-term equity premium of 6.4 per cent, using 10-year bond rates where available and synthetic 10-year bond rates otherwise.

Beta coefficents could be calculated only for the two banks that were listed during the entire sampling period, i.e. Handelsbanken and S-E-Banken, using monthly stock returns for the main share series (series A for both banks) and the stock market general index (AFGX) for the preceding 60 months. The betas for each quarter are reported in *Table 3 – Table 7*. It is noticeable how the betas increase from around 1.0 in 1989 – 1991, to around 1.6 for Handelsbanken and 1.8 for S-E-Banken for the later years. The increase can apparently be explained by the Swedish banking crisis, which affected the stock market valuation of all listed banks deeply, although Handelsbanken less severly than S-E-Banken and the other banks. There is a considerable lag effect when betas are calculated for the preceding 60 months, but the values are declining somewhat from 97:1. (This decline is more pronounced if, e.g., a 48-month calculation period is used).

For the three other banks there is not enough data to calculate beta values: Föreningsbanken was first listed on the Stockholm stock exchange in January 1994, Nordbanken in November 1995, and Swedbank in November 1995. For these three banks I have instead used the beta for the banking industry (Affärsvärlden's banking index AFBA). The banking industry beta more or less follows Handelsbanken's beta and on a slightly higher level throughout. In comparison with S-E-Banken's beta, which is higher than Handelsbanken's from 1991 and onwards, it is therefore a conservative estimate. The calculated opportunity costs of capital rates are reported in *Table 3 – Table 7*. Generally, they fluctuate between 17 and 22 per cent.

The calculated rate of opportunity cost of capital should ideally be used together with the market value of equity to obtain the cost of capital as part of the funding cost for each bank. However, book values of equity (including untaxed reserves) have been used instead of market values of equity for the following reasons:

1. Only two of the banks (S-E-Banken and Handelsbanken) have been listed on the stock exchange for the entire period 1989 – 1997. Using book values of equity therefore facilitates comparisons between banks.
2. The stock market valuation of bank equity has been rather erratic during the period of banking crisis in Sweden, as evidenced in *Tables 3 - 4* and *Fig 2*.
3. Stock market valuations are on average rather close to the book value of equity, (see *Table 3* and *Table 4*, columns EC.ssx and EC.grp, and *Fig 2*). Calculated averages for the entire period are at 95 per cent of the book value of equity for Handelsbanken and at 90 per cent for S-E-Banken.

2.2.4.1 Calculating the amount of allocated equity and the WACF

Equity capital will here be defined as the sum of shareholders' equity and untaxed reserves.[31] Swedish banks are allowed to make income tax deductible appropriations to reserves for lending, bonds, etc., i.e. untaxed reserves.[32] Data on banks' equity capital have been obtained from annual reports, since official statistics are less reliable.[33] The data is reported in *Table 3 – Table 7*.

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[31] Shareholders' equity includes restricted equity, i.e. share capital, reserve fund, and fund for unrealised gains, and non-restricted equity, i.e. profit brought forward from previous years and the current year's result.

[32] Untaxed reserves include: *i*. tax equalisation reserve, *ii*. accrual fund, *iii*. excess depreciation of equipment and leased assets, and *iv*. other untaxed reserves. Transfers between these untaxed reserves may be made via the profit and loss account. The tax rate incurred upon dissolution of untaxed reserves is the corporate profit tax rate, currently 28%. Untaxed reserves are not taxed when they are used to cover losses.

[33] Effective from 1992, untaxed reserves are divided up into deferred taxes, which is reported as "other liabilities", and restricted equity, which is reported as a reserve fund in the official statistics. Untaxed reserves thus disappear as a separately reported item in the balance sheet. For this reason, the official statistics for the period 89:1 – 92:3 are a less reliable source on the level of equity than the banks' annual reports. The officially reported monthly figures on equity are also erratic in comparison to the annually reported figures. Figures on equity for the 1^{st}-3^{rd} quarters have then been derived as moving averages calculated on annual results,

From February 1990, formal capital adequacy reporting regulations were applied to Swedish banks, and became a mandatory regulation from 1993.[34] Capital is allocated in the bank to cover for risks. The risk-weightings give a measure of the riskiness pertaining to different types of assets. Therefore we can use the disclosed risk-weightings to see how large part of the equity capital that is allocated to the activities we are analysing, i.e. domestic, on-balance sheet operations.

