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The performance of universal banks: Evidence from Switzerland

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Abstract

This paper examines the performance of Swiss banks from 1996 to 1999. Using a broad definition of bank output, we find evidence of large relative cost and profit inefficiencies in Swiss banks. A more narrow definition that focuses on only traditional activities leads to efficiency estimates that are even lower. We also find evidence of economies of scale for small and mid-size banks, but little evidence that significant scale economies remain for the very largest banks. Finally, evidence on scope economies is weak for the largest banks that are involved in a wide variety of financial activities. Taken together, these results suggest few obvious benefits from the trend toward larger, universal banks in Switzerland.

JEL classification: G2
Keywords: Efficiency; Scale economies; Distribution free approach; Swiss banks

1. Introduction

As financial institutions continue to evolve and traditional industry lines blur, the question of the optimal structure has been brought to the forefront as a research question. In the US, for example, the Gramm–Leach–Bliley Act has created the ability for commercial banks to expand more fully into securities underwriting and

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insurance businesses. [2] It remains an open question, however, whether fundamental reorganization of the production structure of financial institutions will lead to substantial gains from economies of scale, economies of scope, or improved profit and cost efficiency. Because US banks had been prohibited from expanding into many activities, it is difficult to directly measure these potential synergies. [3]

The financial landscape in Europe, however, has been quite different and there is a long history of "universal banking" where financial institutions offer a broad range of financial services, including lending, deposit-taking, underwriting, brokerage, trading, and portfolio management. Moreover, the implementation of the European Second Banking Directive and the Directive on Investment Services, and the rise of mergers and acquisition between banks, securities companies and insurance companies, have reinforced the universal character of the European banking system (see Cybo-Ottone and Murgia, 2000). This experience provides an ideal opportunity to gauge the potential production benefits from a fully diversified financial institution.

The first goal of this paper is to examine the production structure of banks in Switzerland, which are currently allowed to engage in universal banking. In particular, we measure cost efficiency, profit efficiency, economies of scale, and economies of diversification (scope) for 289 banks from 1996 to 1999. By looking at a broad cross-section of Swiss banks using recent data, we can gain a better understanding of the factors that contribute to success in a financial environment with universal banking.

A second goal of this paper is to better understand the recent consolidation process in the Swiss banking sector. Since the early 1990s, there has been a steady decrease in the importance of small banking institutions that focus on traditional banking operations ("regional" and "cantonal" banks) and an expansion of larger, universal banks. By measuring scale economies, economies of diversification, and profit and cost efficiency for different types of banks, we can identify factors that contribute to this trend. Our research differs from earlier work on Swiss banks' cost economies and cost efficiency by Hermann and Maurer (1991), Sheldon (1994) and Sheldon and Haegler (1993) in three respects. First, we consider a broader set of output definitions that includes trading and off-balance sheet (OBS) activities to capture the effects of universal banking; second, we are the first to examine profit efficiency for universal Swiss banks; and third, we use much more recent data.

Our empirical results indicate substantial relative inefficiency across all types of Swiss banks. Using our preferred definition that includes a "universal" measure of bank output – traditional lending products, OBS credit instruments, trading activities, and brokerage and portfolio management activities – we estimate that roughly

[2] The Gramm–Leach–Bliley Act, passed in October 1999, expands the activities of financial holding companies to include commercial banking, investment banking, and insurance underwriting.

[3] Boyd and Graham (1986, 1988) and Lown et al. (2000) have examined potential diversification benefits by measuring the volatility of earnings using pro-forma data from hypothetical mergers of commercial banks, securities, and insurance firms. These studies, however, cannot capture the potential gains (e.g., scope economies from consolidation of back-office expenses) or potential losses (e.g., inefficiency from conflicting systems or corporate cultures) that might result from broad consolidation.

40% of costs reflect cost inefficiency and about one-half of potential profits are foregone due to profit inefficiency. We then estimate efficiency for alternative output definitions and show the critical importance of including non-traditional activities. If we estimate cost or profit efficiency with a "naïve" output measure that includes only traditional banking products, for example, both cost and profit efficiency are understated relative to estimates from the universal definition. Finally, our efficiency estimates by category of Swiss bank contrast with the widespread idea that regional and cantonal banks are less efficient.

The data show evidence of scale economies for the small to mid-sized banks. For the very largest banks, however, our point estimates indicate scale economies, but we cannot formally reject the null hypothesis of constant returns to scale. This is true for ray scale economies (RSE) and expansion path scale economies. We find some evidence of economies of diversification in our estimates of expansion path subadditivity for the small to mid-sized banks. For the largest banks, the expansion path subadditivity estimates imply higher costs for large, universal banks. These econometric results are supported by simple rank correlations between measures of specialization and return on equity (ROE) and return on assets (ROA), which give ambiguous results. Taken together, these results imply little obvious gains from broader product mixes for the largest, universal banks in Switzerland.

We conclude that the substantial relative inefficiency and presence of economies of scale can partly explain the consolidation trend in the Swiss banking industry. [4] The decline of cantonal banks and regional banks that focus on traditional activities, however, partially remains unexplained because we do not find them to be weaker in terms of profit and cost efficiency and because we do not find strong evidence for economies of diversification for very large banks. Here, the only explanation we may offer lies in the lower degree of profitability observed for traditional activities compared to non-traditional activities. Finally, the weak evidence on economies of diversification for the largest banks suggests that the move toward universal banking in the US and elsewhere will not lead to substantial cost reductions; there will likely be a range of outcomes with some banks succeeding in the new environment and others failing.

2. Understanding the Swiss banking system

The Swiss banking system is typically described as a universal banking system. As in most continental European countries, banking legislation does not distinguish between commercial and investment banks. [5] In principle, any institution authorized to operate as a bank may offer a range of financial services: Lending

[4] In the banking industry, weaker market participants rarely exit the market to be replaced by new firms, but they are usually taken over by firms already present in the market, which leads to consolidation.

[5] Universal banking has been allowed in Switzerland since the Banking Law of 1930.

and deposit-taking, underwriting, brokerage, trading, and portfolio management. Banks, of course, must still comply with prudential requirements including capital requirements, liquidity requirements, and best practices, etc. when engaging in these activities.

2.1. Heterogeneity in Swiss banks

Swiss banks vary in their use of the option to engage in all financial activities. Truly universal banks co-exist with institutions specializing either in traditional banking or in financial market activities. In the official statistics maintained by the Swiss National Bank (Banque nationale suisse, 2000), Swiss banks are classified into ten major groups: big banks, cantonal banks, regional and savings banks, Raiffeisenkassen banks, commercial banks, consumer loan banks, stock exchange banks, other banks, foreign, and private bankers. Since our subsequent empirical work will explore differences among these types, it is useful to provide a brief description of each type.

The big banks pursue all lines of financial activities – from traditional banking to financial markets activities – and they are the key actors in most segments of the domestic market. The big banks are also heavily engaged in international financial activities. Cantonal banks are state-owned banks with the majority of their capital owned by the canton, which guaranties their liabilities. [6] Cantonal banks vary substantially in terms of size and business activities. While the smaller institutions focus on domestic, traditional banking, the larger ones typically engage in all types of financial activities. Regional banks tend to focus on domestic, traditional banking, with an emphasis on mortgage lending. Their activity is limited to small geographical areas.

The Raiffeisenkassen are small banks located mainly in rural areas. They are organized as cooperatives and focus on mortgage lending. The individual cooperatives have access to various services provided by a common institution, called the central bank of the Raiffeisenkassen. These banks may not face the same competitive pressures as the others, and are thus excluded from our analysis. Commercial banks are, in general, universal banks of medium size that combine commercial and mortgage loans with brokerage and portfolio management activities. Stock exchange banks are rather small and they focus on brokerage and portfolio management activities. Their activity is only partially reflected in the balance sheet.

Consumer loan banks are small, and they finance durable consumption expenditures. Foreign banks are institutions operating under Swiss banking law, but whose capital is primarily owned by foreigners. They differ widely in their size and activities. Some qualify as universal banks, while others focus on trade credit or on financial market activities. Other banks include institutions with miscellaneous activities that cannot be assigned to a specific category. Finally, private bankers are unincorporated firms, involved mainly in portfolio management, whose owners are person-

[6] A canton is a territorial subdivision in Switzerland, roughly equivalent to a state in the US.

ally and fully liable for all the debts of their firms. For this reason, they have to comply only with part of the Swiss banking law, and do not qualify as banks in the strict sense and are not included in our analysis.

2.2. Evolution of Swiss banking in the 1990s

We now discuss changes in the Swiss banking industry as a whole during the 1990s as summarized in aggregated industry data compiled in Les banques suisses. Two significant changes are worth mentioning.

