

Working Paper Series

93-02

June 1993

DEREGULATION AND PRODUCTIVITY
DECLINE: THE CASE OF
SPANISH SAVINGS BANKS

E. Grifell-Tatjé
and
C.A.K. Lovell

Department of Economics
CB #3305, Gardner Hall
University of North Carolina
Chapel Hill, NC 27599-3305



93-02
June 1993

DEREGULATION AND PRODUCTIVITY
DECLINE: THE CASE OF
SPANISH SAVINGS BANKS

E. Grifell-Tatjé
and
C.A.K. Lovell

1. INTRODUCTION

The Spanish banking system has traditionally been tightly regulated, not particularly innovative, and largely closed to foreign competition. Liberalization did not begin until 1989, and proceeded slowly until the mid-1980's, when a protracted banking crisis ended and Spain joined the European Economic Community. In anticipation of impending European monetary union, the pace of liberalization has increased in the last few years. In light of recent US experience, which has generally shown banking deregulation to have had a negligible affect on productivity, it is of interest to investigate the recent productivity record of Spanish banking. In this paper we measure, and attempt to explain, productivity change in the savings bank segment of the Spanish banking industry. We focus on savings banks because they have been gaining market share continuously since 1981 at the expense of the other main segment of the industry, the so-called private banks, despite the fact that savings banks have been deregulated more recently than private banks.

There are three types of banking institution in Spain: private banks, savings banks, and credit cooperatives, the latter accounting for only 3% of total assets. The share of savings banks in total assets in the system has grown from 26% in 1976 to over one-third today. Savings banks concentrate on retail banking, providing checking, savings and loan services to individuals. Their market shares in total deposits and total loans have grown steadily to approximately 35% and 45% respectively. Through the decade of the 1980's savings banks tended to be more profitable, in terms of the ratio of before tax profits to assets, than private banks. This was accomplished despite the fact that savings banks had higher staff costs and operating expenses, relative to assets, than did private banks. Caminal *et al.* (1990) attribute the greater profitability, despite the higher operating costs, of savings banks to superior

DEREGULATION AND PRODUCTIVITY DECLINE: THE CASE OF SPANISH SAVINGS BANKS

E. Grifell-Tatjé
Business Department
Universitat Autònoma de Barcelona

C.A.K. Lovell
Department of Economics
University of North Carolina
at Chapel Hill

June 1993

Abstract

During the 1980s many regulatory constraints limiting competition in Spanish banking were relaxed or removed, although deregulation came later to savings banks than to the rest of the banking sector. Two consequences of partial deregulation of savings banks have been a rapid growth in branching activity, much of it geographically dispersed, and a burst of merger activity. In this paper we investigate productive efficiency, and total factor productivity change, in Spanish savings banks over the 1986-1991 deregulation period. Neither branching nor mergers provide an adequate explanation for the magnitude or the nature of the productivity decline we observe over the period.

and customer convenience. The greater profitability and faster growth have been accomplished despite the fact that deregulation came later to savings banks than to private banks. The primary constraint on savings banks has been a restriction on the geographic limits to their operations. They were allowed to expand their number of branches in 1975, but expansion was restricted to their own region. This regional constraint was finally abolished in 1989. Until recently, savings banks have also been constrained by higher investment and reserve requirements than those imposed on private banks.

Thus until very recently savings banks operated under a more restrictive regulatory regime than did their private bank counterparts. Nonetheless they managed to expand, principally through increased branching, a process that quickened after 1989. Since 1989 two features have dominated the savings bank segment of the industry: rapid branching, much of it inter-regional, and mergers and acquisitions. These two features constitute the explanatory variables we use in our effort to shed light on the influences on the recent productivity change record of Spanish savings banks.

In Section 2 we develop the analytical techniques we employ to measure productivity change. We use a Malmquist productivity index number approach. This approach has two distinguishing characteristics that make it more suitable for our purposes than the more popular Törnqvist index number approach. First, it does not require prices of resources used and services provided, and it does not require a behavioral assumption such as profit maximization in competitive markets. This is important because, despite the fact that savings banks have been more profitable than private banks, they are not profit-maximizers. They are structured differently, being unable to raise equity capital and not having to pay dividends to stockholders. Since savings banks are not profit-maximizers, it would be inappropriate to model their behavior with an intertemporal profit function, or with a Törnqvist productivity

index, which assumes both cost-minimizing and revenue-maximizing behavior on competitive markets. Second, it decomposes productivity change into technical change and technical efficiency change, which may shed light on the nature of productivity change. We implement the Malmquist index by solving a series of linear programming problems to construct the distance functions that make up the Malmquist index. These distance functions characterize the production possibilities frontier at any point in time, and they also characterize shifts in the frontier over time as well as movements of producers toward or away from the frontier.

In Section 3 we describe the data we use in the study. Briefly, the data comprise an unbalanced panel of nearly all savings banks in operation during the deregulatory period 1986-1991.

In Section 4 we present our empirical findings. Malmquist indexes of productivity change show a fairly rapid productivity decline throughout the period. The impact of branching has been small but positive, while results concerning the effects of savings bank consolidations are inconclusive, since most consolidations occurred toward the end of the sample period.

Section 5 concludes.

2. THE MEASUREMENT OF PRODUCTIVITY CHANGE

The three currently accepted indexes of productivity change are the Törnqvist index (Törnqvist (1936)), the Fisher Ideal index (Fisher (1922)), which is the geometric mean of the Laspeyres and Paasche indexes, and the Malmquist index (Malmquist (1953)). The popularity of the Törnqvist and Fisher Ideal indexes result from two desirable features they share. First, both can be calculated directly from price and quantity data, and so it is not necessary to recover the structure of the underlying production technology and how it shifts over time,

whether by using econometric techniques to estimate the parameters of functions characterizing the boundary of the technology or by using mathematical programming techniques to construct the feasible set of production possibilities. Second, both are consistent with flexible representations of the underlying technology, i.e., both are superlative indexes (Caves *et al.* (1982), Diewert (1992)). The popularity of the Malmquist index stems from three quite different sources. First, it is calculated from quantity data only, a distinct advantage if price information is unavailable or if prices are distorted. Second, it rests on much weaker behavioral assumptions than the other two indexes, since it does not assume cost minimizing or revenue maximizing behavior. Third, provided panel data are available, it provides a decomposition of productivity change into technical change and technical efficiency change, and so offers insight into the sources of productivity change. Under certain conditions the Malmquist and Törnqvist indexes coincide (Caves *et al.* (1982)), and under generally more restrictive conditions the Malmquist and Fisher Ideal indexes coincide (Färe and Grosskopf (1990)).

In this study we have panel data on input quantities and output quantities, and we have reason to believe that savings banks have neither cost minimization nor revenue maximization as behavioral objectives. Consequently the Malmquist index provides a natural vehicle for our analysis of productivity change. We begin this section with a development of the Malmquist index of productivity change, and we then show how we use linear programming techniques to calculate and decompose the Malmquist productivity index. The techniques were originally developed by Färe *et al.* (1989).

