Productivity Change in European Banking: A Comparison of Parametric and Non-Parametric Approaches

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Abstract

This paper compares parametric and non-parametric estimates of productivity change in European banking between 1994 and 2000. Productivity growth has also been further decomposed into technological change, or change in best practice, and efficiency change. Both the parametric and non-parametric approaches consistently identify those systems that have benefited most (and least) from productivity change during the 1990's. The results also suggest that (where found) productivity growth has mainly been brought about by improvements in the performance of best practice banks and there does not appear to have been 'catch-up' by non best-practice institutions. Competing methodologies sometimes identify conflicting findings for the sources of productivity for individual years. However, the two approaches generally do not yield markedly different results in terms of identifying the broad trends in the level and sources of productivity growth in European banking during the 1990's.

JEL classification: **G21; D24.**

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1. Introduction

During the 1990s there has been a constant emphasis towards the integration of banking and financial system to create a more market oriented, competitive and productive financial sector throughout Europe. At the same time, technological innovations have transformed the banking industry, offering savings in the cost and time of providing financial services and creating a range of new products. To keep pace with such developments a substantial body of efficiency and productivity studies have sought to inform regulators and practitioners on banking sector performance issues relating to the rapidly changing market environment.

The academic literature, particularly in the US, has mainly focused on analysing cost efficiency (and more recently profit efficiency) using both parametric and non-parametric methodologies (see Berger and Humphrey, 1997 and Goddard et al., 2000 for a review of the literature). Another strand of the contemporary literature has focused on productivity change in banking, by employing either non-parametric or parametric methodologies. The former typically adopt the Malmquist Total Factor Productivity (TFP) Index approach whereas parametric models include a time trend as a proxy for disembodied technical change. Recently, Berger and Mester (1999, 2001) reinterpret the literature by proposing a parametric method to decompose total changes in cost over time into a portion due to changes in business conditions and a portion due to changes in bank productivity.

Analysing the productivity of banking systems is of interest from a policy perspective because if banks are becoming more productive then one might expect better performance, lower prices and improved service quality for consumers, as well as greater safety and soundness if productivity improvements are channelled towards strengthening capital buffers that absorb risk. Analysing productivity differences across countries may help to identify the success or failure of policy initiatives or, alternatively, may highlight different strategies undertaken by banking firms. There is some evidence to support the view that financial deregulation leads to productivity growth (Berg et al, 1992). Yet, the main source of productivity growth is uncertain. Berg et al (1992), for instance, find that productivity gains result from improvements in bank efficiency rather than shifts in the best practice frontier, other evidence indicates that technical change is a more important determinant of productivity growth (Alam, 2001 and Mukherjee et al, 2001). The debate about the sources of productivity growth in the banking sector is therefore unresolved. In addition, the picture is now further complicated as there exists two competing methodologies, non-parametric and parametric, to estimate productivity growth and its decomposition.

In order to contribute to the aforementioned debate this paper presents parametric and non-parametric estimates of productivity growth in European banking during the 1990's. The main aim is to investigate the sources of productivity growth and to see if the competing methodologies yield similar results. Overall, we find that both the parametric and non-parametric approaches consistently identify those systems that have benefited most (and least) from productivity change during the 1990's. The results also suggest that (where found) productivity growth has mainly been brought about by improvements in the performance of best practice banks and there does not appear to have been 'catch-up' by non best-practice institutions. However, both approaches reveal a decreasing trend in the performance of best practice banks towards the end of the 1990s. In general, the findings reported in this paper illustrate that different methodologies corroborate productivity change estimates in European banking.

The paper is set out as follows: Section 2 reviews the main literature and Section 3 outlines the approaches to the measurement and estimation of productivity growth. Section 4 illustrates the results and Section 5 concludes.

2. Literature on Productivity Change in Banking

The concept of total productivity was first discussed in the literature of the 1930s and the first explicit calculation of "technical development", obtained by generalising a Cobb-Douglas production function by adding an exponential time-trend, is attributable to Tinbergen (1942) (see Grilliches, 1996 for a review of this early literature). In the context of this study, total factor productivity (TFP) measures changes in total output relative to inputs and the concept derives from the ideas of Malmquist (1953)[1] and the distance function approach[2]. Cave et al. (1982b) have investigated productivity indexes derived from Shephard's distance function and provided the theoretical framework for the measurement of productivity; this forms the basis for what has become known as the Malmquist Productivity Index number approach. Färe et al (1985, 1994) have shown how the Farrell's (1957) efficiency indexes are closely related to Shephard's distance functions[3].