First, traditional banking activities (lending and deposit-taking) have decreased in importance with financial market activities (brokerage, underwriting, and portfolio management) growing. Interest income, for example, accounted for 86% of total income in 1990, but only 63% in 1999. By contrast, the share of brokerage, underwriting and portfolio management fees increased from 11% of total income in 1990 to 26% in 1999. A similar shift occurred in the contribution of different activities to banks' profitability: Net interest income equaled 102% of fees and trading income in 1990, but only 48% in 1999. This trend towards non-traditional activities suggests that one must take a broad view of Swiss banks when examining the production structure.

Second, there was an important wave of consolidation as the number of banks fell from 495 in 1990 to 372 in 1999, while average bank size (measured in assets) increased from Sfr 2260 to 6029 million. During the first half of the 1990s, the economic recession and the collapse of the real estate market were the primary forces behind the consolidation trend. Write-offs and provisioning requirements rose from 0.56% to 1% of total assets from 1990 to 1995 and many institutions, especially regional and cantonal banks, suffered massive losses that put their solvency into question. Big banks faced a less dramatic increase in provisioning requirements and were able to stabilize their profitability due to good returns from financial markets activities. Many ailing regional and cantonal banks were acquired by larger institutions, especially the big banks, and the number of regional banks fell from 204 to 127 and the number of cantonal banks fell from 29 to 25. The market share of the big banks, measured as a percentage of total assets, rose from 48% to 55%, mainly at the expense of the regional banks.

General economic conditions improved in Switzerland in the second half of the 1990s as slow but positive growth returned and the real estate market stabilized. The financial condition of regional and cantonal banks recovered significantly, but big banks faced large increases in provisioning requirements and reported losses. Consolidation of the Swiss banking system continued, although at a less dramatic pace. From 1995 to 1999, the number of banks decreased from 413 to 372. The number of regional banks decreased from 127 to 106, while the number of foreign banks fell from 141 to 123. The market share of the big banks rose from 55% to 67%, mainly at the expense of the declining regional banks (5.5–3.3%) and cantonal banks (19.8–13.2%).

The consolidation trend of the 1990s shows a decline in the importance of the smaller cantonal and regional banks, which focused on traditional banking activities, while the large, universal banks expanded. There is little doubt that the recession and the deterioration of the financial situation of the cantonal and regional banks at the beginning of the 1990s contributed to this consolidation process. After 1995, however, it is more difficult to explain the continuation of the consolidation process. During the late 1990s, general economic conditions improved and regional and cantonal banks were no longer in financial distress. Hence, to better understand the continued restructuring of the Swiss banking system, it is necessary to turn our investigation toward the industrial structure of the banking industry, and to examine the production characteristics of Swiss banks.

2.3. Earlier studies on Swiss banking

Several earlier studies have estimated scale economies and cost efficiency for Swiss banks. Hermann and Maurer (1991), for example, examine scale and scope economies at Swiss banks for a single year, 1989. They find economies of scale, except for the largest banks in their sample. They also report diseconomies of scope for small banks and economies for large banks.

More recently, Sheldon and Haegler (1993) and Sheldon (1994) examine scale economies, scope economies, and cost efficiency for a panel of Swiss banks over the period 1987–1990 using both parametric and non-parametric methods. Both approaches point to significant economies of scale, particularly for small banks, but the evidence on economies of scope is ambiguous. Their parametric methods estimates indicate a low average cost efficiency, which rapidly decreases with bank size. Hence, size seems to be an advantage from an economies of scale perspective, but a disadvantage from an efficiency perspective. This could explain the coexistence of banks of different sizes.

Bikker (1999) examines the cost efficiency of the banking systems in nine European countries using the stochastic cost frontier approach and an alternative method based on country specific dummies. Both methods are based on the translog function and indicate that Swiss banks rank among the best in terms of cost-efficiency. [7] The Bikker study, however, does not examine scale economies, scope economies, or profit efficiency, and does not report correlates between relative efficiency and size.

2.4. Contributions of this paper

The earlier empirical evidence on costs of Swiss banks does not explain why large universal banks continue to gain in importance, and why smaller banks focusing on traditional banking activities seem to be driven out. Moreover, since the earlier lit-

[7] Note that the strong ranking of Swiss banks in international comparison does not necessarily mean that there are not large differences in terms of relative efficiency across Swiss banks themselves. Such variation could translate into a low relative efficiency estimate if many banks are far from the best-practice Swiss bank. To compare relative efficiency levels across countries, one must either include all banks in the same sample, or assume that the best-practice frontier is the same across countries.

erature examined a period that was quite different from the current period using relatively narrow views of bank outputs, it is of limited use in evaluating gains for financial industries that are currently broadening their activities.

To better understand these issues, we present a broad analysis of Swiss banks during the second half of the 1990s. Relative to the earlier literature, our study makes several important contributions. First, our analysis includes several alternative output definitions that range from a narrow view of traditional banking to a broader view of universal banks. Evidence from the US (e.g., Rogers, 1998; Stiroh, 2000) shows that failure to include non-traditional outputs tends to understate measured bank efficiency. By estimating cost and profit efficiency, scale economies, and economies of diversification with a more realistic description of bank outputs, we can gain a more accurate view of universal banking in Switzerland. Moreover, one way to gain an understanding about the future of broader banking in the US is to examine the production structure of existing universal banks.

Second, profit efficiency of Swiss banking was not examined in earlier studies. As argued by Berger and Mester (1997), "profit efficiency is superior to the cost efficiency concept for evaluating the overall performance of the firm (p. 900)". With imperfect competition, cost minimization is not equivalent to profit maximization, and the latter may be a more important driver of the structure of the banking industry. Moreover, several factors suggest that imperfect competition may prevail in banking in general, and in the Swiss banking industry in particular. As one piece of evidence, Egli and Rime (2000) report a significant relationship between rates on savings deposits and the degree of concentration across cantons, which may indicate regional segmentation of the retail banking market. In addition, due to the high degree of concentration in the Swiss banking industry, we cannot exclude some implicit collusion between Swiss banks, even if explicit cartel-like agreements have been abolished. Rime (1999), for example, uses the Panzar and Rosse (1987) statistics and rejects the hypothesis of perfect competition for the Swiss banking system, even after the abolition of cartel-like agreements. [8] A final advantage of the profit efficiency analysis is that it may capture quality effects (solvency of the bank, quality of its services) that are not, or only partially, reflected in the cost analysis (Berger and Mester, 1997). That is, profit efficiency includes both cost and revenue effects, and thus is a more comprehensive indicator of performance.

3. Data and variable definitions

Our primary econometric work is based on estimation of variable cost and variable profit functions for a sample of Swiss banks. This section describes the sample of banks and variables used in the econometric estimates.

[8] The Panzar and Rosse statistics measures the elasticity of income with respect to input prices.

3.1. Sample of Swiss banks

Our main sample includes 289 Swiss banks that operated continuously from 1996 to 1999. Eight of the ten types of banks are included; private banks and the Raiffeisenkassen banks are excluded. Private bankers have to comply with limited reporting requirements, which prevents us from measuring some key variables for that type of institution. The Raiffeisenkassen banks, which are cooperative institutions focused on mortgage lending, may not operate under the same profit maximization goals of other banks and thus it seemed inappropriate to include these banks. All the other groups of banks in the sample face identical accounting rules defined by the Federal Banking Commission and the Banque nationale suisse.

Given the universal character of the Swiss banking system, the inclusion of banks that vary greatly in size and output mix seems appropriate. Moreover, this variation in size and output mix is an advantage for identifying and measuring scale and scope economies. Heterogeneity of the sample, however, increases the risk that we fail to control for some unobservable bank characteristics that could bias our estimates. In earlier work on Swiss banks, Hermann and Maurer (1991), Sheldon and Haegler (1993) and Sheldon (1994) also consider a very broad sample of banks. In contrast, the majority of empirical studies on US banks consider more homogenous samples of financial institutions because US banks are more restricted in the types of outputs they produce.

A priori, we suspect a lack of comparability for two groups of banks: The big banks and the foreign banks. The big banks, because of their size and of their wide range of activities, may be difficult to compare to smaller banks that are more focused. For foreign banks, most are subsidiaries of larger financial institutions located abroad, and an important part of their assets and liabilities consists of loans or deposits to/from the parent institution. These positions experience strong fluctuations and are frequently contracted at special conditions, which makes foreign banks difficult to compare with other banks in terms of observable quantities and prices. To address this comparability issue, we re-estimated the cost and profit function for subsamples excluding these two bank groups. In all cases, our findings were similar, so we choose to focus on the full sample due to the already small number of observations and because the big banks control a large share of Swiss assets.