2.1 The Malmquist Productivity Index

Let $x^t = (x_1^t, \dots, x_N^t) \in R_+^N$ and $y^t = (y_1^t, \dots, y_M^t) \in R_+^M$ denote an input vector and an output vector observed in period t , $t = 1, \dots, T$. The graph of the technology consists of all feasible input vectors and output vectors, and so

$$GR^t = \{(y^t, x^t) : x^t \text{ can produce } y^t\}, \quad t = 1, \dots, T.$$

The output set, or the production possibilities set, can be defined in terms of the graph of the technology as

$$P^t(x^t) = \{y^t : (y^t, x^t) \in GR^t\}, \quad t = 1, \dots, T.$$

A functional representation of the technology is provided by the output distance function (Shephard (1970))

$$D_0^t(x^t, y^t) = \min \{\theta : (y^t/\theta) \in P^t(x^t)\}, \quad t = 1, \dots, T.$$

The output distance function satisfies the inequality $D_0^t(x^t, y^t) \leq 1$, with $D_0^t(x^t, y^t) = 1$ if and only if $y^t \in \text{Isoq } P^t(x^t) = \{y^t : y^t \in P^t(x^t), \lambda y^t \notin P^t(x^t), \lambda > 1\}$. Thus $D_0^t(x^t, y^t) < 1$ signals inefficient production on the interior of the output set, and $D_0^t(x^t, y^t) = 1$ signals (weakly) efficient production on the isoquant of the output set. The relationship between the output distance function and productive efficiency was formalized by Färe and Lovell (1978), who noted that

$$D_0^t(x^t, y^t) = [F_0^t(x^t, y^t)]^{-1},$$

where $F_0^1(x^t, y^t)$ is Farrell's (1957) output-oriented measure of technical efficiency. We will return to this relationship shortly.

Calculation of the Malmquist productivity index is based on four distance functions. $D_0^t(x^t, y^t)$ uses period t data, and is defined above. $D_0^{t+1}(x^{t+1}, y^{t+1})$ uses period $t+1$ data, and is defined similarly. $D_0^t(x^{t+1}, y^{t+1})$ uses data from periods t and $t+1$, and is defined as

$$D_0^t(x^{t+1}, y^{t+1}) = \min \{ \theta : (y^{t+1}/\theta) \in P^t(x^{t+1}) \}.$$

Since $D_0^t(x^{t+1}, y^{t+1})$ relates data from period $t+1$ to technology prevailing in period t (which is calculated from period t data), it follows that $D_0^t(x^{t+1}, y^{t+1}) \geq 1$. Thus period $t+1$ data may be infeasible for period t technology. The final distance function also uses data from periods t and $t+1$, and is defined as

$$D_0^{t+1}(x^t, y^t) = \min \{ \theta : (y^t/\theta) \in P^{t+1}(x^t) \}.$$

Since $D_0^{t+1}(x^t, y^t)$ relates data from period t to technology prevailing in period $t+1$ (which is calculated from period $t+1$ data), $D_0^{t+1}(x^t, y^t) \geq 1$.

The Malmquist productivity index for periods t and $t+1$ can now be defined as

$$M_0(x^{t+1}, y^{t+1}, x^t, y^t) = \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \frac{D_0^{t+1}(x^t, y^t)}{D_0^{t+1}(x^{t+1}, y^{t+1})} \right]^{1/2}.$$

$M_0(x^{t+1}, y^{t+1}, x^t, y^t)$ is the geometric mean of two output distance function ratios. The first ratio is a period t Malmquist index which provides a measure of productivity change using

technology prevailing in period t as a benchmark. The second ratio is a period $t+1$ Malmquist index which provides a measure of productivity change using technology prevailing in period $t+1$ as a benchmark. Since the two technologies can be non-neutrally related, or even non-nested, the Malmquist index calculates the geometric mean of the two productivity ratios.¹

A useful feature of the Malmquist productivity index, first noted by Färe *et al.* (1989), is that it decomposes into an index of technical efficiency change and an index of technical change, as follows

$$\begin{aligned} M_0(x^{t+1}, y^{t+1}, x^t, y^t) &= \frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^t(x^t, y^t)} \left[\frac{D_0^t(x^{t+1}, y^{t+1})}{D_0^{t+1}(x^{t+1}, y^{t+1})} \frac{D_0^{t+1}(x^t, y^t)}{D_0^{t+1}(x^t, y^t)} \right]^{1/2} \\ &= \frac{F_0^t(x^t, y^t)}{F_0^{t+1}(x^{t+1}, y^{t+1})} \left[\frac{F_0^{t+1}(x^{t+1}, y^{t+1})}{F_0^t(x^{t+1}, y^{t+1})} \frac{F_0^t(x^t, y^t)}{F_0^t(x^t, y^t)} \right]^{1/2}, \end{aligned}$$

where the second equality makes use of the reciprocal relationship between Shephard's output distance function and Farrell's output-oriented measure of technical efficiency. Thus the Malmquist productivity index is the product of two subindexes. The first subindex is an index of technical efficiency change, and shows whether observed production is getting closer to or farther away from the shifting boundary of the production possibilities set. The technical efficiency change index is greater than, equal to, or less than unity according as technical efficiency is improving, stagnant or declining. The second subindex is an index of technical change, and shows whether technical progress or technical regress is occurring. The technical change index is greater than, equal to, or less than unity according as technical change is positive, zero or negative.

The Malmquist productivity index is a local index, in the sense that its value can vary across observations. Thus some observations may exhibit an increase in technical efficiency, and others may exhibit a decrease. Similarly, some observations may exhibit technical progress and others may exhibit technical regress. This feature allows for flexibility in explaining variation in productivity change across observations.

When more than two periods of data are available, the Malmquist productivity index can be calculated in either of two ways. One approach is to calculate $M_0(x^{t+1}, y^{t+1}, x^t, y^t)$ for all periods $t \neq 0$ relative to a fixed base period t . The other approach is to calculate $M_0(x^{t+1}, y^{t+1}, x^t, y^t)$ for adjacent periods $t, t+1$, adjacent periods $t+1, t+2$, and so on to adjacent periods $T-1, T$. Both approaches have their virtues, and both are widely used. As Førsund (1991) has noted, the fixed-base version of the Malmquist productivity index has the desirable property that it "chains," in the sense that it obeys Frisch's (1936) circular relation, which requires that $M_0(x^{t+2}, y^{t+2}, x^t, y^t) = M_0(x^{t+2}, y^{t+2}, x^{t+1}, y^{t+1}) \cdot M_0(x^{t+1}, y^{t+1}, x^t, y^t)$. Both components of the fixed-base version of the Malmquist productivity index also chain. Førsund (1991) has also shown that only the technical efficiency change component of the adjacent-period version of the Malmquist productivity index satisfies the chaining property. The adjacent-period version of the Malmquist productivity index and its technical change component do not chain. Färe (1991) obtained a necessary and sufficient condition on the underlying output distance functions for the adjacent-period version of the Malmquist productivity index, and hence its component technical change index, to satisfy the chaining property. This condition is equivalent to Hicks output neutrality of the technology, so that the output set $P^t(x^t)$ is homothetically shifted by technical change. This is a stringent condition, and it is not satisfied by the data we use. Nonetheless, we employ the adjacent-period version of the Malmquist productivity index in our empirical work because it offers an

offsetting advantage over the fixed-base version. It has the virtue of minimizing problems caused by quality change and the introduction of new services that plague the fixed-base version.

