A Note on Productivity Change in European Co-operative Banks: The Luenberger Indicator Approach

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Abstract:

This paper proposes a framework for benchmarking European co-operative banks and the rationalization of their operational activities. The analysis is based on the Luenberger productivity indicator. A key advantage of this method is that it allows for both input contraction and output expansion in determining relative efficiencies and productivity changes. Benchmarks are provided for improving the operations of those banks which perform worse than others. Several interesting and useful managerial insights and implications arise from the study. The general conclusion is that, between 1996 and 2003, productivity increased for the majority of European co-operative banks analyzed.

Keywords: Europe; Co-operative banks; Luenberger productivity indicator.

JEL Classification: G21, D24

Introduction

Efficiency at the level of the enterprise is a major issue in contemporary European economics, due to the ever more intense pressure that competition exerts on prices. This competitive pressure results in two stages of evolution: first, the deregulation of former national markets improves competition between domestic enterprises; secondly, the adoption of the EU's Single Market Programme (SMP) improves competition between domestic and foreign firms. Over the last decade or so, a growing literature, using a variety of approaches, has emerged dealing with the issue of productivity in banking.[1] Generally speaking, the European evidence suggests banks achieved productivity growth during the 1990s although the rate of growth differs across countries. Casu et al (2004) report productivity growth in the Italian and Spanish commercial banking sectors which they attribute to an extensive consolidation process, whereas mixed results are reported for French and German banks. Williams (2001) attributes productivity growth in the European savings banks sector to financial deregulation. Kumbhakar et al (2001) and Dietsch and Weill (2000) find evidence of the impact of technical progress upon productivity growth in the Spanish savings banks sector, and European commercial, mutual and savings banks sectors, respectively. In contrast, the US literature (see Bauer et al, 1993; Humphrey and Pulley, 1997; Stiroh, 2000; Alam, 2001; and Berger and Mester, 2003) find limited evidence of productivity growth.

This paper aims to extend the established literature on banking sector productivity by applying the Luenberger indicator (Chambers, 1996) to estimate and decompose productivity change. Earlier studies of bank productivity tend to employ nonparametric techniques and Malmquist productivity indexes. The Luenberger indicator is a difference-based index of directional distance functions whereas the Malmquist index is a ratio-based measure of the Luenberger.[2,3] Luenberger (1992) introduces the shortage function which has the desirable properties of accounting for both input contractions and output improvements, and establishing duality between the shortage function and the profit function (Chambers et al, 1998). Thus, the indicator can accommodate either an input or output perspective corresponding to cost minimization or profit maximization. We employ the Luenberger productivity indicator of Chambers (1996) to estimate productivity change and its constituents

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[1] See the reviews by Berger and Humphrey (1997) and Casu et al, (2004).

[2] Productivity measures based on differences are termed "indicators" whilst measures based on ratios are termed "indexes". Chambers (1996, 2002) and Diewert (1998, 2000) discuss the two approaches.

[3] The theoretical and empirical relationships between the Luenberger indicator and Malmquist productivity index are discussed by Boussemart et al (2003).

for a sample of European co-operate banks between 1996 and 2003. So far as we are aware, the only other application of the Luenberger indicator to banking is the Park and Weber (2006) application to Korean banks.

In this application, the indicator is constructed for a sample of European co-operative banks. According to the European Association of Co-operative Banks (2004) there are over 3,800 such banks which deal with around 100 million customers through 50,000 or so branches. Co-operative banks play an important role in retail and SME banking and have significant deposit market shares in Austria, France, Germany, Italy and the Netherlands although they play a lesser role in other countries.[4] Analysing the productivity characteristics of co-operative banks is of interest because if productivity has improved then it should be reflected in better performance, lower customer prices and improved service quality. It may also reflect more prudent operations if productivity gains are fed through into capital that helps absorb greater risk. Analysing productivity differences of co-operative banks across countries can benchmark the performance of similar banks and possibly indicate the different strategies undertaken by banking firms across markets (Molyneux and Williams, 2005).

The remainder of the paper is organized as follows: section 2 presents the methodology framework adopted. Section 3 presents the data and the results. Finally, section 5 concludes.