Each Swedish bank is the holding company in a banking group for which a consolidated balance sheet is reported, i.e they are what Walter (1997) in his classification of universal banks calls a "bank parent universal bank". The consolidated balance sheet includes such companies in which the bank has more than 50 per cent of the voting power. This means, among other things, that they are organised in such a way, that mortgage banking, lease-financing etc are undertaken by separately capitalised subsidiaries. All Swedish banks use the "purchase method" when preparing their consolidated accounts. This means that the book values of shares in subsidiaries are eliminated against the amount of equity of each subsidiary at the time of *pro forma* acquisition, and that each subsidiary's contribution to consolidated shareholders' equity consists only of the equity capital that has been created after the acquisition. This leads to the conclusion that shareholders' equity in the parent company covers financial risks also in subsidiaries, and that only the fraction of risk-weighted assets that pertains to the parent company in relation to the risk-weighted assets in the banking group should be accounted for when calculating the opportunity cost of capital. This is essential, since all banks have their mortgage operations organised in one subisidiary company and their leasing operations organised in another subsidiary company, which both have substantial lending volumes in comparison with the parent company, most of which carries a 50 or 100 per cent risk weighting.[35]

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since net income figures reported in quarterly reports are erratic, and subject to revision in the annual reports.

[34] All banks thus reported their capital adequacy only for the period, 1990 – 1997. For 1989, the risk-weighting ratios for 1990 have been used, but recalculated for each quarter, so as to reflect the quarterly figures on total assets and equity.

[35] According to the capital adequacy rules implemented by the Swedish Financial Supervisory Authority, the analysis of capital adequacy from 1995 shall comprise

In order to calculate the opportunity costs of capital, we thus have to adjust the amount of equity capital reported in the annual report for the bank parent company in accordance with the subset of the activities of the bank that we analyse. The first step is to relate the bank parent's capital base to the financial corporate group's capital base, according to the following formula:

$$EC_{alloc} = EC_{pc}\left(\frac{EC_{fcg}}{EC_{pc}}\frac{RWA_{pc}}{RWA_{fcg}}\frac{RWA_{pc,obs}}{RWA_{pc}}\frac{TA_{dom}}{TA}\right) = EC_{fcg}\left(\frac{RWA_{pc}}{RWA_{fcg}}\frac{TA_{dom}}{TA}\right)$$

where EC_{alloc} is the calculated amount of equity capital allocated to domestic, on-balance sheet operations, EC_{pc} is equity capital in the parent company, EC_{fcg} is equity capital in the financial corporate group, *RWA* is risk-weighted assets, *TA* is total assets, *dom* is domestic and *obs* is on-balance sheet. Thus we deduct those parts of the equity that pertains to subsidiaries, foreign assets and to off-balance sheet activities. It should be noted that we thus assume that the foreign operations of the bank has the same risk profile as the domestic operations. Lack of data prevents us from a deeper analysis of this topic. All data is from annual reports and the monthly/quarterly official statistics. The results of calculating the EC_{alloc} are in *Table 3* to *Table 7*.

Risk premia can be observed not only in the stock market, but also in the bond market where banks raise a large part of their long-term funding.[36] Bond funding, or funding through subordinated debt, carries less risk for the investor than equity funding, since these securities will be redeemed on maturity. Both bonds and subordinated debt are traded on the secondary market (SOX, Stockholm Bond Exchange) and reported in the quarterly reports from the Stockholm stock exchange. The normal risk premium, or default spread, for

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the "financial corporate group", which also includes non-consolidaed associated companies, i.e. a somewhat wider concept than in the accounting rules.

[36] As seen in *Table 1*, Liabilities to credit institutions and Securities issued form a substantial part of each bank's balance sheet. However, liabilities to credit institutions are overnight loans or short-term CDs emitted mainly as part of short-term liquidity management, whereas securities issued (bonds and subordinated debt) are part of the long-term funding.

long-term bank debt is around 0.5% on SOX, but increased to around 1.5% during the banking crisis, see *Fig 3*.

The bank-specific cost of capital multiplied with the allocated equity capital gives the total opportunity cost of equity capital for each bank. In *Fig 4,* the different funding rates are graphed for the average bank, as well as the calculated *WACF*. The *WACF* shows a declining trend since 1990 due to the falling market interest rates. The cost of capital is less affected, due to the increase in β values. In *Fig 5,* the distribution of funding costs between funding categories is illustrated for the average bank.