2.2 Calculating the Malmquist Productivity Index

For each pair of adjacent time periods, construction of the Malmquist productivity index requires the calculation of four output distance functions. We now show how to use linear programming techniques to calculate these output distance functions. Suppose we have a panel consisting of I_t producers and T time periods. Then the input data are represented by $x^{it} = (x_1^{it}, \dots, x_N^{it})$, $i = 1, \dots, I_t$, $t = 1, \dots, T$, and the output data are represented by $y^{it} = (y_1^{it}, \dots, y_M^{it})$, $i = 1, \dots, I_t$, $t = 1, \dots, T$. The production possibilities set in period t can be expressed as

$$P^t(x^t) = \{y^t : y_m^t \leq \sum_{i=1}^{I_t} \lambda^i y_m^i, \quad m=1, \dots, M$$

$$\sum_{i=1}^{I_t} \lambda^i x_n^i \leq x_n^t, \quad n=1, \dots, N$$

$$\lambda^i \geq 0 \quad i=1, \dots, I_t\},$$

where λ^{it} is an intensity variable showing how observed (x^{it}, y^{it}) may be scaled or combined with other (x^i, y^i) . The production technology represented by $P^t(x^t)$ satisfies constant returns to scale and strong disposability of inputs and outputs (Grosskopf (1986)). Both restrictions can be relaxed, but we choose not to do so.²

The within period distance functions are calculated as the reciprocal of the solution to the following linear programming problem

$$[D_0'(x^k, y^k)]^{-1} = \max \theta$$

$$\text{s.t. } \theta y_m^k \leq \sum_{i=1}^I \lambda^i y_m^k \quad m=1, \dots, M$$

$$\sum_{i=1}^I \lambda^i x_n^k \leq x_n^k \quad n=1, \dots, N$$

$$\lambda^i \geq 0 \quad i=1, \dots, I_t$$

This problem is solved $\sum_{t=1}^T I_t$ times, once for each observation (x^{t1}, y^{t1}) , $t = 1, \dots, I_t$ in periods $t = 1, \dots, T$.

The first set of adjacent-period distance functions are calculated as the reciprocal of the solution to the following linear programming problem

$$[D_0'(x^{k+1}, y^{k+1})]^{-1} = \max \theta$$

$$\text{s.t. } \theta y_m^{k+1} \leq \sum_{i=1}^I \lambda^i y_m^{k+1} \quad m=1, \dots, M$$

$$\sum_{i=1}^I \lambda^i x_n^{k+1} \leq x_n^{k+1} \quad n=1, \dots, N$$

$$\lambda^i \geq 0 \quad i=1, \dots, I_t$$

This problem is solved $\sum_{t=2}^T I_t$ times, once for each observation (x^{t1}, y^{t1}) , $t = 1, \dots, I_t$ in periods $t = 2, \dots, T$.

The second set of adjacent-period distance functions are calculated as the reciprocal of the solution to the following linear programming problem

$$[D_0'(x^k, y^k)]^{-1} = \max \theta$$

$$\text{s.t. } \theta y_m^k \leq \sum_{i=1}^{I_t-1} \lambda^{k+1} y_m^{k+1} \quad m=1, \dots, M$$

$$\sum_{i=1}^{I_t-1} \lambda^{k+1} x_n^{k+1} \leq x_n^k \quad n=1, \dots, N$$

$$\lambda^{k+1} \geq 0 \quad i=1, \dots, I_t-1$$

This problem is solved $\sum_{t=1}^{T-1} I_t$ times, once for each observation (x^{t1}, y^{t1}) , $t = 1, \dots, I_t$ in periods $t = 1, \dots, T-1$.

After these four distance functions are calculated for every observation in every time period, Malmquist productivity indexes can be constructed and decomposed for every observation in every pair of adjacent time periods.

3. DATA

3.1 The Sample

The data we use in this paper describe the operating performance of nearly all Spanish savings banks over the period 1986-1991. We have collected the data from "Anuario de la Confederación Española de Cajas de Ahorro", which is issued annually. The number of savings banks in operation decreased sharply during this period, from 77 in 1986 to 56 in 1991, a reduction of about 27%. The origin of this reduction was the mergers and, less importantly, the acquisitions that took place during this period. Some of these mergers involved more than two savings banks. Over the entire period there have occurred 15 mergers and acquisitions (m&a), 14 of them taking place in the years 1990 and 1991. The lack of continuity created by m&a activity can cause serious data problems. In most cases

inputs and outputs are accurately aggregated, and no data problems occur. However, particularly when a merger occurs late in the year, the account statements occasionally report input usage or output provision only for the post-merger period, and reported data make no sense for that year. We have deleted five savings banks in 1990 for this reason.³ Additionally, we have deleted one savings bank in 1987 and two savings banks in 1988 for reasons of data reliability unrelated to m&a activity.⁴ For the years 1986, 1989, and 1991 we have used the entire population of savings banks. Table 1 shows the number of savings banks used in the study.⁵

TABLE 1

SPANISH SAVINGS BANKS: POPULATION AND SAMPLE

	1986	1987	1988	1989	1990	1991
Number of Spanish Savings Banks	77	77	77	76	64	56
Sample Size	77	76	75	76	59	56

3.2 Inputs and Outputs

In the banking literature there is a lack of agreement in defining what a bank produces. After analyzing several different approaches Berger and Humphrey (1992b) follow the value added approach. In this approach deposits are included among the outputs, because they produce a very important share of bank value added. We follow this approach, as have many others, including Berg *et al.* (1992), Ferrier and Lovell (1990), Grifell *et al.* (1992). All these authors prefer to define both outputs and inputs in terms of their quantities, although this information is not always available. The main reason for this preference is that input consumption has a closer relationship with the number of loans and deposits than with their

value. We have adopted this point of view, but we do not have enough information to define all the inputs in terms of their quantities. Therefore, for two inputs we use their value. This is common practice in the banking literature. The extent of the departure from a "pure" production model of banking activity caused by this convention depends on the amount of variation that exists in the price component of the input expenditure variables. Unfortunately there is no way of knowing the degree of price variation, but there is probably a bias of unknown magnitude against big city banks unless the unobserved price variation captures quality variation.