Our sample period covers 1996–1999. The choice of this sample period reflects three factors. First, new accounting principles were introduced in 1996, implying significant breaks in the series with respect to 1995 that could affect the comparability of the earlier data. Moreover, the data based on the new accounting principles allow a better differentiation between traditional banking and financial market activities, e.g., the breakdown of fee income between brokerage, underwriting and portfolio management on the one side and loans on the other side, and a more exhaustive view of OBS positions. Second, we are interested in estimates that are not affected by the instability generated by the deterioration of banks financial strength during the first half of the 1990s. Third, the use of a relatively short observation period provides us with estimates that are more representative of the present situation and of future trends. A disadvantage in our efficiency estimates, however, is that random fluctua-

Table 1
Recent trends in Swiss bank performance, 1996–1999

Year	Number of Observations	Total assets	Equity capital	Variable costs	Variable profits			ROA	ROE	C/A
					Naïve, *Y-1*	Intermediate, *Y-2*	Universal, *Y-3*			
1996	289	3733.7	251.0	143.0	−6.3	0.2	50.7	0.91	5.49	4.63
1997	289	4476.0	272.7	158.6	−5.6	0.7	64.5	1.26	7.94	4.32
1998	289	6675.4	336.8	206.6	0.3	6.4	84.5	1.54	10.14	4.27
1999	289	7338.5	344.9	211.8	−15.4	−8.8	97.6	1.52	10.37	3.79

Note: All values are simple means. Variable costs and variable profits are defined in Section 3. Output definitions *Y-1*, *Y-2*, and *Y-3* are defined in Section 3. Total assets, equity capital, variable costs, and variable profits are measured in millions of 1999 Swiss francs. ROA is net income divided by assets. ROE is net income divided by equity. C/A is variable costs divided by total assets. ROA, ROE, and C/A are percentages.

tions play a more important role. Over a four years period, however, any good or back "luck" should not be the main driver of the efficiency estimates.

Table 1 presents summary statistics for these 289 banks for each year from 1996 to 1999. The data show a steady increase in the average size of the institutions as consolidation continued. These surviving banks also improved their performance with ROA and ROE rising, while costs per assets (C/A) fell.

3.2. Cost and profit functions

The production literature for financial institutions distinguishes between intermediation and production approaches. In this study, we assume that banks transform deposits, purchased funds, and labor into loans, other assets, and a range of financial services. Hence, our definition of bank activities can be assimilated to a "broad" intermediation approach. The general cost and profit function methodology is quite common in the literature and we discuss the theoretical framework only briefly. [9]

The general cost function can be written as

$$C = f(\mathbf{w}, \mathbf{Y}, \mathbf{Z}, u, t) \tag{1}$$

and the general (alternative) profit function as

$$\Pi = f(\mathbf{w}, \mathbf{Y}, \mathbf{Z}, \pi, t), \tag{2}$$

where C is variable costs, Π is variable profits, $\mathbf{w}$ is a vector of input prices, $\mathbf{Y}$ is vector of variable outputs, $\mathbf{Z}$ is a vector of fixed netputs (either inputs or outputs), u is bank-specific cost inefficiency, π is bank-specific profit efficiency, and t is time,

[9] See Berger and Humphrey (1997) for a detailed review of the literature and Berger and Mester (1997) for methodological details. In the literature on Swiss banks, Sheldon and Haegler (1993) and Sheldon (1994) also use the intermediation approach.

which proxies for technological and other environmental changes. [10] We drop firm and time subscripts for ease of exposition.

Note that we focus on an alternative profit function, which includes output quantities as the arguments of the profit function, rather than a "standard" profit function, which include output prices as the arguments. As discussed below, this reflects a lack of reasonable output price data for some of our sample and our belief that it is a more appropriate function. [11]

A critical decision in this type of analysis is the choices of the vectors of outputs, inputs, and netputs. The remainder of this section describes our choices for each, the rationale for these decisions, and summary data.

3.2.1. Outputs and netputs

As mentioned above, Swiss banks vary considerably in their involvement with non-traditional financial activities. This makes the definition of the output vector crucial to appropriately gauge the industry's production characteristics. In a universal banking system like Switzerland, it is imperative to consider the outputs related to financial market activities (portfolio management, trading, brokerage, etc.), as well as those related to traditional banking activities (different types of loans or securities). Thus, our study includes measures of brokerage and portfolio management activities, OBS items, and trading activities.

While conceptually desirable, the inclusion of these financial market activities also introduces several measurement problems due to limitations in the regulatory data. First, brokerage and portfolio management activities can be measured only jointly. For OBS activities, we can only measure them in terms of quantities using the credit equivalent amounts, but it is not possible to isolate the income generated by these positions. Finally, trading activities can be measured in terms of income and quantity, but these two measures fluctuate strongly with market movements and are thus harder to interpret.

These measurement issues make it difficult to identify a priori the best output definition. To avoid arbitrarily selecting one output definition, we use several variants ranging from a very narrow output definition to a very broad one. These broader definitions are richer than used by Sheldon and Haegler (1993) and Sheldon (1994), who do not consider OBS positions and trading activities, and provide a more accurate picture of the production structure of Switzerland's universal banks. The three definitions are defined as follows.

The "naïve" definition, *Y-1*, includes only three traditional measures of bank outputs in the output vector **Y**: Loans to banks, mortgage loans, and loans to customers (excluding mortgages). Equity capital and physical capital comprise the netput vector, **Z**. All quantities are measured by the inflation-adjusted book value of the variable.

[10] Fixed netputs are quasi-fixed quantities of either inputs or outputs that affect variable costs or profits due to substituability or complementarity with variable netputs.

[11] As a robustness check, we estimate a standard profit function for a reduced sample of banks and a narrower output specification. Details are provided in Section 6.

The "intermediate" definition, *Y-2*, augments the output vector with a fourth output, securities and participations, which is again measured by the balance sheet position. This is still a relatively traditional view of bank activities, although somewhat broader than the strict lending definition. In addition, we augment the netput vector with a third variable: The credit equivalent of traditional OBS positions such as contingent liabilities, irrevocable facilities, and commitment credits. These positions are credit related and thus a natural extension of the narrow specification. The credit-equivalent of these positions is obtained by multiplying their notional amount with the conversions factors defined in the Swiss Banking Law.

The "universal" definition, *Y-3*, extends the output vector to include two non-traditional outputs: trading activities, and brokerage and portfolio management. Trading activities are measured by assets recorded in the trading book position, while brokerage and portfolio management activities are measured by the amount of securities accounts outstanding. The former is an imprecise measure of the quantity of trading activities, but data constraints force us to make this approximation because we do not have data on the number or volume of transactions. The netput vector is also extended to include the credit-equivalent of derivative activities, measured as the replacement value or initial exposure, depending on the bank's accounting method. This universal definition spans the full range of activities that Swiss banks undertake.

3.2.2. Inputs

On the input side, the price vector, **w**, includes the price of labor (measured as the average wage and benefit per employee) and the interest rate on all liabilities (measured as the interest payments on money-market paper, liabilities to banks, demand, savings and term deposits, bonds and mortgage bonds). Because Swiss banks are required to report only their total interest expenses, we were unable to calculate specific interest rates for the different kinds of liabilities. As mentioned above, premises and other fixed assets are considered as fixed netputs, and not as inputs. This choice reflects the difficulty in calculating a reliable input price in the absence of data on the market value of real estate and premises. Sheldon and Haegler (1993) and Sheldon (1994) recognize the measurement problem, but nevertheless include a third input price defined as expenditures on office space and materials divided by total employees.

3.2.3. Costs and profits

From these definitions, variable costs, C, and variable profits, Π, are defined as follows. For all three definitions, variable costs are the interest expenses on all banks liabilities plus total salaries and benefits expenditure. Variable profits depend on the output definitions. For *Y-1*, variable profits, Π*-1*, is defined as the interest income from all loans less variable costs. For *Y-2*, Π*-2* equals Π*-1* plus interest income from securities and participations. For the third definition, *Y-3*, Π*-3* equals Π*-2* plus trading income and fee income generated by brokerage, underwriting, and portfolio management fees.

Table 2
Cost and profit function variables, 1999

	Mean	Standard deviation	Minimum	Maximum
Variable costs	211.8	1710.9	0.3	27,325.8
Variable profits				
Naïve, *Y-1*	−15.4	208.8	−3153.4	301.6
Intermediate, *Y-2*	−8.8	199.0	−3113.2	390.2
Universal, *Y-3*	97.6	646.0	−4.7	1020.0
Variable input prices				
Deposits	2.22	1.59	0.02	18.35
Wages and salaries	132.6	57.8	17.0	421.3
Variable output quantities				
Money market claims	1776.7	15,833.5	0.0	257,617.7
Bank loans	2150.8	22,350.4	0.1	356,858.0
Mortgage loans	1574.9	8604.4	0.0	123,151.3
Securities	246.4	1113.7	0.0	11,794.0
Trading assets	826.9	11,634.0	0.0	196,811.7
Amount of securities accounts	5875.0	39,759.5	0.0	613,753.1
Fixed netputs				
Equity capital	344.9	2179.1	1.7	34,919.4
Physical capital	59.6	560.9	0.0	6741.6
OBS commitments	418.5	4460.6	0.0	73,966.9
Derivatives	2.2	11.5	0.0	137.7
Total assets	7338.5	66,907.7	15.5	1,098,175.4

Note: Variable costs, variable profits, variable output quantities, fixed netputs, and total assets are measured in millions of 1999 Swiss francs. Price of deposits is a percentage. Price of labor is in thousands of 1999 Swiss francs. Output definitions *Y-1*, *Y-2*, and *Y-3* are defined in Section 3. Results for main sample of 289 banks.