2. Methodological Framework

In proposing new, more flexible, measures involving production theory, Chambers et al (1996, 1998) introduced the "directional distance function"[5], which is the transposition in production theory of Luenberger's (1992) "benefit function" in a consumer context. The directional distance function determines a shortcut in one direction which permits an observed production unit to reach the production frontier. In economic terms, this function makes it possible to evaluate the scale of the economies which can be achieved and the possible improvements in production. It also provides a "benchmark" by defining a reference point to be reached. The principal advantage of this function lies in its ability to take account simultaneously, and in a broader context, of both inputs and outputs. This function therefore

[4] According to the European Association of Co-operative Banks (2004) co-operative banks deposits market share in 2003 was: 32% in Austria, 47% in France, 21% in Germany, 29% in Italy and 38% in the Netherlands.
[5] See also Färe and Grosskopf (2000) for an overview of the directional distance function.

measures the smallest changes in inputs and outputs in a given direction which are necessary for a firm to reach the production frontier, rendering it an indicator of firm performance.

Let the technology be described by a set, $T \subseteq R_+^N \times R_+^M$, defined by

$$T_t = \{(x_t, y_t) : x_t \text{ can produce } y_t\} , \qquad (1)$$

where $x_t \in R_+^N$ is a vector of inputs and $y_t \in R_+^M$ is a vector of outputs at the time period *t*. Throughout this paper, technology satisfies the following conventional assumptions[6]:

A1: $(0,0) \in T_t, (0, y_t) \in T_t \Rightarrow y_t = 0$ i.e., no fixed costs and no free lunch;

A2: the set $A(x_t) = \{(u_t, y_t) \in T_t; u_t \leq x_t\}$ of dominating observations is bounded $\forall x_t \in R_+^N$, i.e., infinite outputs are not allowed with a finite input vector;

A3: T_t is closed;

A4: $\forall (x_t, y_t) \in T_t, (x_t, -y_t) \leq (u_t, -v_t) \Rightarrow (u_t, v_t) \in T_t$, i.e., fewer outputs can always be produced with more inputs, and inversely (strong disposal of inputs and outputs);

A5: T_t is convex.

The directional distance function generalizes the traditional Shephard distance function (1970). Directional distance functions project input and/or output vector from itself to the technology frontier in a preassigned direction. In the case of a radial direction out of the origin, we retrieve the classical Shephard distance function. The directional distance function is defined as follows.

The function $D_t : R^{n+p} \times R^{n+p} \to R \cup \{-\infty\} \cup \{+\infty\}$ defined by

$$D_t(x_t, y_t; g) = \begin{cases} \sup\{\delta : (x_t - \delta h; y_t + \delta k) \in T_t\} & if \quad (x_t - \delta h; y_t + \delta k) \in T_t, \delta \in R \\ -\infty & otherwise \end{cases} \qquad (2)$$

is called directional distance function in the direction of $g = (h, k)$.

To operate the approach, it is necessary to take an appropriate direction. We do this by considering the direction $g = (x, y)$. Then, the directional distance function is similar to the proportional distance function introduced by Briec (1995, 1997). This distance function is

[6] See Shephard (1970) and Färe et al. (1985) for thorough analysis of their implications on technology.

based on simultaneous proportional modifications of inputs and outputs; it generalizes Debreu's and Farrell's measure and is equally straightforward to interpret.

To estimate the proportional distance function, we use a non-parametric approach (see Banker and Maindiratta, 1988; Varian, 1984). The technology can be written as:

$$T_t = \left\{ (x_t, y_t), x_t \geq \sum_j \theta_j x_t^j, y_t \leq \sum_j \theta_j y_t^j, \sum_j \theta_j = 1, \theta_j \geq 0, j = 1, \dots, J \right\}. \quad (3)$$

The linear program that calculates the values of the directional distance function is given by[7]:

$$\begin{aligned} D_t(x_t, y_t) &= \max \delta_t \\ \text{s.t. } & x_t - \delta_t x_t \geq \sum_j \theta_j x_t^j , \\ & y_t + \delta_t y_t \leq \sum_j \theta_j y_t^j , \\ & \sum_j \theta_j = 1, \; j = 1 \dots J . \end{aligned} \quad (4)$$

Suppose that an individual bank is represented by a production vector (x_t, y_t) with corresponding technology T_t, and then the production vector is changed to (x_{t+1}, y_{t+1}) with corresponding technology T_{t+1}. In order to assign a cardinal measure to the productivity change we can use the directional distance function in one of two ways; corresponding to using either the initial technology at *t* or the final technology at *t+1* as reference. In this case, the Luenberger productivity indicator proposed by Chambers (1996) can be employed to evaluate productivity change. The productivity indicator is constructed as the arithmetic mean of the productivity change measured by the technology at T_{t+1} and the productivity change measured by the technology at T_t.