The three basic outputs are: the number of loans,⁶ the number of checking accounts, and the number of savings accounts. A fourth output used in part of the analysis is the number of branch offices. We have included this output in part of the analysis because it can be argued that the number of branch offices expresses a quality or convenience dimension of service that a savings bank offers its customers. We have defined three inputs: the number of employees, expenditure on materials, and direct expenditure on buildings plus accounting depreciation. The expenditures on materials and buildings have been deflated to 1986 prices, using the consumer price index. Table 2 shows the arithmetic mean and the maximum and the minimum of each output and input. Inspection of the summary statistics reveals two significant features of the industry. First, there is enormous size dispersion among savings banks, by any measure. Second, whereas outputs have grown by anywhere from 45% to 90% over the period, inputs have grown by anywhere from 67% to 176% over the period. Hence the title of the paper, and hence the search for an explanation.

TABLE 2
SUMMARY STATISTICS FOR SPANISH SAVINGS BANKS
1986-1991

OUTPUTS	Number of Loans			Number of Checking Accounts			Number of Savings Accounts			Number of Branch Offices			Number of Employees			Expenditure on Materials (million 1986 pts)			Expenditure On Buildings (million 1986 pts)		
	Min	Max	Arithmetic Mean	Min	Max	Arithmetic Mean	Min	Max	Arithmetic Mean	Min	Max	Arithmetic Mean	Min	Max	Arithmetic Mean	Min	Max	Arithmetic Mean	Min	Max	Arithmetic Mean
1986	51612.1	414713	1530	100436.9	1049263	1988	481421.3	4404166	3470	147	1005	5	835.1	6517	23	1118.7	10655	26	640.3	8541	11
1987	58106.6	619967	1585	103408.6	962070	2401	471209.0	4095697	5457	152	1143	5	851.6	6262	31	1263.3	11529	35	771.7	13101	20
1988	65218.0	623715	1951	108035.1	969390	2816	476643.4	4095697	8315	160	1248	7	904.5	6279	38	1351.4	13458	36	809.4	10247	25
1989	66639.1	638360	2375	117965.4	1179197	2979	505230.4	5225599	10264	174	1571	7	973.0	7210	35	1602.2	16240	52	952.0	11063	25
1990	82203.9	635050	1530	140588.5	2055452	3129	585685.2	5963328	9694	214	2296	8	1181.8	10513	40	2010.8	23781	61	1276.6	18386	28
1991	98343.5	650071	2428	161715.9	2125309	3271	699098.5	7957320	13492	249	2296	9	1392.8	10526	41	2392.7	24035	55	1763.7	19668	36

4. PRODUCTIVE EFFICIENCY AND PRODUCTIVITY CHANGE

In this section we analyze the performance of Spanish savings banks in terms of their ability to provide maximum service (and service growth) with the resources at their disposal (and with the growth of those resources). We specify three resources (labor, materials and buildings) and three services (loans, checking accounts and savings accounts). We solve the linear programs described in Section 2.2 to calculate the within-year and between-year output distance functions that are required to construct the Malmquist productivity index. Since the within-year output distance functions are reciprocals of the output-oriented Farrell measures of technical efficiency, we begin our analysis with a discussion of technical efficiency.⁷

Annual efficiency results are summarized in Table 3. It appears that savings banks provide on average only about 75%-80% of the services provided by the best-practice savings banks.⁸ The slight increase in this fraction over time suggests a gradual narrowing of the gap between standard practice and best practice. A portion of the narrowing of the gap is attributable to the increase in the number of efficient savings banks, from 8 of 77 in 1986 to 17 of 56 in 1991, as indicated by (#) in the second column of Table 3. Note, however, that no inference can be drawn concerning improvement in efficiency through time, since the analysis is conducted for each year separately. For an analysis of efficiency change it is necessary to examine the Malmquist index and its decomposition.

TABLE 3
PRODUCTIVE EFFICIENCY IN SPANISH SAVINGS BANKS,
1986-1991

	MEAN	MAXIMUM (#)	MINIMUM
1986	0.756	1.000 (8/77)	0.464
1987	0.745	1.000 (9/76)	0.334
1988	0.754	1.000 (9/75)	0.407
1989	0.801	1.000 (13/76)	0.477
1990	0.777	1.000 (9/59)	0.431
1991	0.801	1.000 (17/56)	0.396

Productivity change results are summarized in Table 4. In no year does the geometric mean of the savings bank Malmquist indexes exceed unity, and for the entire 1986-1991 period the geometric mean of annual Malmquist indexes suggests a 5.5% annual productivity decline. This suggests that by 1991 savings banks were providing only about 75% as much service per unit of resource consumed as they were providing just five years earlier.⁹ The decomposition of the Malmquist index helps to guide the search for an explanation for the productivity decline. In three of five years, and for the overall period under investigation, there occurred an improvement in productive efficiency. This catching up with best practice increased productivity by 1.7% per annum over the period. However best practice was deteriorating in every year, and over the period technical regress reduced productivity by 7.0% per annum. Moreover, there appears to be no trend in the rate of productivity change, or in either component, over time. The rate of productivity change has not improved as deregulation has proceeded.

TABLE 4
PRODUCTIVITY CHANGE IN SPANISH SAVINGS BANKS,
1986-1991

	MALMQUIST INDEX	TECHNICAL EFFICIENCY CHANGE	TECHNICAL CHANGE
1986-87	0.966	0.988	0.977
1987-88	0.931	1.012	0.920
1988-89	0.944	1.057	0.893
1989-90	0.930	0.977	0.952
1990-91	0.956	1.051	0.909
Geometric Mean	0.945	1.017	0.930

The picture that emerges is one of fairly rapid productivity decline, all of which and then some being attributable to a deterioration in production possibilities. Since production possibilities are determined by best practice savings banks, it appears that other savings banks have been catching up with best practice savings banks by declining more slowly. We now turn to a deeper examination of this strange pattern of productivity decline.

In any given year the production possibilities frontier is established by the subset of technically efficient savings banks. The frontier is shifted by the subset of efficient savings banks that are technically efficient in the subsequent year, and the subsets can differ from year to year. The frontier shift is outward in regions where efficient savings banks have $D_0^j(x^{t+1}, y^{t+1}) > 1$, and the shift is inward in regions where efficient savings banks have $D_0^j(x^{t+1}, y^{t+1}) < 1$. Table 5 lists all savings banks that were noted as technically efficient in at least one of the years 1987-1991, and hence that defined the frontier in years 1987-1991, and hence that shifted the frontier in periods 1986-87 through 1990-91. For each savings bank that shifted the frontier, its value of $D_0^j(x^{t+1}, y^{t+1})$ is reported. An entry greater than one indicates an outward shift in the frontier, and an entry less than one indicates an inward shift in the frontier.