One of the first studies to investigate productivity change in the banking industry was by Berg et al. (1992). They employed Malmquist indices for productivity growth in Norwegian

[1] Important developments in this field have been introduced, among others, by the work of Diewert (1976, 1978, 1981), Caves, Christensen and Diewert (1982a and 1982b) and Färe, Grosskopf and Lovell (1985, 1994).
[2] Shephard's (1970) distance functions have guided much of the development in efficiency and productivity analysis. In a multi-input multi-output framework, an output distance function is defined as the reciprocal of the maximum proportional expansion of the output vector, given inputs. An input distance function is defined as the reciprocal of the maximum proportional contraction of the input vector, given outputs.
[3] In his empirical work, Farrell (1957) defines technical efficiency as the maximum proportional contraction of inputs. He also indicated that, under constant returns to scale, this may be interpreted as the percentage by which output could be increased using the same inputs. The interpretation of Farrell's measures of

banking during the years 1980-89 and found that productivity fell prior to the period experiencing deregulation but grew rapidly when deregulation took place. Grifell-Tatjé and Lovell (1997) investigated the sources of productivity change in Spanish banking over the period 1986-1993 using a generalised Malmquist productivity index. They found that commercial banks had a lower rate of productivity growth compared to savings banks, but a higher rate of potential productivity growth. Wheelock and Wilson (1999) used the Malmquist index to study productivity change for all US banks between 1984 and 1993. They found that productivity declined on average during this period because of reductions in efficiency. Alam (2001) adopts a similar approach to Wheelock and Wilson (1999) to investigate productivity change in US commercial banking over the 1980s and finds a significant productivity increase between 1983 and 1984, followed by a fall in 1985 and growth thereafter. Chaffai et al. (2001) use a Malmquist type index that allows for intercountry productivity differences to be broken down into pure technological and environmental effects. These indices are used to calculate productivity gaps across four main EU countries.

A number of studies (see for example, Berger and Humphrey, 1992; Bauer et al., 1993; Humphrey 1993, Humphrey and Pulley, 1997; Stiroh, 2000) have used various econometric model specifications to estimate either TFP growth or technological progress in US banking during the 1980s and 1990s. Generally this literature finds little evidence of productivity growth whereas evidence on technological progress is mixed.

A handful of European studies have also addressed this issue. For instance, Altunbas et al. (1999) found that technical change has systematically reduced European banks total cost during the 1990s, although Battese et al.'s (2000) study of Swedish banks found that technical change became exhausted with 'average' banks catching up with industry best practice.

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technical efficiency as reciprocals of distance functions can be found in Fare et al (1985, 1994).

Williams (2001) estimates the rate of productivity growth for European savings banks between 1990 and 1998 and concludes that financial deregulation appears to have increased the rate of frontier progress. Kumbhakar et al. (2001) also investigate the savings bank sector using a profit function approach. Empirical results suggest declining technical efficiency but also find evidence of technical progress and productivity growth.

All the parametric studies reviewed so far use variations of the time trend approach to estimate technological change and productivity growth. Berger and Mester (1999, 2001) introduce a decomposition of total cost changes into a portion due to changes in business conditions and a portion due to changes in productivity. Their main result is that during the period 1991-97 cost productivity deteriorated while profit productivity improved substantially, particularly for banks that engaged in mergers. Stiroh (2000) employs various econometric techniques, including the cost decomposition suggested by Berger and Mester (1999, 2001) and finds productivity growth of about 0.4% and these results are found to be consistent across methodologies.

3 Methodology and Data

This section briefly describes the parametric and non-parametric methodological approaches followed; illustrates the sample and discusses the measurement of the inputs and the outputs used in our analysis.

Parametric and non-parametric approaches differ in the assumptions they make regarding the shape of the efficient frontier and the existence of random error. Non-parametric methods do not require any assumptions with respect to efficiency or the underlying functional form for the technology. Although there is no consensus in the literature as to the “best method" for estimating the frontier, Bauer *et al*. (1997) point out that it is not necessary to reach such consensus but it is important instead to find 'consistency' for the approaches to be most useful for regulators or other decision makers. Indeed, by using multiple frontier techniques the robustness of the results can be tested (methodological cross-checking).