Table 2 reports summary statistics for the 289 Swiss banks for all of the variables used in the cost and profit function estimates in 1999. As can be seen from all variables, there is considerable variation within our sample. Total assets, for example, ranges from Sfr 15 millions to over Sfr 1 trillion. Similarly, there is wide variation in outputs, with many banks choosing to produce none of a particular output. Table 2 also reports the mean value of measured costs and profits for each definition.

4. Methodology

In this section, we present the methodology used to estimate relative cost and profit efficiency, economies of scale, and economies of diversification. We begin with the functional form for both the cost and alternative profit function, and then detail the definitions used for cost efficiency, profit efficiency, economies of scale, and economies of diversification.

4.1. Translog function

We use a parametric approach with a translog specification throughout our analysis. This choice was motivated by the fact that the Fourier-flexible specification, which is somewhat more flexible than the translog and common in many studies, requires the estimation of additional parameters and truncation of data. This is a problem for us due to the already small size of our sample. Moreover, while studies often find that the additional parameters are jointly statistically significant, Berger and Mester (1997) indicate that the improvement obtained through the use of the Fourier-flexible is not "significant from an economic viewpoint (p. 924)". The translog specification takes the following form:

$$\begin{aligned}\ln X = {} & \alpha + \sum_i \alpha_i \ln w_i + \sum_i \beta_i \ln Y_i + \sum_{ii} \varphi_i \ln Z_i + \sum_i \sum_j \lambda_{ij} \ln w_i \ln w_j \\ & + \sum_i \sum_j \delta_{ij} \ln Y_i \ln Y_j + \sum_u \sum_j \phi_{ij} \ln Z_i \ln Z_j + \sum_i \sum_j \tau_{ij} \ln w_i \ln Y_j \\ & + \sum_i \sum_j \eta_{ij} \ln w_i \ln Z_j + \sum_i \sum_j \kappa_{ij} \ln Y_i \ln Z_j + \varepsilon, \end{aligned} \tag{3}$$

where X is a transformation of either variable costs or variable profits, and w_i, Y_i, and Z_i represent elements of the vectors, $\mathbf{w}$, $\mathbf{Y}$, and $\mathbf{Z}$, respectively. Time and bank subscripts are suppressed. [12]

There are several points to note about Eq. (3). First, Eq. (3) is the basic specification for all results, but the details differ across applications. Most important, the number of outputs and netputs varies across the three output definitions described above. Second, in the cost and profit efficiency estimates, the independent variable and all right-hand side quantities are scaled by equity capital. This helps to reduce heteroskedasticity and scale bias. In addition, this gives a nice interpretation for the profit function estimates as a return on equity. Third, we impose linear homogeneity in all estimates. Finally, symmetry restrictions in all quadratic terms are imposed in accordance with economic theory, $\lambda_{ij} = \lambda_{ji}, \delta_{ij} = \delta_{ji}$, $\phi_{ij} = \phi_{ji}$.

Sheldon and Haegler (1993) and Sheldon (1994) use both a parametric and a non-parametric approach. We chose a parametric technique primarily because they correspond well with the cost and profit efficiency concepts outlined above. As argued by Berger and Mester (1997), non-parametric methods generally ignore input and output prices and account only for technical inefficiency (using too many inputs or producing too few outputs) and not for allocative inefficiency (errors in choosing inputs and outputs given relative prices). Thus, non-parametric techniques focus on technological optimization rather than economic optimization, and do not correspond to the cost and profit efficiency discussed earlier.

[12] To avoid taking logs zero values, all right-hand side quantities are set equal to one plus their reported value.

We examine efficiency as well as scale and scope economies, so one methodological issue is whether one should include cost share equations when estimating the Eq. (3). That is, Shephard's Lemma implies that the derivative of the log cost function with respect to a log input price equals that input's share of total costs. We follow Berger and Mester (1997) and estimate Eq. (3) without the cost share equations because the restrictions underlying Shephard's Lemma impose the undesirable assumption of no allocative inefficiency. Then, because we find evidence of substantial inefficiency, we also exclude the share equations for our estimation of scale economies and economies of diversification. [13]

4.2. Cost and profit efficiency: The distribution-free approach

Our estimates of relative cost and profit efficiency are mainly based on the "distribution-free" approach developed by Berger (1993), and recently employed by Berger and Mester (1997) and others. This approach has been described extensively in the literature and we provide only a brief summary of our methodology. [14]

The distribution-free approach estimates production efficiency by comparing the relative performance, measured either by costs or profits, for a common set of institutions over several periods. Intuitively, if a bank consistently reports higher costs (lower profits), *ceteris paribus*, it is considered cost (profit) inefficient. The econometric difficulty is in identifying the persistent part of unexplained costs (profits), which is considered the important firm-specific characteristic, from the transitory part, which is considered random noise. The distribution-free approach does this by comparing many observations of observed and predicted costs for each bank and inferring that the average difference is a good indicator of the unobserved inefficiency parameter.

More precisely, consider the following general specification for the cost function:

$$\ln C = f(\mathbf{w}, \mathbf{Y}, \mathbf{Z}) + \ln u_i + \varepsilon, \tag{4}$$

where $f(\cdot)$ follows Eq. (3), u_i represents unobservable firm-specific cost inefficiency, and ε is random error.

To estimate the unobserved cost inefficiency component, the distribution-free approach uses separate cross-section regressions of Eq. (4) for each of the t years

[13] As a practical matter, inclusion of the share equation did not change the point estimates of scale economies and economies of diversification dramatically, although the standard errors were smaller with joint estimation of the cost function and the share equations.

[14] As a consistency check, we also estimated cost efficiency using the "stochastic frontier," which assumes the random error has a two-sided distribution, while the inefficiency term is half-normal. Berger and Mester (1997) discuss the relative advantages and disadvantages of the two approaches and report efficiency estimates based on the stochastic frontier only for the years where the distribution of the residuals shows the appropriate skew. We follow this approach and find the appropriate distribution for only one year for the cost function, and for three years for the profit function. Therefore, the results obtained from the stochastic frontier are not very representative, although we will use them as a robustness check of our main distribution-free approach.

of data in the sample. Under the assumption that the random errors average to zero over time for each bank, a simple average of the t regression residuals approximates the unobserved bank-specific cost inefficiency term. [15] That is, banks with a small u_i are considered relatively cost efficient since they incur lower costs, all else equal.

A formal definition of bank-specific relative cost efficiency is

$$C\text{-EFF}_i = \frac{\exp(f(\mathbf{w}, \mathbf{Y}, \mathbf{Z})) \cdot \exp(\ln u_{\min})}{\exp(f(\mathbf{w}, \mathbf{Y}, \mathbf{Z})) \cdot \exp(\ln u_i)} = \frac{u_{\min}}{u_i}, \tag{5}$$

where u_i is the average regression residual for bank i and $u_{\min}$ is the smallest value for all banks, i.e., the "best cost-practice" bank. Eq. (5) provides a natural ranking of relative cost efficiency that ranges from 1.0 for the best cost-practice bank on the efficient frontier to zero (in the limit) for a highly inefficient bank. This definition also has a nice interpretation for banks that are labeled cost inefficient, i.e., if $C\text{-EFF}_i = 0.95$ then 5% of its observed costs can be attributed to cost inefficiency.

Relative profit efficiency is estimated in a similar conceptual manner, but a practical issue makes it more difficult to implement. Profits can reasonably be negative, so the simplified cost function in Eq. (4) must be transformed to prevent taking logs of a negative number. This is done by adding a constant, Θ, set equal to one plus the absolute value of the minimum profit in each year, so that the general specification for the profit function becomes

$$\ln(\Pi + \Theta) = f(\mathbf{w}, \mathbf{Y}, \mathbf{Z}) + \ln \pi_i + \varepsilon \tag{6}$$

and the measure of relative profit efficiency is

$$\Pi\text{-EFF}_i = \frac{\exp(f(\mathbf{w}, \mathbf{Y}, \mathbf{Z})) \cdot \exp(\ln \pi_i) - \Theta}{\exp(f(\mathbf{w}, \mathbf{Y}, \mathbf{Z})) \cdot \exp(\ln \pi_{\max}) - \Theta}, \tag{7}$$

where π_i is estimated as the average residual for bank i, $\pi_{\max}$ is the maximum residual for the "best profit-practice" bank, and the $f(\cdot)$ function is evaluated using the estimated coefficients for each year and the right-hand side variables for each bank. The fitted values are then averaged across years to generate a single estimate of Π-EFF for each bank. Note that unlike the cost efficiency measure, profit efficiency is not bounded at zero. A bank could inefficiently loose more than 100% of potential profits, which would cause profit efficiency to be negative.