2.2.5 Estimation results

Most published bank cost studies have the advantage of large cross-section data sets due to the large number of banks in some countries, notably the many studies made on the US banking industry. The current study is confined to a cross-section of five banks, comprising some 85% of the overall market volume.[37] There are 33 quarterly observations per bank, or a total of 165 observations, since the data set can be pooled. Initial regressions revealed highly significant positive auto-regression. Hence, the data series for each bank (outputs, inputs, costs, cost shares) was tested for stationarity with the augmented Dickey-Fuller test. This revealed that almost all of the series are non-stationary and that the first differences of each series is stationary in each case (on at least 5 per cent level of significance), i.e. they are all I(1), see *Table A1*. Prior to estimation of the cost functions, all series were therefore differenced once and then brought back to their mean levels.[38]

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[37] From this section and onwards, I revert to anonymity for the included banks, see footnote 13.

[38] As an alternative to the more simple technique of differencing, Berndt (1991, ch 9) proposes a vector autoregressive process specification in the presence of autocorrelation. This involves applying an autocovariance matrix to the cost function (4) as well as to the factor share equations (5). However, the singularity of the factor share system "imposes severe identificability and diagonality constraints on the autocovariance matrix" (p. 478), in essence that all equations in the whole system have the same lag coefficient for all lagged variables. Since this is "a very

After adding error terms to the *r* composite cost functions (1) and the *m* – 1 factor share equations, they are estimated with the iterative Zellner estimation procedure (seemingly unrelated regression) with the linear homogeneity in input prices and symmetry restrictions imposed across equations. As already noted above, the five-output, three input model was not possible to estimate as a pool due to non-convergence, and estimates for individual banks were very poor due to the low degrees of freedom. The number of parameters was therefore reduced by simplifying the statistical cost function to the model with three outputs and three inputs. The drawback is that the aggregation will eliminate any interactions among the individual loan and deposit outputs.

The estimated parameters and their standard errors and *t*-statistics are given in *Table A2*. Goodness-of-fit measurements for the cost equations and the estimated share equations are in *Table A3*. Because of the few observations, there is a rather large difference between the R^2 values and the R^2 values adjusted for degrees of freedom, especially for the cost equations.[39] This lack of fit is likely to be caused by a violation of the assumption of a common technology in the industry, which is the basis for pooling the data set. Another explanation could be a lack of degrees of freedom, since there are 25 parameters and 160 observations per variable. In order to improve the estimates, I tried simpler versions of equation (1), by omitting first the quadratic input structure (the $\ln w_k \ln w_l$ terms), then the quadratic output structure (the $q_i q_j$ terms), and finally the quadratic input-output structure (the $q_i \ln w_k$ terms). The major problems in the estimation were caused by the quadratic output structure, and the resulting estimates after leaving this out are reported in *Tables A4 – A5*.

Using the obtained parameter estimates, it is possible to analyse the production structure of Swedish banks. The resulting analysis is not

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strong restriction" (op cit), I have refrained from using the VAR specification in this case.

[39] Initial estimates yielded negative adjusted R^2 values for some of the functions. Upon closer inspection of the underlying time series, it was revealed that the total costs for bank 1 displayed a strongly significant end-of-the-year, seasonal pattern for the observations 91:4 – 95:4. After correcting for this, all estimated equations had positive adjusted R^2 values, except two of the cost share equations which have slightly negative values, see *Table A3*.

qualitatively influenced by whether the results from the full model or from the restricted model are used.

Regularity conditions are satisfied at the means of the estimated functions for all the five banks. The output regularity condition (calculated MC>0 using estimated parameters) is violated for 8.6 percent of the observations. There are no cost share violations for the estimated cost share equations, i.e. $0 < CS_i < 1, \forall i$.

2.2.5.1 Economies of scope and scale

Scope and scale estimates are computed for each quarter using the parameter estimates reported in *Table A2*, and then averaged over the sampling period. Point estimates of scope economies are very small, see *Table 3*. All banks display slight diseconomies of scope, with an average of -1.5%. There is no discernible relationship between the size of the total assets of the individual banks and their economies of scope. Also product-specific economies of scope are negative for all banks and for all three outputs, with an average of –0.75%, except for bank 3, which has slightly positive global economies of scope.