The Luenberger productivity indicator is defined as[8]:

$$L(z_t, z_{t+1}) = \frac{1}{2}\left[D_{t+1}(z_t; g) - D_{t+1}(z_{t+1}; g) + D_t(z_t; g) - D_t(z_{t+1}; g) \right]. \quad (5)$$

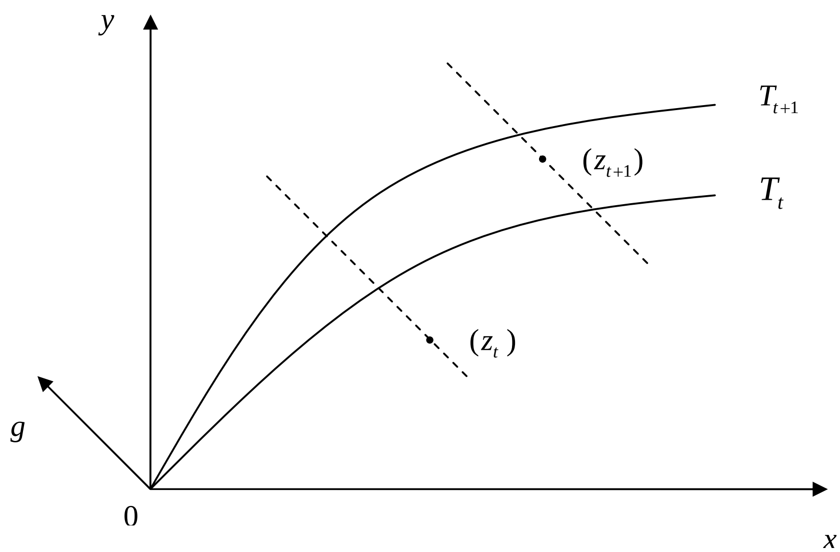
[7] All the computations are programmed in Mathematica language with the mathematica 5.0 software.
[8] We simplify the notations by posing $z_t = (x_t, y_t)$.

Positive growth (decline) is indicated by positive (negative) value. Unlike the Malmquist index, the Luenberger productivity indicator is additively decomposed as follows:

$$L(z_t, z_{t+1}) = \left[D_t(z;g) - D_{t+1}(z_{t+1};g)\right] + \frac{1}{2}\left[D_{t+1}(z_{t+1};g) - D_t(z_{t+1};g) + D_{t+1}(z_t;g) - D(z_t;g)\right], \qquad (6)$$

where the first term (inside the first brackets) measures efficiency change between time periods *t* and *t*+1 while the arithmetic mean of the difference between the two figures inside the second brackets expresses the technological change component, which represents the shift of technology between the two time periods. This decomposition was inspired by the breakdown of the Malmquist productivity index in Färe et al. (1989). For a complete overview of the decompositions of productivity measures, see Grosskopf (2003). Figure 1 illustrates the Luenberger productivity indicator.

Figure 1: The Luenberger productivity indicator



Finally, in an aggregate context, following Farrell (1957) and Briec et al. (2003), we use an aggregate directional distance function constructed as:

$$D_t\left(\sum_{k=1}^{K} x_t^k, \sum_{k=1}^{K} y_t^k\right). \qquad (7)$$

This aggregate efficiency indicator is referred to as a structural efficiency indicator, and the aggregate Luenberger productivity indicator (*AL*) is constructed as follows:[9]

$$AL\left(\sum_{k=1}^{K} z_t^k, \sum_{k=1}^{K} z_{t+1}^k\right) = \frac{1}{2}\left[D_{t+1}\left(\sum_{k=1}^{K} z_t^k\right) - D_{t+1}\left(\sum_{k=1}^{K} z_{t+1}^k\right) + D_t\left(\sum_{k=1}^{K} z_t^k\right) - D_t\left(\sum_{k=1}^{K} z_{t+1}^k\right)\right], \quad (8)$$

Equation [8] allows similar decompositions to equation [6].

4. Data and Results

We use the dataset on European co-operative banks of Molyneux and Williams (2005). Table 1 shows the number of cooperative banks in the sample by country and across 1996 to 2003. Clearly, the sample is dominated by observations of German and Italian co-operative banks. Nevertheless, it must be noted that co-operative banking sectors have been consolidated into a large entity in countries like the Netherlands.