4.3. Economies of scale and diversification

Our sample of Swiss banks spans a wide range of sizes and a natural question is the existence of economies of scale. This has been a common topic in the empirical analysis of commercial bank performance with the most recent research finding strong evidence of scale economies in the US, e.g., Berger and Mester (1997)

[15] Note that this differs from a fixed-effect regression since each cross-section is estimated separately, effectively allowing all coefficients to vary year-by-year. Sheldon and Haegler (1993) and Sheldon (1994), for example, use a constrained model where all coefficients are held constant over time and relative inefficiency is calculated from a traditional fixed effect. The distribution-free approach is less restrictive.

and Hughes and Mester (1998). Evidence from Switzerland, reported in Sheldon (1994) finds strong economies of scale throughout his sample using parametric methods.

To assess the importance of scale economies, intuitively described as a reduction in average costs as output size increases, we examine several related measures. Again, the methodology has been explained in detail elsewhere and we only brief review our approach.

The most obvious way to compare the performance of different size institutions is to look at familiar accounting ratios like ROA, ROE, or the efficiency ratio (defined as non-interest expense as a percent of net interest income plus non-interest income). In addition to these standard ratios, we create a cost to assets ratio (C/A) using costs, as defined above in Section 2, and total assets. By comparing this ratio across different size institutions, we obtain a crude measure of scale economies.

A more formal measure is given by RSE developed by Baumol et al. (1982) and applied to banking by Berger et al. (1987). RSE is essentially the multi-product extension of the cost-output elasticity and measures the elasticity of costs with respect to a proportional increase in all outputs. RSE is defined as

$$\mathrm{RSE} = \sum_i \frac{\mathrm{d}\ln C(\overline{\mathbf{w}}, \overline{\mathbf{Y}}, \overline{\mathbf{Z}})}{\mathrm{d}\ln Y_i}, \tag{8}$$

where Y_i is the ith output from the output vector and bars reflect means of the vectors. RSE < 1 signifies scale economies since costs increase proportionally less than outputs, while RSE > 1 means diseconomies of scale.

While a useful statistic, RSE suffers from an important limitation. By assuming all outputs grow proportionally, it ignores the vast differences in output mixes across different size institutions. In Switzerland, for example, large banks hold more trading assets as a percent of total assets, while the smaller ones hold more securities and participations as a percent of total assets. To account for this distinction, Berger et al. (1987) developed an alternative measure of scale economies called expansion path scale economies, $\mathrm{EPSCE}^{A,B}$, which measures the proportional changes in costs as banks move along the observed expansion path from the small bank A to the large bank B. $\mathrm{EPSCE}^{A,B}$ is defined as

$$\begin{aligned}\mathrm{EPSCE}^{A,B} = {} & \sum_i \frac{\mathrm{d}\ln C(\overline{\mathbf{w}}, \overline{\mathbf{Y}}^B, \overline{\mathbf{Z}}^B)}{\mathrm{d}\ln Y_i} \cdot \frac{\left(Y_i^B - Y_i^A\right)}{Y_i^B} \\ & \times \frac{\left(C(\overline{\mathbf{w}}, \overline{\mathbf{Y}}^B, \overline{\mathbf{Z}}^B) - C(\overline{\mathbf{w}}, \overline{\mathbf{Y}}^A, \overline{\mathbf{Z}}^B)\right)}{C(\overline{\mathbf{w}}, \overline{\mathbf{Y}}^B, \overline{\mathbf{Z}}^B)},\end{aligned} \tag{9}$$

where $\overline{\mathbf{Y}}^A$ and $\overline{\mathbf{Z}}^A$ are the mean output and netput bundle of banks in the smaller class A, $\overline{\mathbf{Y}}^B$ and $\overline{\mathbf{Z}}^B$ are the mean output and netput bundle of banks in the larger class B, and other input price means are for the entire sample. Like, RSE, $\mathrm{EPSCE}^{A,B} < 1$ implies economies of scale since costs increase proportionally less than outputs, while $\mathrm{EPSCE}^{A,B} > 1$ implies diseconomies of scale. The important difference, however, is that $\text{EPSCE}^{A,B}$ accounts for observed changes in the output mix between small and large banks.

Our final measure is called expansion path sub-additivity (EPSUB), and is somewhat of a hybrid measure of pure scope and scale economies, which we refer to as "economies of diversification" to distinguish it from the pure scope measure. EPSUB measures the predicted cost differences if an observed bank were arbitrarily divided into two smaller banks that produced the same total output, i.e., an observed bank B with output bundle $\mathbf{Y}^B$ divided into two smaller, hypothetical banks, A and D where $\mathbf{Y}^A + \mathbf{Y}^D \equiv \mathbf{Y}^B$. Following Jagtiani and Khanthavit (1996), the hypothetical banks A and D can be created from observed bank B by breaking down the mean output vector in a size class into the minimum of each output and a residual (mean output less minimum output). This approach is called the "min–mean" path. Alternatively, one can break the maximum output into the mean output and a residual (maximum output less mean output). This is called the "mean–max" path. The third approach, following Mitchell and Onvural (1996), estimates EPSUB along the expansion path from the mean output vector of one size class to the mean of the next size class. This approach is called the "mean–mean" path.

More formally, EPSUB compares the predicted costs from the two hypothetical bank to the observed bank as

$$\text{EPSUB} = \frac{C(\overline{\mathbf{w}}, \mathbf{Y}^A, \overline{\mathbf{Z}}) + C(\overline{\mathbf{w}}, \mathbf{Y}^D, \overline{\mathbf{Z}}) - C(\overline{\mathbf{w}}, \mathbf{Y}^B, \overline{\mathbf{Z}})}{C(\overline{\mathbf{w}}, \mathbf{Y}^B, \overline{\mathbf{Z}})}, \tag{10}$$

where the cost functions are evaluated at the means of the other variables. $\text{EPSUB} < 0$ implies the two smaller banks could produce the same output at a lower total cost and output bundle B is not competitively viable. This is referred to as "superadditive" costs. $\text{EPSUB} > 0$ implies the larger bank incurs lower costs and the smaller banks have an incentive to expand since joint production can occur at lower costs. This is referred to as "subadditive" costs. [16]

5. Results

We now turn to our estimates of cost and profit functions for 289 Swiss banks from 1996 to 1999. We use these parameter estimates to examine relative cost and profit efficiency, economies of scale, and economies of scope for the Swiss banks. [17]

[16] EPSUB is a generalized version of a more conventional measure of scope economies that compares the observed bank to a hypothetical set of perfectly specialized banks. We do not use this measure of scope economies due to the unrealistic assumption of perfectly specialized banks. Moreover, as pointed out by Berger et al. (1987), estimates of traditional scope economies depend critically on the evaluation point for output quantities set arbitrarily near zero.

[17] The analysis began with 389 banks. We dropped 83 banks either because of obvious data errors or incomplete data for all years. In addition, since the price data are measured with error, we followed Berger and Mester (1997) and dropped questionable input price observations (more than 2.5 standard deviations from the annual mean). This left 289 banks with reasonable data for all four years.

5.1. Efficiency results

Our overall cost efficiency and profit efficiency results for all Swiss banks in our sample are reported in the top panel of Table 3. For both measures, we report the mean efficiency (weighted averages across all banks) for each of the three output definitions and the corresponding standard deviations. Weights are the denominator of the efficiency ratios, Eqs. (5) and (7), so that the averages better represent the sample. As far as we know, these are the first estimates of profit efficiency for Swiss banks.