3.1 Malmquist Total Factor Productivity (TFP) Index

Total factor productivity (TFP) measures changes in total output relative to inputs and the concept derives from the ideas of Malmquist (1953)[4]. As discussed by the review of the non-parametric literature, the Malmquist TFP index is the most commonly used measure of productivity change.[5] The Malmquist TFP index measures TFP change between two data points by calculating the ratio of the distances of each data point relative to a common technology. Following Shephard (1970), Färe (1988) and Färe et al. (1994) the output distance function is defined[6] at t as

$$D_0^t(x^t, y^t) = \inf\{\theta : (x^t, y^t/\theta) \in S^t\}$$

$$= (\sup\{\theta : x^t, \theta y^t) \in S^t\})^{-1} \qquad (1)$$

The distance function seeks the reciprocal of the greatest proportional increase in output, given input, such as output is still feasible. The distance function is the reciprocal of Farrell's (1957) measure of output technical efficiency, which calculates "how far" an observation is from the frontier of technology.

[4] Important developments in this field have been introduced, among others, by the work of Diewert (1976, 1978, 1981), Caves, Christensen and Diewert (1982a and 1982b) and Färe, Grosskopf and Lovell (1985, 1994).
[5] For a literature survey on the subject, see Grosskopf (1993) and Färe, Grosskopf and Roos (1997). Also, Ray and Desli (1997) discuss the conceptual framework and Mukherjee, Ray and Miller (2001) derive the geometric decomposition for a generalised Malmquist index.
[6] The input distance function is similarly defined.

To define the Malmquist index, it is necessary to define distance functions with respect to two different time periods

$$D_0^t(x^{t+1}, y^{t+1}) = \inf\{\theta : (x^{t+1}, y^{t+1}/\theta) \in S^t\} \qquad (2)$$

This distance function measures the maximum proportional change in outputs required to make (x^{t+1}, y^{t+1}) feasible in relation to the technology at t.

Following Färe et al. (1994) the Malmquist (output oriented) TFP change index between period *s* (the base period) and period *t* is given by:

$$M_0(y_s, x_s, y_t, x_t) = \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_s, x_s)} \times \frac{d_0^t(y_t, x_t)}{d_0^t(y_s, x_s)}\right]^{1/2} \qquad (3)$$

where the notation $d_0^s(x_t, y_t)$ represents the distance from the period *t* observation to the period *s* technology. A value of M_0 greater than one will indicate positive TFP growth from the period *s* to period *t* while a value less than one indicates TFP decline. Note that equation (3) is, in fact, the geometric mean of two TFP indices, the first evaluated with respect to period *s* technology and the second with respect to period *t* technology.

An equivalent way of writing the index is:

$$M_0(y_s, x_s, y_t, x_t) = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)}\left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)} \times \frac{d_0^s(y_s, x_s)}{d_0^t(y_s, x_s)}\right]^{1/2} \qquad (4)$$

where the ratio outside the square brackets measures the change in the output oriented measure of Farrell technical efficiency between period *s* and *t*. That is, the efficiency change is equivalent to the ratio of the Farrell technical efficiency in period t to the Farrell technical efficiency in period *s*. The remaining part of the index in equation (2) is a measure of technical change. It is the geometric mean of the shift in technology between the two periods, evaluated at x_t and x_s. Therefore,

$$M_0\,(y_s, x_s, y_t, x_t) = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \times \qquad \text{(Efficiency change)}$$

$$\left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)} \times \frac{d_0^s(y_s, x_s)}{d_0^t(y_s, x_s)}\right]^{1/2} \qquad \text{(Technological change)} \qquad (3)$$

Productivity change (M_0) is decomposed into Technological Change (TC), which reflects improvement or deterioration in the performance of best practice Decision Making Units (DMUs); and Technical Efficiency Change (TEC), which reflects the convergence towards or divergence from the best practice on part of the remaining DMUs. The value of the decomposition is that it provides information on the sources of the overall productivity change. Several different methods can be used to compute the distance functions which compose the Malmquist TFP index; to date, the most popular method has been the DEA-like programming method suggested by Färe et al. (1994), which is the method that will be followed in our empirical analysis.

Färe et al. (1994) also propose an "enhanced decomposition", which takes the efficiency change component calculated relative to the constant returns to scale (CRS) technology and further decomposes into a "pure technical efficiency change" component (calculated relative to the variable returns to scale (VRS) technology) and a residual "scale efficiency" component, which captures changes in the deviation between the VRS and CRS technologies.