Table 1: Number of Co-operative Banks & Observations: by Country, 1996-2003

	1996	*1997*	*1998*	*1999*	*2000*	*2001*	*2002*	*2003*	*Total*
Austria	19	18	26	31	45	50	40	20	249
Belgium	10	9	8	7	7	7	7	6	61
Finland	1	1	1	1	1	1	1	1	8
France	64	67	70	101	106	104	91	83	686
Germany	1,012	993	1,184	1,171	1,069	974	816	370	7,589
Italy	181	428	417	475	482	500	477	132	3,092
Luxembourg	2	2	2	2	2	2	2	2	16
Netherlands	2	2	1	1	1	1	1	1	10
Portugal	1	1	1	1	2	2	2	1	11
Spain	10	15	13	8	11	15	13	7	92
All banks	1,303	1,537	1,723	1,798	1,726	1,656	1,450	623	11,816

Source: BankScope.

We construct aggregate efficiency and productivity measures for co-operative banks in ten EU countries. Banks are assumed to produce four outputs: (i) total customer loans, (ii) interbank loans, (iii) securities, and (iv) off-balance-sheet items, from two inputs: (v) fixed assets and (vi) variable cost. The descriptive statistics are shown in Table 2.

[9] See Färe and Primont (2003) and Färe and Grosskopf (2004) for discussion of the aggregation of the Luenberger productivity indicator.

Table 2: Descriptive Statistics: ECU million (inflation-adjusted); 1996-2003

		Inputs		Outputs			
Country	Statistic	Fixed Assets	Variable Cost	Customer Loans	Interbank Loans	Securities	OBS
AUS	Average	29.66	126.12	1,207.18	792.73	409.23	162.86
	Std dev	61.12	331.73	2,926.01	2,229.60	1,037.32	393.33
BEL	Average	17.56	187.17	1,251.08	1,301.09	1,273.23	1,060.28
	Std dev	47.07	524.42	2,872.97	3,851.44	3,751.96	3,533.41
FIN	Average	614.55	1,294.99	20,678.66	895.56	5,103.35	3,694.88
	Std dev	121.83	109.02	3,571.04	583.89	558.41	919.64
FRA	Average	139.32	1,204.28	8,787.42	5,578.85	5,883.21	4,869.44
	Std dev	526.14	4,451.62	32,984.55	26,360.68	26,782.04	20,284.89
GER	Average	13.28	41.69	400.26	193.02	195.43	70.81
	Std dev	173.17	431.30	3,461.31	3,034.14	2,455.10	1,035.72
ITA	Average	16.83	52.97	541.03	135.10	192.16	167.89
	Std dev	83.46	246.52	2,807.71	695.52	792.65	959.21
LUX	Average	11.66	61.46	618.46	638.69	132.97	121.13
	Std dev	11.32	56.25	602.09	524.69	192.23	108.81
NL	Average	3,010.26	14,498.44	152,577.43	27,475.78	62,028.50	29,882.20
	Std dev	1,520.75	7,903.83	85,253.20	16,004.37	37,666.80	16,430.58
PTE	Average	142.32	273.17	2,907.49	533.66	682.77	276.54
	Std dev	105.03	202.59	2,272.23	346.29	516.51	325.89
SPA	Average	45.32	98.45	1,259.81	499.69	360.69	175.63
	Std dev	65.58	99.86	1,742.15	910.18	549.42	210.31

The aggregate Luenberger productivity indicators are calculated using linear programming techniques. The results are presented in Table 3, with the productivity indicators (AL) decomposed into its constituents: technical efficiency change (the diffusion or catch-up component - EFFCH); and technological change (the innovation or frontier-shift component - TECH). EFFCH represents the diffusion of best-practice technology in the management of banking activities and it is attributable to investment planning, technical experience, and management and organization. TECH results from innovations and the adoption of new technologies by best-practice banks in each country.