Overall, there are also slight dis-economies of scale, with an average of about 98 per cent. There are some differences between banks, though, and one of them displays constant returns to scale. Again, there is no discernible relationship between the size of total assets and economies of scale. Product-specific economies of scale are positive for both loans (105%) and deposits (102%) on average. Product-specific economies of scale for securities are close to 1 for all banks, and also for different specifications of the estimated cost function. This seems to be evidence of weak interaction with other outputs in the cost function, and the underlying production technology. This might be due to the main role of securities, as an instrument in the management of financial risks on the balance sheet, involving mainly financial inputs but little real inputs such as staff and other resources.

Test→ Bank# ↓	Scope: *global*	Scope: *loans*	Scope: *deposits*	Scope: *secur's*	Scale: *global*	Scale: *loans*	Scale: *deposits*	Scale: *secur's*
Average	-0.0148 (0.134)	-0.00752 (0.0683)	-0.00764 (0.0679)	-0.00732 (0.0667)	0.975 (0.122)	1.05 (0.295)	1.02 (0.233)	1.01 (0.045)
Bank 1	-0.0322 (0.111)	-0.0160 (0.0568)	-0.0161 (0.0579)	-0.0166 (0.0534)	0.978 (0.0819)	1.07 (0.285)	1.04 (0.237)	1.00 (0.0282)

Bank 2	-0.0182 (0.163)	-0.0117 (0.0842)	-0.0124 (0.0821)	-0.00652 (0.0820)	0.932 (0.190)	0.924 (0.344)	0.964 (0.314)	1.01 (0.042)
Bank 3	0.00822 (0.130)	0.00476 (0.0661)	0.00468 (0.0660)	-0.00357 (0.0645)	1.003 (0.108)	1.11 (0.267)	1.09 (0.238)	1.01 (0.0347)
Bank 4	-0.0154 (0.133)	-0.00674 (0.0674)	-0.00620 (0.0663)	-0.00884 (0.0669)	0.979 (0.119)	1.01 (0.326)	0.966 (0.223)	1.02 (0.112)
Bank 5	-0.0162 (0.134)	-0.00784 (0.0671)	-0.00771 (0.0670)	-0.00833 (0.0668)	0.985 (0.112)	1.13 (0.256)	1.06 (0.155)	1.00 (0.00914

Table 3. Calculated tests for scope and scale economies as averages over the entire sampling period. Standard deviations for each time series in parentheses.

It should be noted that the results have been obtained under the assumption that banks operate on the frontier of their production sets. The use of data from nonoptimising banks would confound the results on scale and scope efficiencies with differences in X-efficiency. However, there are not enough comparable banks left in Sweden to test for differences in X-efficiency.

2.2.5.2 Two alternative specifications

The inclusion of equity costs is a novelty in bank cost studies, so it is of interest to estimate the cost function after excluding them from the *WACF*. Results calculated from parameters estimated from this alternative specification are reported in *Table A6*, and show small increases in the calculated diseconomies of both scope and scale in comparison to the base model reported above. In conformity with these results, Clark (1996) also finds that the omission of economic costs in the cost function makes estimated cost inefficencies larger.

In comparison with other recent studies utilising the composite cost function, McKillop *et al.* (1996) report significant economies of scale for the giant five Japanese banks and statistically insignificant positive economies of scope. Their study is built on the intermediation approach to banking, which means that deposits are omitted from the output vector. Clark (1996, p 358), evaluates how this omission influences his results and concludes that it “appears to produce a significant overstatement of both the production and economic efficiencies associated with increases in size and product mix”.[40] In order to

[40] Also, Jagtiani *et al.* (1995) test for economies of scale in a wide range of model specifications for the omission of deposits and find that: “…models that exclude deposits from the output specification suggest economies of scale, which vanish

test for this alternative specification, the cost function was estimated with only two outputs, loans and securities. Results calculated from parameters estimated from this alternative specification are reported in *Table A7*, and show smaller diseconomies of scope compared to the base model. The results on scale economies are reverted compared to the base model, so that this alternative specification displays positive economies of scale. Also these results are fully in line with Clark's findings, that the intermediation model overstates economies.

2.3 Conclusions

This paper investigates the extent of economies of scale and economies of scope on the cost side in the five big banks of the Swedish banking industry. It is one of the first empirical bank cost studies internationally to use the economic cost concept instead of merely production costs. Economic costs include operating costs as well as opportunity costs of equity capital, where the opportunity costs are calculated with the *CAPM* model. Banks can easily lower their production costs by more risk-taking behaviour, such as quickly expanding their loan portfolio without increasing monitoring, etc. What appears to be improved production cost efficiency should then be offset by an increase in risk, that increases economic costs. These considerations have not only theoretical relevance, but are also of specific relevance to this study, which covers the years from 1989 to 1997, during which a profound credit-risk related banking crisis took place in 1991-93.