TABLE 5

VALUES OF $D_0^l(x^{t+1}, y^{t+1})$ FOR SAVINGS BANKS SHIFTING THE FRONTIER, 1986/87-1990/91

	1986/87	1987/88	1988/89	1989/90	1990/91
Catalunya	1.229	0.939	1.003	0.830	1.149
Burgos C	1.093	0.831	0.825	0.953	0.906
Caceres	0.943	0.960	0.969		
Carlet	0.906				
Huelva	1.315	1.097	1.114		
Asturias	1.092	0.992	0.895	0.981	0.900
Las Palmas	1.108			0.916	1.170
San Fernando	1.041	1.009	0.928		
Vigo	1.096				
Badajoz		0.886			0.995
Soria		*			
Castellon		1.005	0.958		
Torrent			*		
Plasencia			0.890		
Granada G			0.956	1.097	0.946
Palencia			0.870		
Murcia			0.918	1.100	0.999
Soria			0.839	0.827	
Mediterraneo				1.020	0.986
Tenerife				0.823	1.180
Pensiones					1.029
Bizkaia					0.952
Extremadura					*
Huelva-Sevilla					*
Jerez					0.898
Manlleu					0.880
Sagunto					0.781
Terrassa					0.939
Geometric Mean	1.085	0.962	0.927	0.944	0.975

*: Four savings banks were efficient in a year following a year in which they were deleted from the data set due to suspicious data. Consequently $D_0^l(x^{t+1}, y^{t+1})$ cannot be calculated for these observations.

In each year the production possibilities frontier has been shifted inward by some efficient savings banks, and shifted outward by other efficient savings banks. Only in 1986/87 was the shift outward on balance; in each of the last four years the efficient savings banks shifted the production possibilities frontier inward on balance, by an average of 4.8% per year. We now examine this pattern of technical regress in more detail.

Table 5 lists a total of 57 savings banks that were rated technically efficient in at least one year during the period 1987-1991. To this collection we add eight savings banks that were rated technically efficient in 1986. This set of 65 sometimes-efficient savings banks was then subjected to a further analysis, by solving linear programming problems for $D_0^l(x^l, y^l)$, where $l = 1, \dots, 65$ indexes the sometimes-efficient savings banks. The purpose of this analysis is to construct a "grand" production possibilities frontier for the entire period 1986-1991. We are interested in identifying those savings banks that determine not just an annual frontier, but also the entire period frontier. These savings banks, and some useful descriptive information about them, are listed in Table 6. Three features of the period frontier are readily apparent. First, consistent with our technical regress findings, the period frontier is dominated by 1986 and 1987 savings banks. Of the 17 efficient observations, 14 are 1986 and 1987 savings banks. No 1991 savings bank is efficient. Although it is not reported in Table 6, average annual efficiency scores decline monotonically through time, from 0.945 in 1986 to 0.757 in 1991. Second, savings banks of all sizes determine the period frontier; Catalunya is among the five largest savings banks, and Soria and Manlleu are among the 15 smallest savings banks. Third, efficient savings banks with relatively small loan/deposit ratios are from 1986 and 1987, while efficient savings banks with relatively large loan/deposit ratios are from 1988-1990. This suggests that the annual production possibilities frontiers have shifted inward in the small loan/deposit region of service space, and have shifted outward in the large loan/deposit region of service space. Though it is not apparent in Table 6, the

annual production possibilities frontiers intersect frequently in the intermediate loan/deposit region of service space.

We can summarize the results of this section as follows. Productivity has declined at an annual rate of 5.5%. This decline has resulted from two countervailing phenomena: an increase in productive efficiency at a rate of 1.7% per year relative to a production possibilities frontier that has been shifting inward at a rate of 7.0% per year. The inward shift in the production possibilities frontier has not been neutral: a rapid inward shift in the small loan/deposit region has occurred simultaneously with a slower outward shift in the large loan/deposit region.¹⁰

TABLE 6

EFFICIENT SAVINGS BANKS FOR THE ENTIRE PERIOD
1986-1991

	SIZE TOTAL DEPOSITS (#, thousands)	SERVICE MIX LOANS/TOTAL DEPOSITS
1986		
Catalunya	2243	0.080
Burgos C	436	0.034
Huelva	279	0.184
Manlleu	201	0.127
Asturias	1092	0.067
San Fernando	770	0.055
Soria	165	0.031
Vigo	745	0.112
1987		
Catalunya	2282	0.100
Burgos C	429	0.039
Huelva	289	0.206
Asturias	1131	0.080
Las Palmas	870	0.063
San Fernando	813	0.061
1988		
Huelva	298	0.233
1989		
Huelva	306	0.265
1990		
Mediterraneo	1757	0.275

In section 2 the Malmquist index of productivity change is decomposed into one component called technical efficiency change and another called technical change. In this section we have calculated the second component to be less than one, on balance and for most savings banks in most years. This does not mean that technology once known is either forgotten or discarded. It does mean that institutional, demographic and other changes that show up as shifts in the production possibilities frontier have been biased against deposit-taking activity and in favor of loan-making activity. In the next section we explore two phenomena that may help explain the observed productivity decline and its decomposition: the rapid expansion in branching activity, and the merger movement.

5. THE IMPACT OF BRANCHING AND CONSOLIDATIONS ON PERFORMANCE

5.1 Branching

Table 2 shows that mean resource use in Spanish savings banks approximately doubled during the 1986-1991 period, while provision of the three basic services increased much less rapidly. However the number of branch offices operated by each savings bank increased by nearly 70% on average during the period, and it is tempting to think of branch offices as a costly omitted service that provides transactions convenience to customers. We have so far debited savings banks with the resources required to operate a growing number of branches, without crediting them with the service these branches provide. Doing so may help explain the measured productivity decline when only three services are included. This is in fact the conjecture offered by Bauer *et al.* (1993) and Humphrey (1993) for the measured productivity stagnation in U.S. banking, and it may have motivated Berg *et al.* (1993) to include the number of branches in the output vector of Nordic banks. An examination of the effect of branching on performance is particularly appealing in the case of Spanish savings banks for

two reasons. First, the branch growth has been unevenly distributed over time, with the total number of branches growing by less than 9% during the early 1986-1988 period, and by over 13% during the 1989-1991 period after restrictions on inter-regional branching were lifted. If branch growth influences productivity growth, subperiod productivity growth rates can be expected to differ. Second, there has been wide dispersion across savings banks in the rate of branch growth. For example, five savings banks actually reduced the number of branch offices through post-merger branch closings. Other savings banks increased the number of branch offices, by as much as 40%-70%, before and after mergers. Non-merging savings banks generally increased the number of branch offices they operated, by percentages ranging up to 100%. If branch growth influences productivity growth, fast-branching savings banks can be expected to experience different rates of productivity growth than slow-branching savings banks.

We test the omitted service hypothesis in two general ways. The first approach is based on the three-service model analyzed in Section 4. In this approach we compare the measured productivity change in savings banks with slow-growing branch networks with the measured productivity change in savings banks with fast-growing branch networks. If the hypothesis that branches are a costly omitted service is accurate in this setting, then savings banks with fast-growing branch networks should exhibit worse productivity change than savings banks with slow-growing branch networks. Results reported in Table 7 suggest just the opposite. The 16 slow-branching savings banks have a rate of productivity decline in excess of that of the 12 fast-branching savings banks.¹¹ It appears that if branching has created costly excess capacity, it has been partly offset by increased transactions, some of which may have been competed away from slow-branching savings banks.