From Table 3, we observe the productivity change score (AL) is positive for European co-operative banks across all countries; all banking sectors experienced productivity gains between 1996 and 2003. The mean is distorted by the result for Portugal; omitting the Portuguese score yields a mean productivity score of 0.2073 that is bettered by the co-operative banking sectors in Italy, Spain, Finland and France, and which is consistent with the earlier results of Casu et al (2004). In terms of productivity decomposition, it is clear that technological change drives productivity change in the European co-operative banking industry. Excluding the TECH score for Portugal, the mean score is 0.1723; the best performing co-operative banks are in Finland, France, the Netherlands and Spain. The score is positive for all sectors; this implies there was investment in new technologies (methodologies, procedures and techniques) and in the commensurate skills upgrades related to this. Technical efficiency change (EFFCH) matches technological change in explaining productivity growth only in Italy and Spain: in these two countries, co-operative banks are catching-up with best practice. However, the scores imply that German co-operative banks are moving further away from best practice whilst in six co-operative banking sectors, the indicator is equal to zero.

Table 3: Productivity Changes in European Co-operative Banks (1996-2003)

Country	**AL**	**EFFCH**	**TECH**
Austria	0,0761	0,0000	0,0761
Belgium	0,1182	0,0000	0,1182
Finland	0,2836	0,0000	0,2836
France	0,2514	0,0000	0,2514
Germany	0,1672	-0,0091	0,1763
Italy	0,3562	0,1733	0,1829
Luxembourg	0,1062	0,0000	0,1062
Netherlands	0,1876	0,0000	0,1876
Portugal	5,9091	0,2482	5,6609
Spain	0,3189	0,1507	0,1681
Mean	0,7774	0,0563	0,7211
Median	0,2514	0,0000	0,1829
St.Dev.	1,6402	0,0882	1,5787

Overall, we observe three combinations of technical efficiency change and technological change. (i) In the first group, we find three countries where improvements in technical efficiency co-exist with improvements in technological change: Portugal, Spain and Italy. These are the best-performing European co-operative banks; improvements in technical efficiency denote upgraded organizational factors associated with the use of inputs and outputs, as well as the relationship between inputs and outputs. (ii) In the second group, we find six countries in which nil technical efficiency change co-exists with improvements in technological change: Austria, Belgium, Finland, France, Luxembourg and Netherlands. These are the European banks which are always efficient. (iii) Finally in the third group, we find one country in which improvements in technological change co-exist with deterioration of technical efficiency: German co-operative banks should upgrade their managerial skills and scale if they are to improve performance.

5. Discussion and Conclusion

An aggregate Luenberger productivity indicator is used to estimate and decompose productivity growth on 11,816 observations of EU co-operative banks between 1996 and 2003. These data were used previously by Molyneux and Williams (2005) who employed stochastic frontier analysis and Fourier flexible functional form methodologies, and the productivity decomposition approach of Berger and Mester (2003) to estimate productivity growth. The present set of results using an alternative productivity measure can confirm the consistency of both methodological approaches.

There is productivity growth in the co-operative banking industry which is driven by improvements in technological change. Even though it is positive, the rate of technological change varies across countries. This finding is consistent with previous research on the co-operative banking sector (see Molyneux and Williams, 2005) and the European banking industry in general (see Casu et al, 2004). As in Casu et al (2004) and Williams (2001), we observe evidence that banks in a limited number of markets are catching-up with European best practice: in Portugal, Italy and Spain, technical efficiency change is as important as technological change in driving productivity growth. Possible explanations for this feature of the results include the establishment of a more competition environment (and ensuing banking sector consolidation) brought about by the single market and other deregulatory acts.

Several policy implications arise from the results. First and foremost, it is clear that there is considerable room for improving technical efficiency if co-operative banks are to catch-up with industry best practice. Technical inefficiency is a consequence of one or more of the following factors: (i) structural rigidities that create principal-agent problems (Jensen and Meckling, 1976); (ii) rigidities associated with EU labour markets which give rise to collective-action problems (Olson, 1965); (iii) organisational factors associated with X-efficiency (Leibenstein, 1966); and (iv), dimensional factors associated with scale and scope economies. Due to any, some or all of these factors, co-operative banks may produce at a level below the maximum possible output, given the production environment. Arguably, some of the above problems might be reduced by changing the ownership structure of co-operative banks and encouraging a wave of M&A. However, this would need to be considered against the role that smaller, local-oriented banks play in regional economic development.

Given that technological change (innovation) is the main driver of productivity growth in the EU co-operative banking industry, an appropriate policy recommendation is for larger, or centralized co-operative banks to develop and franchise technology to smaller, co-operatives. Indeed, the group structure, which is a feature of co-operative and savings banks sectors in Europe, is ideally suited for this strategy. However, the general conclusion is that there is room for improvement in the management of European banks.

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