In order to properly evaluate economies of scope, the study employs the composite functional form for the cost function proposed by Pulley and Braunstein (1992). Results imply small dis-economies of scope for all five banks from about 0 to –3 percent. Product-specific economies of scope are also (with one exception) slightly negative for all products and all banks. Economies of scale are weakly negative, ca 98 percent on average, and ranging from about 93 percent for one of the banks, to constant returns to scale for one of them.

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when deposits are included" (p 1187). However, their study uses the translog cost function and thus cannot evaluate economies of scope correctly.

In two alternative specifications, results show that the omission of economic costs from the cost function increases estimated dis-economies of both scale and scope. Omission of deposits from the output vector, according to the intermediation model of banking, on the other hand influences results in the opposite direction, so that estimated dis-economies of scope are smaller, and economies of scale become positive, i.e. a reversion compared to the base model. The results from these alternative specifications are in line with similar findings by Clark (1996).

Looking back to the many credible arguments in sections 2.1.1 and 2.1.2, as to why economies of scale and economies of scope might exist in banking, it is relevant to ask why we do not find any evidence of them in reality. One explanation could be that economies are exhausted at bank sizes smaller than the ones examined here. However, since the sample contains only rather big banks, it is not practicable to evaluate possible differences in economies between different size classes of banks.

The results indicate that there is no evidence on the cost-side that banks can become more efficient in their domestic operations by increasing their scale. There are also no cost-side arguments for the many mergers and acquisitions that have recently taken place within the industry proper. The combined results on the absence of economies to both scale and scope suggest that smaller, specialised banking institutions, e.g. "narrow" banks, might be cost competitive.

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Appendix 1. Estimation results

		CS_1	CS_2	CS_3	q_1	q_2	q_3	w_1	w_2	w_3	OC	FC	TC
Bank 1	*Level*	1.1	2.4	2.4	2.4	1.2	0.95	1.1	3.0	1.8	1.9	$2.9^{\dagger}$	3.0^{*}
	1st diff	4.4*	4.8^{**}	6.2^{**}	3.9^{**}	5.4^{**}	5.6^{**}	5.2^{**}	5.4^{**}	4.8^{**}	4.7^{**}	6.9^{**}	4.8^{**}
Bank 2	*Level*	2.5	1.0	2.5	2.3	2.1	3.1^{*}	$2.8^{\dagger}$	1.4	2.5	0.26	1.8	2.9
	1st diff	6.1^{**}	5.2^{**}	5.9^{**}	3.9^{*}	4.7^{**}	5.3^{**}	6.0^{**}	5.0^{**}	6.9^{**}	6.4^{**}	7.2^{**}	5.3^{**}
Bank 3	*Level*	0.82	1.2	3.0^{*}	1.4	1.9	1.8	1.1	0.7	0.33	1.3	2.6	$2.9^{\dagger}$
	1st diff	4.4^{**}	3.6^{**}	5.6^{**}	3.7^{**}	3.3^{**}	6.5^{**}	3.3^{**}	4.2^{**}	6.6^{**}	3.0^{**}	5.5^{**}	6.3^{**}
Bank 4	*Level*	0.09	1.3	1.0	1.4	2.1	2.2	1.4	2.5	2.8	1.1	2.1	0.60
	1st diff	5.1^{**}	4.3^{**}	5.9^{**}	3.8^{**}	4.4^{**}	6.1^{**}	3.3^{**}	4.2^{**}	7.1^{**}	3.6^{*}	7.1^{**}	5.3^{**}
Bank 5	*Level*	2.1	1.5	1.6	0.24	0.49	3.2^{*}	1.5	1.3	2.6	0.45	1.8	0.60
	1st diff	4.2^{**}	5.9^{**}	4.2^{**}	2.9^{**}	6.5^{**}	6.1^{**}	4.5^{**}	4.0^{**}	7.5^{**}	2.6^{*}	8.4^{**}	4.9^{**}

Table A1. Augmented Dickey-Fuller (ADF) tests: Absolute t-ratios. CS_i is the cost share, q_i is the output, w_i is the input price, OC is operating costs, FC is funding costs and TC=OC+FC is total costs. †, *, and ** denotes significance at the 10%-level, 5%-level and 1%-level respectively, based on MacKinnon critical values. A constant and a time trend have been included in the ADF regressions, if significant. All 1st differences are significant on at least the 5% level, and almost all of them at the 1% level.