TABLE 7
THE EFFECT OF BRANCHING ON THE MALMQUIST INDEX,
1986/87 - 1990/91,

	MALMQUIST INDEX	
	Branch Growth < 10% (l = 16)	Branch Growth > 30% (l = 12)
1986/87	0.941	0.964
1987/88	0.921	0.848
1988/89	0.910	0.968
1989/90	0.908	0.965
1990/91	0.917	0.991
Geometric Mean	0.919	0.944

Although fast-branching savings banks have performed better than slow-branching savings banks, they still exhibit productivity decline. If the omitted service hypothesis is valid in this context, then including the number of branches in the output vector should lead to an improvement in the productivity performance of savings banks, or at least for the fast-branching segment of the industry. In the second approach we recalculate the Malmquist index in the context of a four service, three resource model. Results are summarized in Tables 8 and 9. We do not report new estimates of technical efficiency. They are slightly higher than the corresponding three-service efficiency scores, as they must be when a variable is added, and they are highly correlated with the corresponding three-service efficiency scores.

Table 8 reports new productivity change results, by year and over the entire period. Including branches as a service reduces measured productivity decline from 5.5% per year to 4.5% per year. There is empirical support for the omitted service hypothesis, but crediting

savings banks for service provided by new branches accounts for only a small portion of the measured productivity decline. Moreover, there is no trend to the rate of productivity change or to its components. This lack of improvement is consistent with the pattern observed in Table 4, confirming the observation that deregulation has not yet generated productivity gains. It also confirms another finding of Table 4: productivity change in the fast-branching 1989-1991 subperiod was no different from that in the slow-branching 1986-1988 subperiod.

TABLE 8
PRODUCTIVITY CHANGE IN SPANISH SAVINGS BANKS,
1986-1991,
TREATING BRANCHES AS AN ADDITIONAL SERVICE

	MALMQUIST INDEX	TECHNICAL EFFICIENCY CHANGE	TECHNICAL CHANGE
1986-87	0.961	0.980	0.981
1987-88	0.943	1.001	0.942
1988-89	0.960	1.037	0.925
1989-90	0.950	1.060	0.896
1990-91	0.963	1.000	0.963
Geometric Mean	0.955	1.015	0.941

We also repeated the exercise of Table 7 in the four-service context, to compare the productivity performance of slow-branching and fast-branching savings banks when branches are included in the output vector. Results reported in Table 9 are consistent with those reported in Table 7. Measured productivity decline is not as rapid as in the three-service model, but the differential favoring the fast-branching savings banks remains.

TABLE 9
THE EFFECT OF BRANCHING ON THE MALMQUIST INDEX,
1986/87 - 1990/91,
TREATING BRANCHES AS AN ADDITIONAL SERVICE

	MALMQUIST INDEX	
	Branch Growth < 10% (l = 16)	Branch Growth > 30% (l = 12)
1986/87	0.960	0.960
1987/88	0.946	0.887
1988/89	0.923	0.975
1989/90	0.927	0.999
1990/91	0.942	0.983
Geometric Mean	0.940	0.960

Since including branches as a service does not reverse the measured productivity decline, we conclude that there is merit to the argument that branching creates costly excess capacity, at least temporarily, and thereby has contributed to the measured productivity decline. However productivity decline in fast-branching savings banks has been less severe than in slow-branching savings banks, from which we conclude that aggressive branching has been an effective competitive strategy.¹²

We conclude that the measured productivity decline survives the addition of branches as an additional service provided by savings banks to their customers. Since the number of branches per bank grew at about the same rate as the number of loan and deposit services per bank, this finding is unsurprising. However if branching was a costly activity that required more additional resources than it provided in services (as we have measured them, simply by the number of branches), then those savings banks exhibiting relatively slow branch growth

would exhibit relatively slow rates of productivity decline, perhaps even productivity growth. We have found just the opposite to have happened. It appears that incorporating branch services into the model accounts for some of the measured productivity decline, but the impact is very small.

5.2 Consolidations

During the period 15 mergers and acquisitions occurred. However 14 of them occurred during 1990 and 1991, and so we have complete before and after results for only six combinations of savings banks. We want to know whether this activity caused performance to improve or deteriorate. It is frequently argued that bank consolidations are undertaken in an effort to exploit the cost-reducing effects of scale and scope economies and to reduce operating inefficiencies, particularly in the acquired bank. However recent evidence suggests that these potential gains rarely occur; for example, Berger and Humphrey (1992), Fixler and Zieschang (1993) and Rhoades (1993) all find U.S. bank mergers to have yielded little or no efficiency improvements. It is of interest to see whether these same negative findings carry over to Spanish savings bank amalgamations.

Consolidations occurred between pairs (or groups of five savings banks in two cases) of savings banks which were both relatively efficient, both relatively inefficient, or one relatively efficient and one relatively inefficient. When relatively efficient savings banks combined, their efficiency generally improved, both relatively and absolutely. When relatively inefficient savings banks combined, their relative and absolute efficiency generally declined. When a relatively efficient savings bank combined with a relatively inefficient savings bank, efficiency improved in some cases and declined in others. Both five-bank consolidations involved relatively efficient and relatively inefficient savings banks, and in both cases

efficiency declined after the consolidation. The size of the combining savings banks seems unrelated to their previous or subsequent performance. We conclude that consolidations produced both successes and failures, and did not generally improve or reduce productive efficiency in savings banks.

There is less evidence on the relationship between consolidation and productivity change. Our data set contains subsequent information on productivity change for only five consolidations, and this information is summarized in Table 10. In four cases subsequent productivity decline occurred, and in three of these cases productivity decline was worse than average for the period. The geometric mean of all five consolidation productivity changes is 0.938, suggesting a 6.2% annual rate of productivity decline in consolidating savings banks, a below-average performance.¹³

The source of the sub-par productivity change in consolidating savings banks is their below average efficiency change. As a group, their annual rate of technical regress is exactly the same as that of the entire sample, 7% per year. However their annual rate of efficiency change is 0.8% per year, slightly less than that for the sample as a whole.

The effect of consolidation on productive efficiency varies, depending on the previous efficiency of the consolidating savings banks. The effect of consolidation on productivity change is negative, and is attributable to the fact that consolidating savings banks catch up with best practice savings banks more slowly than other savings banks do. This extremely short run evidence is consistent with the U.S. experience, although it is of course possible that the longer run effects of consolidation among Spanish savings banks will be more favorable.