In terms of cost efficiency, estimated from Eq. (5), the estimates range from 0.49 for the naïve definition *Y-1* to 0.69 for the intermediate definition *Y-2*. These estimates imply substantial relative inefficiency in the Swiss banking system with one-third to one-half of all costs attributed to inefficient production. Our preferred

Table 3
Average cost and profit efficiency, 1996–1999

	C-EFF	Π-EFF
Weighted means for all banks		
Naïve, *Y-1*	0.487	−0.129
	(0.099)	(0.719)
Intermediate, *Y-2*	0.686	−0.010
	(0.139)	(0.625)
Universal, *Y-3*	0.574	0.482
	(0.085)	(0.179)
Weighted means by size deciles		
Smallest	0.529	0.447
2	0.595	0.393
3	0.631	0.493
4	0.572	0.617
5	0.643	0.526
6	0.614	0.484
7	0.633	0.445
8	0.628	0.551
9	0.612	0.560
Largest	0.566	0.470
Median by type of bank		
Cantonal	0.588	0.557
Big	0.530	0.506
Regional	0.606	0.575
Commercial	0.654	0.451
Stock exchange	0.588	0.606
Consumer	0.600	0.553
Other	0.574	0.544
Foreign	0.604	0.436

Note: Weighted mean efficiency measures are weighted averages for all 289 banks with weights equal to the denominator of the efficiency ratio. C-EFF = 1 for the "best cost-practice" bank and Π-EFF = 1 for the "best profit-practice" bank. Standard deviations are in parentheses. Output specifications *Y-1*, *Y-2*, and *Y-3* are defined in Section 3. Size deciles are based on average assets for the period 1996–1999. Weighted means by size deciles and medians by bank type are based on the *Y-3* output specification.

universal definition *Y-3*, which includes the broadest combination of outputs and netputs, yields an estimate of 0.57 and is the most precisely estimated measure. This implies that about 40% of observed costs are due to inefficiency relative to the best cost-practice bank. [18]

These results are partially consistent with earlier work on Swiss banks, e.g., Sheldon (1994) reports an estimate of cost efficiency 0.56 for 477 Swiss from 1987 to 1990 using non-parametric methods, although only 0.04 using parametric methods. Our universal definition, *Y-3*, yields a larger estimate, which likely reflects both our more flexible estimation procedure and our broader output concept. Given our results and the non-parametric results of Sheldon (1994), we conclude that Swiss banks operate with substantial relative inefficiency, but not the "astronomical" level from Sheldon and Haegler (1993) parametric results. Those estimates appear implausible from an economic standpoint and seem to be driven by a few outliers (Sheldon and Haegler, 1993, Fig. 4). [19]

These average estimates are also lower than those estimated for US institutions, e.g., Berger and Mester (1997) and Stiroh (2000). While we cannot draw any inferences about the comparative levels of efficiency because each study's estimates are relative to that study's best practice, it is interesting to note that more Swiss banks, on average, appear to be operating farther from the efficient frontier than in the US. One explanation might be the larger heterogeneity in the universal Swiss system.

In terms of profit efficiency, estimated from Eq. (7), our estimates show considerable variation over the three output definitions, ranging from −0.13 for the naïve definition *Y-1* to 0.48 for universal definition *Y-3*. [20] We do not, however, give much credence to the profit efficiency estimates from the naïve and intermediate cases because they are estimated very imprecisely and ignore large parts of the activities that are clearly important to Swiss banks. This comparison, however, is quite informative and shows the critical importance of accounting for the large range of activities undertaken by universal banks in Switzerland. Failure to do so leads profit efficiency to be dramatically understated. Even with our preferred *Y-3* universal definition,

[18] Mean cost efficiency could be estimated only for 1996 (half normal distribution); this is consistent with the fact that the distribution of efficiencies derived from the distribution-free approach is largely symmetric. Mean cost efficiency is higher with the stochastic frontier approach, e.g., 0.79 vs. 0.57, although the rank correlation is quite high at 0.79. We prefer the efficiency estimate based on the distribution-free approach because it is based on a larger number of years.

[19] One possible explanation is that Sheldon (1994) and Sheldon and Haegler (1993) do not exclude banks with "abnormal" input prices. These outliers may bias the efficiency estimates based on the parametric approach, but not those based on the non-parametric approach since the latter does not take input prices into consideration.

[20] Mean profit efficiency could be estimated for 1996, 1998 and 1999; this is consistent with the fact that the distribution of profit efficiencies derived from the distribution-free approach has the appropriate skew. Mean profit efficiency averaged over the three years is higher with the stochastic frontier approach, e.g., 0.62 vs. 0.48, and again the correlation of estimates from the two approaches is high at 0.84. We consider the efficiency estimate based on the distribution-free approach as more representative, as it is based on a larger number of years.

however, we conclude that about one-half of potential profits are foregone relative to the best profit-practice bank.

We interpret these differences across output definitions as strong evidence that one must take a broad view of Swiss banks and include non-traditional banking activities to correctly gauge their productive efficiency. The remainder of our empirical work uses the universal definition because it appears to provide the most reasonable representation of the bank activities.

Our preferred efficiency estimates based on the *Y-3* definition show little variation in cost or profit efficiency across size classes (second panel of Table 3), a result that is robust to the definition of bank size. [21] Except for the very largest, banks appear most cost efficient when our universal banking definition is used. Turning to variation across types of Swiss banks, the results indicate that the commercial banks are the most cost efficient, while the stock exchange banks appear the most profit efficient (bottom panel of Table 3). As discussed earlier, Swiss banking consolidation has been most intense among the cantonal and regional banks. Both of these groups, on average, appear to be similar to the industry as a whole in terms of relative efficiency, which suggests that inefficiency was not a driving force behind their demise. This interpretation is tentative, however, since we are looking at surviving banks, and a survivor bias cannot be excluded. That is, the most inefficient banks may be the ones that have exited our sample. We can only conclude that regional and cantonal banks taken as a category are not currently less efficient that other banks. [22]

There may be some concern that these efficiency estimates are being driven by a subset of banks that behaves in fundamentally different ways from the majority. As a robustness check, we re-estimated cost and profit efficiency excluding the three largest Swiss banks. Our efficiency estimates did not change substantially, e.g., cost and profit efficiency from the universal specification were 0.599 and 0.521, respectively, so we conclude that these banks are not driving our results.

5.2. Economies of scale and diversification results

We now turn to our estimates of economies of scale for Swiss banks for various size classes. Given the implausible profit efficiency findings using output definitions *Y-1* and *Y-2*, we report estimates of RSE, $\text{EPSCE}^{A,B}$, and EPSUB based on the universal definition *Y-3*. In all cases, we estimate the cost function in Eq. (3) for each year. We then evaluate Eqs. (8)–(10) using the estimated coefficients and either annual means from the entire sample (input prices) or annual means for each size class (output and netput quantities). This emphasizes the impact of changes in the output

[21] Reported results are weighted means by size deciles, where banks are placed into groups based on average assets for the period 1996–1999. Similar results hold if we use income as the size measure.

[22] We obtained the same ranking by group using the stochastic frontier approach. This is due to the high rank-order correlation, 0.79 (0.84), with the cost (profit) efficiency estimates based on the distribution-free method. Allen and Rai (1997) also find high rank-order correlation in spite of substantial differences in mean efficiency.

bundle, ceteris paribus. The size classes are defined as: Class 1, assets < Sfr 100 million; Class 2, Sfr 100 million < assets < Sfr 200 million; Class 3, Sfr 200 million < assets < Sfr 500 million; Class 4, Sfr 500 million < assets < Sfr 1.5 billion; Class 5, Sfr 1.5 billion < assets < Sfr 10 billion; Class 6, assets > Sfr 10 billion.

Table 4 reports estimates for C/A, RSE, $EPSCE^{A,B}$ for each size group for each year. The most primitive measure, C/A, shows declining average costs with size. In all years, the smallest banks incur the highest costs per assets and costs remain relatively flat through the fifth size class (about Sfr 10 billion). The largest size class shows the lowest average cost in all years. This is somewhat different from Sheldon (1994), who found that diseconomies of scale set in between Sfr 160 million and Sfr 1.2 billion.

Turning to the more formal measures of economies of scale, we find some evidence of economies of scale in all years from both RSE and $EPSCE^{A,B}$ for the small and mid-size banks. In 1999, for example, we estimate that a 1.0% increase in all assets would raise predicted costs by 0.58% for the smallest size classes and by 0.85% for the largest banks as measured by RSE. For $EPSCE^{A,B}$, a 1.0% increase along the expansion path increases costs by 0.96% from Classes 1 to 2 and a 0.95% increase from Classes 5 to 6. We cannot formally reject the null hypothesis of no economies of scale for the large banks in most cases, however, so we interpret the results as economies of scale for small banks, but not for the largest banks. Note, however, that there is some variation across years, particularly for $EPSCE^{A,B}$.

In general, these results are consistent with the earlier parametric results of Sheldon and Haegler (1993). They report RSE of 0.33 for the smallest asset class and 0.75 for the largest, with a sample average of 0.54; their $EPSCE^{A,B}$ ranged between 0.68 and 0.83.

Table 5 reports EPSUB estimates, calculated in three different ways. Recall that the "min–mean" path creates hypothetical banks A and D from observed bank B by breaking down the mean output vector in each size class into the minimum of each output and the residual. The "mean–max" path breaks the maximum output into the mean output and the residual. The "mean–mean" path measures along EPSUB the expansion path from the mean output vector of one size class to the mean of the next size class. In all cases, total predicted costs are then calculated using sample means of input prices and netput quantities.

For EPSUB to capture scope effects, it is necessary that the hypothetical banks A and D be more specialized than bank B. To check this, we computed a Herfindahl-like indicator of each bank's specialization, defined as the sum of the squared shares of traditional and non-traditional income, where non-traditional income equals brokerage fees, trading income, and other fees. Indeed, we observe a negative correlation between specialization and size (discussed later in Table 6). This negative relationship between size and specialization means that bank B (the large bank) is less specialized than bank A and D (the two smaller banks) and implies that EPSUB captures some scope effects. Because the hypothetical banks A and D are not perfectly specialized, however, EPSUB captures not only economies of diversification but also scales economies.