Pooled estimates					
Parameter	Variable	Coeff.	S.E.	*t*-ratio	Prob.>|*t*|
$\alpha_0 + \rho_1$	const+dummy$_1$	3500**	132	26.5	0.0000
$\alpha_0 + \rho_2$	const+dummy$_2$	5866**	225	26.1	0.0000
$\alpha_0 + \rho_3$	const+dummy$_3$	3055**	124	24.5	0.0000
$\alpha_0 + \rho_4$	const+dummy$_4$	4436**	124	35.8	0.0000
$\alpha_0 + \rho_5$	const+dummy$_5$	2006**	59.4	33.8	0.0000
α_1	q_1	0.0119**	0.00167	7.11	0.0000
α_2	q_2	0.0151**	0.00229	6.59	0.0000
α_3	q_3	0.00648**	0.000480	13.5	0.0000
α_{11}	$q_1\,q_1$	-1.56E-06**	1.75E-07	-8.88	0.0000
α_{12}	$q_1\,q_2$	2.40E-06**	1.46E-07	16.4	0.0000
α_{13}	$q_1\,q_3$	1.75E-07**	3.46E-08	5.07	0.0000
α_{22}	$q_2\,q_2$	-1.87E-06**	2.70E-07	-6.90	0.0000
α_{23}	$q_2\,q_3$	-1.36E-07**	3.78E-08	-3.61	0.0003
α_{33}	$q_3\,q_3$	-2.60E-08**	4.44E-09	-5.85	0.0000
δ_{11}	$q_1 \ln w_1$	-0.00165**	0.000293	-5.65	0.0000
δ_{12}	$q_1 \ln w_2$	0.00160**	0.000301	5.31	0.0000
$\delta_{13} = -\delta_{11}-\delta_{12}$	$q_1 \ln w_3$	0.000057**	0.000297	5.21	0.0000
δ_{21}	$q_2 \ln w_1$	-0.00195**	0.000344	-5.68	0.0000
δ_{22}	$q_2 \ln w_2$	0.00168**	0.000335	5.03	0.0000
$\delta_{23} = -\delta_{21}-\delta_{22}$	$q_2 \ln w_3$	0.00027	0.000339	1.26	0.2086
δ_{31}	$q_3 \ln w_1$	-0.000888**	8.38E-05	-10.5	0.0000
δ_{32}	$q_3 \ln w_2$	-0.000866**	7.87E-05	-10.9	0.0000
$\delta_{33} = -\delta_{31}-\delta_{32}$	$q_3 \ln w_3$	0.0000022**	8.12E-05	-10.7	0.0000
β_1	$\ln w_1$	-0.000959	0.000923	-1.04	0.2993
β_2	$\ln w_2$	-0.000337	0.000872	-0.387	0.6988
$\beta_3 = 1-\beta_1-\beta_2$	$\ln w_3$	1.001**	0.000898	1.44	0.1610
β_{11}	$\ln w_1 \ln w_1$	0.159**	0.00182	87.1	0.0000
$\beta_{12} = \beta_{21}$	$\ln w_1 \ln w_2$	-0.0126**	0.00176	-7.13	0.0000
$\beta_{13} = -\beta_{11}-\beta_{12}$	$\ln w_1 \ln w_3$	-0.146**	0.00179	-47.5	0.0000
β_{22}	$\ln w_2 \ln w_2$	0.176**	0.00184	96.0	0.0000
$\beta_{23} = -\beta_{12}-\beta_{22}$	$\ln w_1 \ln w_3$	-0.164**	0.00180	-65.8	0.0000
$\beta_{33} = \beta_{11}+2\beta_{12}+\beta_{22}$	$\ln w_3 \ln w_3$	0.310**	0.00179	110.6	0.0000

Table A2. Parameter estimates from pooled regressions, standard errors and t-statistics. Derived parameters have approximate standard errors. * and ** indicates significance at .05 level and .01 level, respectively.