TABLE 10

PRODUCTIVITY CHANGE IN MERGING SAVINGS BANKS.
1986/87-1990/91

	1986/87	1987/88	1988/89	1989/90	1990/91
Mediterraneo	0.946	--	--	1.087	0.880
Torrent	0.959	--	--		
Barcelona	0.942	0.954	0.998	--	1.161
Pensiones	0.951	1.035	1.090		
Bilbao	0.941	0.966	1.074		0.965
Vizcaya	0.987	1.006	1.008	--	
Granada G	0.993	1.162	0.961	1.023	0.777
Granada P	1.035	0.978	0.963	1.024	
Valencia M	0.858	0.857	0.823	0.930	--
Segorbe	0.818	0.901			

6. CONCLUDING OBSERVATIONS

Gradual deregulation of Spanish savings banks has generated impressive service growth in the industry during the six year period under investigation. However resource use has grown even faster, and consequently productivity change in the industry has been negative. Other authors have found stagnation and productivity decline in the financial services sector of other countries in recent years in which deregulation has occurred, but we are unaware of any estimates of productivity decline as rapid as the 5.5% per year we calculate for Spanish savings banks.

We have documented the productivity decline using a nonparametric technique to compute and decompose a Malmquist productivity index. Our findings suggest that standard-practice savings banks have been catching up with best-practice savings banks by declining more slowly. The productivity decline has not been neutral, however. A substantial inward

shift in the production possibilities frontier in the small loan/deposit region has been partially offset by a smaller outward shift in the large loan/deposit region. In addition, there is no apparent link between size and performance, with both large and small savings banks shifting the production possibilities frontier both inward and outward.

It is frequently hypothesized that expansion of branch networks, by creating costly excess capacity, is a source of productivity decline. We have not found that to be the case with Spanish savings banks. We have found fast-branching savings banks to have experienced slower productivity decline than that experienced by slow-branching savings banks. This suggests that the productivity dampening effects of rapid branch network growth are partly offset by increased business attracted by the increased convenience offered by a growing branch network. It is also consistent with the hypothesis that rapid branching is a successful competitive strategy that induces customers to switch from slow-branching savings banks and from private banks. We think it likely, however, that diffusion of ATM and home-banking technologies will soon replace branching as a means of providing customer convenience. Whether this will lead to widespread branch closings, as it has in the U.S. and elsewhere, and whether it will finally generate productivity gains, remains to be seen.

Like other authors, we have found no productivity gains following mergers and acquisitions, although the brief subsequent period is much too short to provide a fair basis for evaluating the effects of the combinations that have occurred.

Vives (1991a, 1991b) has suggested that the main consequence of the deregulatory process leading to European monetary integration "will be to change the focal point of the strategies of banks from collusion and regulatory capture to competition" (1991a: 512). Our results suggest that the path to more open competition has been difficult for Spanish savings banks.

ENDNOTES

*. This paper was written while the first author was a Visiting Scholar at the Department of Economics of the University of North Carolina at Chapel Hill, with financial support from CIRIT, Generalitat de Catalunya.

1. Caves *et al.* (1982) showed that if period t technology is characterized by a translog output distance function, and if period $t+1$ technology is characterized by a different translog output distance function having the same second-order parameters, and if producers maximize profit in both periods, then $M_0(x^{t+1}, y^{t+1}, x^t, y^t)$ is a Törnqvist productivity index, apart from a scale factor.
2. The theoretical developments in Section 2.1 do not require the assumption of constant returns to scale. The calculation and decomposition of the Malmquist index developed in this section does impose constant returns to scale, because this assumption eliminates the possibility that no solution exists to the adjacent-period linear programming problems presented below. To our knowledge, there exists no three-way decomposition of the Malmquist index into technical efficiency change, technical change, and a scale effect, and we have not yet succeeded in obtaining such a decomposition. Thus we do not know how unmodelled scale economies influence the two-way decomposition we employ. Fortunately, limited experimentation with the data analyzed in this paper suggests that departures from constant return to scale are not serious.

3. Consider the following data for San Sebastian and Guipuzcoa, which merged in 1990 to become Caja de Ahorros y Monte de Piedad de Guipuzcoa y San Sebastian (G y SS):

	1986	1987	1988	1989	1990	1991
<i>Expenditure on Materials (million pts)</i>						
San Sebastian	957	1152	1376	1561	467	--
Guipuzcoa	2012	2094	2445	2352	0	--
TOTAL	2969	3246	3821	3913	--	--
G y SS	--	--	--	--	467	4515
<i>Expenditure on Buildings (million pts)</i>						
San Sebastian	472	529	579	732	354	--
Guipuzcoa	1040	1225	1272	1423	0	--
TOTAL	1512	1754	1851	2155	--	--
G y SS	--	--	--	--	354	4155

We have found no way to correct these reported data, and so we have deleted San Sebastian and Guipuzcoa for the year 1990, although we have retained both savings banks for the 1986-1989 period and we have retained the merged savings bank in 1991.

4. We deleted one savings bank in 1987 because it reported an increase in excess of 115% in one output that year and a 93% decrease in the same output the next year. We deleted a second savings bank in 1988 because it reported a 150% increase in one output that year and a 40% decrease in the same output the next year. We deleted a third savings bank in 1988 because it reported a large reduction in its input use with no corresponding reduction in its output.
5. Note that we retain pre-merger savings banks as separate entities, and so our data set is an unbalanced panel. Even with the assumption of constant returns to scale we find this strategy preferable to that of Berg *et al.* (1992), who aggregate pre-merger banks into fictitious entities so as to maintain a balanced panel.
6. Savings banks made real estate, commercial and installment loans, but we do not have quantity information by bank at this level of disaggregation.
7. The radial Farrell measure understates productive inefficiency when slacks are present in the solutions to the linear programming problems. We find slack in at least one variable in approximately one-third of all observations. However the slacks are generally small in magnitude, and so the understatement of productive inefficiency is also small. Moreover, there is no trend to frequency or magnitude of slacks, and so the productivity change calculations are not systematically biased by slacks.
8. This range is not out of line with comparable estimates of banking efficiency reported for the U.S. and various European countries.
9. That a productivity decline should accompany deregulation is perhaps surprising, and hopefully temporary, but it is not unusual. Bauer *et al.* (1993) report productivity change rates in the range (-3.55%, +0.16%) in U.S. banking during the 1977-1988 period during which deregulation was occurring. Using similar data and the same time period, Humphrey (1993) reports productivity change rates in the range (-1.4%, -0.8%). Using aggregate financial services data for 11 OECD countries over the period 1971-1986, Fecher and Pestieau (1993) estimate productivity change to have been +0.4% per year, and negative in five countries. Each of these studies employed econometric techniques. Berg *et al.* (1992) used linear programming techniques similar to ours to compile Malmquist indexes in Norwegian banking over the 1980-1989 period. They found evidence of productivity decline followed by deregulation-induced productivity growth, which they attributed to improvements in efficiency, or catching up to best practice.
10. This bias in technical change in favor of loan-making activity at the expense of deposit-taking activity is consistent with the findings of Hunter and Timme (1991) for U.S. banking in recent years, and may be a consequence of the increased convenience afforded borrowers by growing branch networks.
11. The results are unchanged by replacing the 16 slow-branching savings banks and the 12 fast-branching savings banks with similarly-sized groups of savings banks that branched most slowly, and most rapidly, in each year.