Table 4
Economies of scale by size class, 1996–1999

Classes	Size range	Year			
		1996	1997	1998	1999
Costs/assets					
1	$A < 100$	5.94	5.32	5.59	4.55
		(3.42)	(2.77)	(3.20)	(2.22)
2	$100 < A < 200$	4.84	4.58	4.07	3.70
		(2.04)	(2.47)	(2.06)	(1.75)
3	$200 < A < 500$	3.99	3.88	3.97	3.58
		(1.19)	(1.29)	(1.95)	(1.95)
4	$500 < A < 1500$	4.38	4.20	4.25	3.93
		(1.56)	(1.45)	(1.83)	(2.17)
5	$1500 < A < 10,000$	4.28	4.02	3.95	3.66
		(0.86)	(1.09)	(1.42)	(1.31)
6	$10,000 < A$	3.80	3.56	3.41	2.99
		(0.40)	(0.59)	(0.74)	(0.56)
RSE					
1	$A < 100$	0.470*	0.498**	0.552**	0.584**
		(0.312)	(0.203)	(0.213)	(0.170)
2	$100 < A < 200$	0.451*	0.539**	0.588*	0.622**
		(0.295)	(0.191)	(0.211)	(0.172)
3	$200 < A < 500$	0.488*	0.621**	0.702	0.658*
		(0.295)	(0.187)	(0.196)	(0.174)
4	$500 < A < 1500$	0.544	0.671*	0.708	0.680*
		(0.307)	(0.195)	(0.202)	(0.178)
5	$1500 < A < 10,000$	0.620	0.791	0.805	0.732
		(0.304)	(0.196)	(0.200)	(0.187)
6	$10,000 < A$	0.747	1.000	0.949	0.854
		(0.313)	(0.210)	(0.199)	(0.209)
EPSCE^{A,B}					
1	$A < 100$	na	na	na	na
2	$100 < A < 200$	0.010**	0.781	0.701***	0.957
		(0.473)	(0.165)	(0.109)	(0.074)
3	$200 < A < 500$	0.532**	0.917	0.706**	1.391
		(0.216)	(0.136)	(0.131)	(0.424)
4	$500 < A < 1500$	0.614**	0.797	0.791**	0.943
		(0.179)	(0.125)	(0.105)	(0.078)
5	$1500 < A < 10,000$	0.587**	0.872	0.837	0.993
		(0.195)	(0.120)	(0.111)	(0.087)
6	$10,000 < A$	0.655	0.990	0.957	0.947
		(0.239)	(0.174)	(0.167)	(0.162)

Note: Costs/assets is actual variable costs per assets multiplied by 100 and the standard deviation for each size class is in parentheses. RSE and EPSCE^{A,B} are estimated from a separate cost function using *Y-3* for each year and evaluated with means from each size class. Standard errors are in parentheses. Size classes are based on total assets, in Sfr millions. RSE $<$ ($>$)1 implies scale economies (diseconomies). EPSCE^{A,B} $<$ ($>$)1 implies scale economies (diseconomies) on the path from A to B. ***, **, * indicate that the estimates are significantly different from 1.0 at the 99%, 95%, and 90% level, respectively.

Table 5
Economies of scale and scope by size class, 1996–1999

Classes	Size range	Year 1996	1997	1998	1999
EPSUB – min–mean					
1	$A < 100$	0.116	0.004	−0.002	0.001*
		(0.277)	(0.008)	(0.002)	(0.001)
2	$100 < A < 200$	0.007	0.002	0.001	−0.001
		(0.018)	(0.007)	(0.007)	(0.001)
3	$200 < A < 500$	0.002	−0.006	−0.008	−0.003
		(0.011)	(0.013)	(0.015)	(0.002)
4	$500 < A < 1500$	0.001	−0.004	−0.004	−0.013
		(0.012)	(0.013)	(0.009)	(0.010)
5	$1500 < A < 10,000$	−0.015	−0.039	−0.005	−0.023
		(0.030)	(0.031)	(0.038)	(0.024)
6	$10,000 < A$	−0.020	−0.043**	−0.035*	−0.033
		(0.044)	(0.018)	(0.022)	(0.025)
EPSUB – mean–max					
1	$A < 100$	0.291	0.249	0.125	0.156
		(0.286)	(0.159)	(0.146)	(0.119)
2	$100 < A < 200$	0.362	0.170	0.052	0.104
		(0.314)	(0.173)	(0.136)	(0.153)
3	$200 < A < 500$	0.285	0.106	0.040	0.079
		(0.288)	(0.144)	(0.125)	(0.147)
4	$500 < A < 1500$	0.261	0.125	0.077	0.148
		(0.279)	(0.154)	(0.148)	(0.175)
5	$1500 < A < 10,000$	0.217	0.052	0.029	0.086
		(0.266)	(0.131)	(0.127)	(0.135)
6	$10,000 < A$	0.082	−0.073	−0.069	−0.062
		(0.216)	(0.079)	(0.064)	(0.076)
EPSUB – mean–mean					
1	A < 100	na	na	na	na
2	$100 < A < 200$	–	0.306*	0.253	0.158
		–	(0.182)	(0.179)	(0.148)
3	$200 < A < 500$	0.411	0.285*	–	0.189
		(0.295)	(0.169)	–	(0.157)
4	$500 < A < 1500$	0.362	0.212	0.168	0.173
		(0.311)	(0.161)	(0.160)	(0.146)
5	$1500 < A < 10,000$	0.195	0.084	0.087	0.118
		(0.250)	(0.138)	(0.133)	(0.135)
6	$10,000 < A$	0.073	−0.015	−0.009	0.001
		(0.152)	(0.053)	(0.042)	(0.050)

Note: EPSUB is estimated from a separate cost function for each year using specification *Y-3* and evaluated with mean prices and netputs from each sample. Missing values reflect cases where at least one output did not decline between size classes. Standard errors are in parentheses. Size classes are based on total assets in Sfr millions. EPSUB $<$ ($>$) 0 imply lower (higher) estimated costs for the two component firms. ** and * indicate that the estimates are significantly different from zero at the 95% and 90% level, respectively.

These results provide mixed evidence in terms of economies of diversification. While most estimates are positive, which implies costs are "subadditive" with cost savings for the combined bank, standard errors are often large. The min–mean estimates, on the other hand, are much smaller and show weak evidence of diseconomies of scope. We interpret this as limited evidence for economies of diversification for the smaller banks in our sample, but not for large ones.

Sheldon and Haegler (1993) report similar results in their EPSUB estimates, which ranged from 0.42 to 0.28 for banks with assets below Sfr 45 billion, and −0.11 for larger banks. They also estimate a more traditional measure of scope economies, which indicated diseconomies of scope. Based on this ambiguous evidence, those authors infer the presence of diseconomies of scope and conclude that banks would gain greater cost savings if they specialized as they grew. Sheldon and Haegler (1993), however, do not report standard errors so it is difficult to judge significance.

6. Robustness checks

Our econometric work provides estimates of cost and profit efficiency, scale economies, and economies of diversification using traditional parametric methods. To address the reasonability of the results and issues of robustness, we performed several additional calculations that provide corroborating evidence, use alternative methods, and examine particular subsamples of our data.

6.1. *Efficiency correlates*

To examine the consistency, robustness, and reasonability of the efficiency results we calculated several rank correlations with standard accounting variables. We report rank correlations between cost efficiency, profit efficiency, ROA, ROE, size, traditional income share, degree of specialization, and credit risk in Table 6. [23]

The correlations are mostly reasonable. Both cost efficiency and profit efficiency are negatively correlated with C/A and positively correlated with ROA and ROE. Similar to results from the US in Berger and Mester (1997), we find a significant negative correlation between cost and alternative profit efficiency. Asset size and specialization are negatively related, as expected since larger banks are typically more diversified and universal in nature.

In terms of scale economies, there is no significant correlation between asset size and C/A, ROA, cost efficiency, or profit efficiency, although asset size is correlated with ROE, which likely reflects the higher leverage of large banks. In terms of economies of diversification, the rank correlation between ROE and degree of

[23] Size is measured as total assets or gross income. Traditional income share is defined as net interest income on loans, securities, and trading assets as a percent of gross income (net interest income on loans, securities, and trading assets plus brokerage fees, trading income, and other fees). Specialization is defined above. Credit risk is measured as the sum of provisioning and write-offs divided by total assets.