	Equation	R^2	Adj R^2	Standard error	DW-statistic
Bank 1	Cost equation	0.67	0.039	297	1.91
	Labour cost share	0.69	0.29	0.013	2.31
	Other op. Cost share	0.67	0.23	0.013	2.26
Bank 2	Cost equation	0.66	0.010	418	2.17
	Labour cost share	0.56	-0.0089	0.012	2.17
	Other op. Cost share	0.83	0.62	0.014	1.52
Bank 3	Cost equation	0.66	0.016	417	1.69
	Labour cost share	0.74	0.41	0.011	1.28
	Other op. Cost share	0.69	0.29	0.013	1.45
Bank 4	Cost equation	0.67	0.052	470	2.07
	Labour cost share	0.52	-0.088	0.017	1.88
	Other op. Cost share	0.60	0.078	0.015	2.16
Bank 5	Cost equation	0.70	0.14	141	1.95
	Labour cost share	0.68	0.27	0.011	0.94
	Other op. Cost share	0.72	0.37	0.013	1.20

Table A3. Goodness-of-fit mesaures.

		R^2	Adj R^2	Standard error	DW-statistic
Bank 1	Cost equation	0.71	0.46	222	1.94
	Labour cost share	0.69	0.51	0.011	2.37
	Other op. Cost share	0.69	0.50	0.011	2.24
Bank 2	Cost equation	0.72	0.47	305	2.29
	Labour cost share	0.60	0.36	0.0095	2.15
	Other op. cost share	0.83	0.74	0.012	1.57
Bank 3	Cost equation	0.74	0.51	293	1.48
	Labour cost share	0.76	0.62	0.0091	1.33
	Other op. cost share	0.70	0.52	0.010	1.52
Bank 4	Cost equation	0.59	0.24	411	2.09
	Labour cost share	0.58	0.33	0.014	1.85
	Other op. cost share	0.63	0.41	0.012	2.14
Bank 5	Cost equation	0.74	0.50	107	1.86
	Labour cost share	0.69	0.51	0.0094	0.92
	Other op. cost share	0.74	0.59	0.011	1.21

Table A5. Goodness-of-fit mesaures for the alternative cost function specification, without the quadratic output structure.

Pooled estimates					
Parameter	Variable	Coeff.	S.E.	*t*-ratio	Prob.>|*t*|
$\alpha_0 + \rho_1$	const+dummy$_1$	3513**	163	21.5	0.0000
$\alpha_0 + \rho_2$	const+dummy$_2$	5982**	222	26.9	0.0000
$\alpha_0 + \rho_3$	const+dummy$_3$	3634**	142	25.7	0.0000
$\alpha_0 + \rho_4$	const+dummy$_4$	4759**	198	24.0	0.0000
$\alpha_0 + \rho_5$	const+dummy$_5$	2078**	79.7	26.1	0.0000
α_1	q_1	0.0146**	0.00174	8.40	0.0000
α_2	q_2	0.0186**	0.00250	7.42	0.0000
α_3	q_3	0.00548**	0.000522	10.5	0.0000
δ_{11}	$q_1 \ln w_1$	-0.00197**	0.000362	-5.44	0.0000
δ_{12}	$q_1 \ln w_2$	0.00223**	0.000374	5.95	0.0000
$\delta_{13} = -\delta_{11}-\delta_{12}$	$q_1 \ln w_3$	-0.000330**	0.000368	-0.897	0.3876
δ_{21}	$q_2 \ln w_1$	-0.00289**	0.000469	-6.16	0.0000
δ_{22}	$q_2 \ln w_2$	0.00123**	0.000434	2.83	0.0048
$\delta_{23} = -\delta_{21}-\delta_{22}$	$q_2 \ln w_3$	0.00166**	0.000451	3.68	0.0003
δ_{31}	$q_3 \ln w_1$	-0.000836**	9.80E-05	-8.52	0.0000
δ_{32}	$q_3 \ln w_2$	-0.000839**	8.74E-05	-9.60	0.0000
$\delta_{33} = -\delta_{31}-\delta_{32}$	$q_3 \ln w_3$	0.00168**	9.24E-05	18.1	0.0000
β_1	$\ln w_1$	-0.000699	0.000901	-0.776	0.4381
β_2	$\ln w_2$	-0.000169	0.000853	-0.198	0.8433
$\beta_3 = 1-\beta_1-\beta_2$	$\ln w_3$	1.001	0.000876	0.991	0.3577
β_{11}	$\ln w_1 \ln w_1$	0.157**	0.00338	46.3	0.0000
$\beta_{12}=\beta_{21}$	$\ln w_1 \ln w_2$	-0.0179**	0.00249	-7.18	0.0000
$\beta_{13} = -\beta_{11}-\beta_{12}$	$\ln w_1 \ln w_3$	-0.139**	0.00294	-47.3	0.0000
β_{22}	$\ln w_2 \ln w_2$	0.179**	0.00296	60.4	0.0000
$\beta_{23} = -\beta_{12}-\beta_{22}$	$\ln w_1 \ln w_3$	-0.161**	0.00272	-59.2	0.0000
$\beta_{33}=\beta_{11}+2\beta_{12}+\beta_{22}$	$\ln w_3 \ln w_3$	0.300**	0.00283	106.1	0.0000