12. Aggressive branching, although it creates costly excess capacity, has apparently redistributed customers from slow-branching savings banks to fast-branching savings banks. Additional evidence suggests that the increased convenience provided by branch expansion is an effective, if temporarily costly, competitive strategy. The market shares of all savings banks for loans and deposits have grown during the 1986-1991 period, while the market shares of private banks have declined. For details see Caminal, Gual and Vives (1990) and Gual and Vives (1992).

13. We have excluded from Table 10 the acquisition of Ceuta, a very small savings bank on the north coast of Africa, by Madrid, a very large savings bank. Post-acquisition efficiency and productivity growth both declined to below-average levels.

REFERENCES

- Bauer, P.W., A.N. Berger and D.B. Humphrey (1993), "Efficiency and Productivity Growth in U.S. Banking," in H.O. Fried, C.A.K. Lovell and S.S. Schmidt, eds., *The Measurement of Productive Efficiency: Techniques and Applications*. New York and Oxford: Oxford University Press.
- Berg, S.A., F.R. Försund and M. Suominen (1993), "Banking Efficiency in the Nordic Countries," *Journal of Banking and Finance*, forthcoming.
- Berg, S.A., F.R. Försund and E.S. Jansen (1992), "Malmquist Indices of Productivity Growth During the Deregulation of Norwegian Banking," *Scandinavian Journal of Economics* 94, S211-S228.
- Berger, A.N., and D.B. Humphrey (1992a), "Megamergers in Banking and the Use of Cost Efficiency as an Antitrust Defense," *The Antitrust Bulletin* 37, 541-600.
- (1992b), "Measurement and Efficiency Issues in Commercial Banking," in Z. Griliches, ed., *Output Measurement in the Service Sectors*, National Bureau of Economic Research Studies in Income and Wealth, Volume 56. Chicago and London: The University of Chicago Press.
- Caminal, R., J. Gual and X. Vives (1990), "Competition in Spanish Banking," in J. Dermine, ed., *European Banking After 1992*. Oxford: Basil Blackwell.
- Caves, D., L. Christensen and W.E. Diewert (1982), "The Economic Theory of Index Numbers and the Measurement of Input, Output, and Productivity," *Econometrica* 50, 1393-1414.
- Colwell, R.J., and E.P. Davis (1992), "Output and Productivity in Banking," *Scandinavian Journal of Economics* 94, S111-S130.
- Diewert, W.E. (1992), "Fisher Ideal Output, Input, and Productivity Indexes Revisited," *Journal of Productivity Analysis* 3, 211-48.
- Färe, R. (1991), "The Malmquist Productivity Index and the Circular Test," paper presented at the Second European Workshop on Efficiency and Productivity Measurement, October 25-26, CORE, Université Catholique de Louvain, Louvain-la-Neuve, Belgium.
- Färe, R., and S. Grosskopf (1990), "Theory and Calculation of Productivity Indexes: Revisited," paper presented at the Fifth Karlsruhe Seminar, International Symposium on Models and Measurement of Welfare and Inequality, August 12-19, University of Karlsruhe, Karlsruhe, Germany.

Färe, R., S. Grosskopf, B. Lindgren and P. Roos (1989), "Productivity Developments in Swedish Hospitals: A Malmquist Output Index Approach.", paper presented at a Conference on New Uses of DEA in Management, September 27-29, IC² Institute, Austin, TX, USA, and forthcoming in A. Charnes, W.W. Cooper, A.Y. Lewin and L.M. Seiford, eds., Data Envelopment Analysis: Theory, Methodology and Applications. Boston, Dordrecht, London: Kluwer Academic Publishers.

Färe, R., and C.A.K. Lovell (1978), "Measuring the Technical Efficiency of Production," Journal of Economic Theory 19, 150-62.

Farrell, M.J. (1957), "The Measurement of Productive Efficiency," Journal of the Royal Statistical Society, Series A, General, 120, 253-81.

Fecher, F., and P. Pestieau (1993), "Efficiency and Competition in O.E.C.D. Financial Services," in H.O. Fried, C.A.K. Lovell and S.S. Schmidt, eds., The Measurement of Productive Efficiency: Techniques and Applications. New York and Oxford: Oxford University Press.

Farrier, G.D., and C.A.K. Lovell (1990), "Measuring Cost Efficiency in Banking: Econometric and Linear Programming Evidence," Journal of Econometrics 46, 229-45.

Fisher, I. (1922), The Making of Index Numbers. Boston: Houghton-Mifflin.

Fixler, D.J., and K.D. Zieschang (1993), "An Index Number Approach to Measuring Bank Efficiency: An Application to Mergers," Journal of Banking and Finance, forthcoming.

Førsund, F.R. (1991), "The Malmquist Productivity Index," paper presented at the Second European Workshop on Efficiency and Productivity Measurement, October 25-26, CORE, Université Catholique de Louvain, Louvain-la-Neuve, Belgium.

Frisch, R. (1936), "Annual Survey of General Economic Theory: The Problem of Index Numbers," Econometrica 4, 1-38.

Griffell-Tatjé, E., D. Prior Jiménez, and V. Salas Fumás (1992), "Eficiencia Frontera y Productividad en las Cajas de Ahorros Españolas (1989-1990)," Documentos de Trabajo, Fundación Fondo para la Investigación Económica y Social, Obra Social de la Confederación Española de Cajas de Ahorros.

Grosskopf, S. (1986), "The Role of the Reference Technology in Measuring Technical Efficiency," Economic Journal 96, 499-513.

Gual, J., and X. Vives (1992), Ensayos Sobre el Sector Bancario Español. Madrid: FEDEA.

Humphrey, D.B. (1993), "Cost and Technical Change: Effects from Bank Deregulation," Journal of Productivity Analysis 4, 9-34.

Hunter, W.C., and S.G. Timma (1991), "Technological Change in Large U.S. Commercial Banks," Journal of Business 64, 339-62.

Malmquist, S. (1953), "Index Numbers and Indifference Surfaces," Trabalhos de Estatística 4, 209-42.

Rhoades, S.A. (1993), "Efficiency Effects of Horizontal Bank Mergers," Journal of Banking and Finance, forthcoming.

Shephard, R.W. (1970), Theory of Cost and Production Functions. Princeton: Princeton University Press.

Törnqvist, L. (1936), "The Bank of Finland's Consumption Price Index," Bank of Finland Monthly Bulletin 10, 1-8.

Vives, X. (1991a), "Regulatory Reform in European Banking," European Economic Review 35, 505-15.

____ (1991b), "Banking Competition and European Integration," in A. Giovanni and C. Mayer, eds., European Financial Integration. Cambridge: Cambridge University Press.