Table 6
Rank correlations for selected variables

	Cost efficiency	Profit efficiency	C/A	ROA	ROE	SD of ROE	Sharpe ratio	Distance to default	Total assets	Gross income	Traditional share	Specialization	Credit risk
Profit efficiency	-0.27^{***}												
C/A	-0.16^{***}	-0.19^{***}											
ROA	0.13^{**}	0.08	0.48^{***}										
ROE	0.02	0.29^{***}	0.38^{***}	0.86^{***}									
SD of ROE	−0.02	−0.04	0.53^{***}	0.47^{***}	0.50^{***}								
Sharpe ratio	0.04	0.19^{***}	-0.46^{***}	-0.22^{***}	-0.19^{***}	-0.91^{***}							
Distance to default	0.04	0.07	-0.54^{***}	-0.45^{***}	-0.47^{***}	-0.94^{***}	0.87^{***}						
Total assets	0.07	0.07	−0.07	−0.03	0.21^{***}	0.09	0.00	−0.07					
Gross income	0.05	0.05	0.44^{***}	0.41^{***}	0.53^{***}	0.50^{***}	-0.35^{***}	-0.49^{***}	0.71^{***}				
Traditional share	0.02	0.05	-0.76^{***}	-0.64^{***}	-0.55^{***}	-0.69^{***}	0.57^{***}	0.68^{***}	−0.04	-0.63^{***}			
Specialization	-0.16^{***}	0.25^{***}	-0.24^{***}	−0.05	-0.13^{**}	-0.14^{**}	0.14^{**}	0.19^{***}	-0.52^{***}	-0.54^{***}	0.26^{***}		
Credit risk	0.00	0.08	0.41^{***}	0.20^{***}	0.13^{**}	0.36^{***}	-0.32^{***}	-0.35^{***}	−0.08	0.27^{***}	-0.48^{***}	−0.04	
Excess capital	0.19^{***}	-0.34^{***}	0.43^{***}	0.52^{***}	0.18^{***}	0.37^{***}	-0.37^{***}	-0.38^{***}	-0.47^{***}	0.00	-0.53^{***}	0.14^{**}	0.23^{***}

Note: All variables are averages over the four-year period for each of the 289 banks in the main sample, except standard deviation (SD) which is the bank's standard deviation. Cost efficiency and profit efficiency are estimated from output specification *Y-3*. Sharpe ratio is defined as mean ROE divided by standard deviation of ROE. Distance to default is defined as mean ROA plue mean equity/asset, divided by standard deviation of ROA. Credit risk is defined as provisions plus write-offs divided by total assets. Excess capital is defined as available capital less required capital divided by required capital. Other variables defined in text. *, **, *** indicate statistical significance at the 10%, 5%, and 1% level, respectively.

specialization was negative, indicating that a diversified earnings stream is associated with higher profits. This correlation, however, was not very robust and does not hold for standard ROE correlations or for ROA rank correlations. Specialized banks also appear to be more profit efficient. Both are consistent with our weak evidence for economies of diversification. Traditional activities appear less profitable than non-traditional activities, as indicated by the negative correlation between ROA and ROE and the traditional income share. Taken together, these correlations provide the same general picture as the more formal econometric work.

6.2. Risk issues

We also looked at the relationship between risk and performance, size, and product mix. When bank managers or shareholders are not risk-neutral, cost minimization and profit maximization may explain only part of bank behavior. Hughes et al. (2001) address this issue by modeling the bank's objective as value-maximization, thereby accounting for the possibility that, when ranking and choosing production plans, managers consider not only the expected cash-flows, but also their risk. Implementation of this methodology, however, requires data on output prices, which are not available for our complete sample of Swiss banks or for our broadest output definition. As an alternative, we briefly discuss the risk-related correlates in Table 6. Of course, these simple measures do not account for the multiple links between these variables and cannot capture the complexity of the underlying relationships, but they are still useful robustness checks.

We begin with the link between risk and performance, and find no significant correlation between cost efficiency and two risk proxies: credit risk (defined as the ratio of provisions and write-offs to total assets) and the standard deviation of ROE. This suggests our cost efficiency estimates are not biased by banks that may limit their screening and monitoring activities or the diversification of their loan portfolio to save on operational costs. Similar results hold for profit efficiency.

We find a positive correlation between ROA and ROE and the standard deviation of ROE, credit risk, and excess capital (defined as the percent of capital held above the regulatory minimum). This implies that higher profitability is associated with higher risk and higher market capital requirements. The net effect appears to be a higher probability of default, as indicated by the negative correlation between ROE and the distance to default (defined as the ratio of average ROA plus the average equity ratio to the standard deviation of ROA).

The correlates between risk and bank size and output mix also provide several interesting results. We observe no significant correlation between the variability of bank profits and total assets, but a positive correlation with bank gross income. In terms of bank specialization, the degree of specialization is negatively correlated with the bank ROE, suggesting some diversification benefits in terms of risk reduction. The effects of risk diversification may, however, be masked by a voluntary increase in risk-taking by large, universal banks. Finally, the standard deviation of ROE is negatively correlated with the share of traditional activities, indicating that the higher profitability of non-traditional activities also implies more risk.

6.3. Standard profit function

As a consistency check, we also estimated profit efficiency from a standard profit function that uses output prices as dependent variables. As discussed above, we consider this an inferior measure but it is worthwhile to compare results. One caveat, however, is that data limitations forced us to limit both the size of our sample and the breadth of the definition. For example, the Swiss data only report interest income for loans as a whole, so we were forced to combine all loans into a single output class. In addition, many banks experienced losses on non-traditional activities, so we were left with negative prices on certain assets. These observations had to be dropped. Despite these problems, we re-estimated cost efficiency, alternative profit, and standard profit efficiency for a set of 144 banks with complete data for the four years. [24] For this subsample of banks, the average efficiency levels were 0.46 for cost, 0.50 for alternative profit, and 0.40 for standard profit. The correlation between the two measures of profit efficiency was 0.94. We conclude from this that alternative profit function gives a reasonable description of profit efficiency for the sample of Swiss banks.

6.4. Other robustness checks

We created new size classes based on gross income, rather than total assets. Evaluating the cost-based RSE, $EPSCE^{A,B}$, and EPSUB across these different size classes did not materially change the results. We again found evidence of cost scale economies for small and mid-size banks, but little evidence of significant economies of diversification for large banks.

We also estimated cost functions excluding Swiss banks owned by foreigners. By dropping these 96 banks, our sample declined somewhat, but we avoid possible measurement problems associated with foreign-owned banks. These banks have balance sheet positions that change relatively quickly and are involved in contracts with parent companies that might not represent market conditions, so estimates could be biased. The estimate of RSE, $EPSCE^{A,B}$, and EPSUB did not change materially for these subsets, however, so we conclude that the foreign banks were not driving our results.

6.5. Caveats

We end this section with a note of caution about our results. While both the rank correlations and the econometric results point in the same direction, these findings must nonetheless be interpreted cautiously. Important data limitations forced us

[24] This specification included four outputs (loans, securities and participations, trading, and amount of securities accounts outstanding) and four netputs (equity capital, physical capital, OBS commitments, and derivatives). The inputs were the same as earlier.

to approximate parts of non-traditional outputs. In addition, absence of data on output prices prevented us from estimating the standard profit function for the broadest output definition for the complete sample, so we were unable to fully address bank efficiency in choosing the profit-maximizing output mix. Finally, the current state of the art does not allow for a clean measurement of economies of diversification or scope. Since we have no direct way of knowing how large the approximation errors are, we cannot conclude that there are no scale and scope economies for the largest Swiss banks. Rather, we can only conclude that there is no obvious evidence when we use currently available data from regulatory sources and traditional methods.

7. Conclusions

This paper evaluates the production structure of Swiss banks in the late 1990s. Our results indicate substantial relative cost and profit inefficiency across all types of Swiss banks. Moreover, by employing alternative output definitions with a broad range of outputs, we are able to capture the universal nature of Swiss banking and gauge the impact on banks' profitability and efficiency. A comparison of results across alternative output definitions indicate that failure to account for OBS items, trading, and brokerage and portfolio management activities leads profit efficiency to be dramatically understated. We also find evidence of cost scale economies for small and mid-size banks, but little evidence for larger banks. Finally, estimates of economies of diversification suggest that larger banks do no substantially benefit from continued size gains and product diversity.

These results provide some insight into the recent evolution of the Swiss banking system. The large observed differences in relative efficiency and the presence of some economies of scale partially explain the consolidation trends observed during the last decade. Our results, however, contrast with the growing importance of large universal banks at the expense of regional and cantonal banks: We find only little evidence of economies of diversification and the regional and cantonal banks do not appear less efficient than other types of Swiss banks. The higher profitability in financial market activities in recent years, however, may explain why banks formerly concentrating on traditional banking activities are entering that segment, even in the absence of economies of diversification.

By looking at empirical evidence for the Swiss banking sector, where banks with very different scopes of activity have been co-existing for many years, we can also draw some implications for other economies that are moving towards a universal banking system. The lack of evidence for substantial gains from either scale economies or economies of scope for the largest banks suggests that the creation of larger banks with broader product mixes will not necessarily lead to improved efficiency or performance. Note, however, that the results obtained for a banking sector in a small country like Switzerland are not necessarily representative of the reality of the banking industry elsewhere.

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