Table A4. Parameter estimates from pooled regressions, standard errors and t-statistics from the alternative cost function specification, without the quadratic output structure. Derived parameters have approximate standard errors. * and ** indicates significance at .05 level and .01 level, respectively.

Test → Bank# ↓	**Scope:** *global*	**Scope:** *loans*	**Scope:** *depos-its*	**Scope:** *securi-ties*	**Scale:** *global*	**Scale:** *loans*	**Scale:** *depos-its*	**Scale:** *securi-ties*
Average	-0.0486 (0.170)	-0.0243 (0.0859)	-0.0245 (0.0855)	-0.0243 (0.0841)	0.967 (0.123)	1.04 (0.145)	1.03 (0.216)	1.02 (0.121)
Bank 1	-0.0517 (0.134)	-0.0256 (0.0676)	-0.0261 (0.0693)	-0.0269 (0.0645)	0.977 (0.0816)	1.05 (0.138)	1.11 (0.280)	1.00 (0.0307)
Bank 2	-0.0715 (0.209)	-0.0372 (0.107)	-0.0390 (0.105)	-0.0340 (0.104)	0.927 (0.172)	1.02 (0.167)	1.01 (0.173)	0.985 (0.111)
Bank 3	-0.0105 (0.136)	-0.00467 (0.0692)	-0.00462 (0.0691)	-0.00528 (0.0671)	0.978 (0.154)	1.07 (0.156)	1.05 (0.168)	1.01 (0.0241)
Bank 4	-0.0421 (0.173)	-0.0206 (0.0880)	-0.0195 (0.0860)	-0.0216 (0.0877)	0.979 (0.108)	1.02 (0.216)	0.962 (0.402)	1.09 (0.428)
Bank 5	-0.0671 (0.195)	-0.0335 (0.0976)	-0.0332 (0.0975)	-0.0335 (0.0972)	0.975 (0.0999)	1.02 (0.0472)	1.03 (0.0566)	1.001 (0.00926

Table A6. Calculated tests for scope and scale economies with the alternative specification where equity costs are excluded from *WACF* as averages over the entire sampling period. Standard deviations for each time series in parentheses.

Test → Bank# ↓	**Scope:** *global*	**Scope:** *loans*	**Scope:** *securities*	**Scale:** *global*	**Scale:** *loans*	**Scale:** *securities*
Average	-0.0302 (0.203)	-0.0151 (0.101)	-0.0152 (0.101)	0.999 (0.199)	1.04 (0.149)	1.01 (0.048)
Bank 1	-0.0325 (0.167)	-0.0159 (0.0835)	-0.0156 (0.0845)	0.997 (0.222)	1.07 (0.210)	1.01 (0.0397)
Bank 2	-0.0320 (0.251)	-0.0160 (0.127)	-0.0160 (0.124)	0.982 (0.212)	1.02 (0.146)	1.01 (0.046)
Bank 3	-0.0135 (0.179)	-0.00689 (0.0902)	-0.00652 (0.0892)	1.03 (0.208)	1.08 (0.154)	1.01 (0.0310)
Bank 4	-0.0818 (0.240)	-0.0406 (0.120)	-0.0410 (0.119)	0.969 (0.223)	1.02 (0.186)	1.03 (0.112)
Bank 5	-0.00849 (0.175)	-0.00422 (0.0876)	-0.00422 (0.0876)	1.02 (0.129)	1.02 (0.0482)	1.001 (0.0123)

Table A7. Calculated tests for scope and scale economies with the alternative specification where deposits are excluded from the output vector as averages over the entire sampling period. Standard deviations for each time series in parentheses.