The decomposition becomes

$$M_0\,(y_s, x_s, y_t, x_t) = TC \times TE \times SE \qquad (4)$$

where TC represents Technical Change, TE represents pure efficiency change and SE represents scale change. The scale change and pure efficiency change components are the decomposition of the efficiency component TEC = TE x SE[7].

This further decomposition has been subjected to a number of criticisms (see, for example Ray and Desli, 1997) on the basis of the roles of the VRS and CRS frontier on the decomposition. However, there seem to be consensus that the Malmquist index is correctly measured by the ratio of the CRS distance function even when the technology exhibits variable returns to scale. Whereas Färe et al. (1994) and Ray and Desli (1997) calculate the Malmquist productivity index in the same way, they propose alternative decompositions[8].

3.2 Productivity Growth from a Decomposition of Cost Changes

In contrast with the aforementioned literature, econometric studies generally represent technical change by including a simple time trend in the estimated cost or profit functions. Estimates of the rate of technical change are then calculated as the percentage change in production or cost over time. With the introduction of flexible functional forms (e.g., translog and Fourier Flexible) the simple time trend representation of technical change has been modified to include time squared, and interactions between time and other explanatory variables (Heshmati, 2001).

Berger and Mester (1999, 2001) extended the established parametric approach to estimate productivity growth. Using both cost and standard profit function estimates they decompose productivity growth into a portion due to changes in business conditions and a portion due to

[7] The TEC term refers to efficiency change calculated under CRS and the TE term refers to efficiency change calculated under VRS. SE = TEC/TE. Scale efficiency in each period is calculated as the ratio of the distance function satisfying constant returns to scale to the distance function restricted to satisfy variable returns to scale.
[8] These alternative ways to decompose the Malmquist productivity index may, in empirical application lead to different conclusions about the sources of productivity change.

changes in productivity. Furthermore, they decompose productivity change into the change in best practice and change in inefficiency components.

In this study, we compare the decomposition of productivity growth derived from the cost function approach with the Malmquist estimates. As in Berger and Mester (2001), we represent the cost of the industry at time t by the predicted cost of a bank with average business conditions, average inefficiency for the period and a zero random error. This gives $\exp\,[f_{Ct}(\overline{X}_{Ct})] \times \exp\,[\ln \overline{u}_{Ct}]$, where $\overline{X}_{Ct}$ gives the average values of the business condition regressors at time t and $\ln \overline{u}_{Ct}$ gives the average value of the inefficiency factor. The total gross change in cost between period t and period $t+k$ is measured by the ratio of the predicted costs in the two periods:

$$\Delta TOTAL_{Ct,t+k} \equiv \{\exp[f_{Ct+k}(\overline{X}_{Ct+k})] \times \exp[\ln \overline{u}_{Ct+k})]\} / \{\exp[f_{Ct}(\overline{X}_{Ct})] \times \exp\,[\ln \overline{u}_{Ct})]\} \qquad (5)$$

Further, we decompose $\Delta TOTAL_C$ into the gross changes in best practice, inefficiency and business conditions:

$$\begin{aligned} \Delta TOTAL_{Ct,t+k} = \; & \{\exp[f_{Ct+k}(\overline{X}_{Ct})] / \{\exp[f_{Ct}(\overline{X}_{Ct})]\} \times && \text{(Change in best practice)} \\ & \{\exp[\ln \overline{u}_{Ct+k}) / \exp\,[\ln \overline{u}_{Ct})]\} \times && \text{(Change in inefficiency)} \\ & \{\exp[f_{Ct+k}(\overline{X}_{Ct+k})] / \exp[f_{Ct+k}(\overline{X}_{Ct})]\} && \text{(Change in business conditions)} \\ \equiv \; & \Delta BESTPR_{Ct,t+k} \times \Delta INEFF_{Ct,t+k} \times \Delta BUSCOND_{Ct,t+k} && (6) \end{aligned}$$

Therefore, the changes in costs are decomposed into three multiplicative terms. The change in best practice, $\Delta BESTPR_C$, gives the change in costs due to changes in the best practice cost function $f_C(\bullet)$, since it holds business conditions and inefficiency constant; $\Delta INEFF_C$ gives the contributions from changes in inefficiency whereas $\Delta BUSCOND_C$ gives the contributions from changes in business conditions only. All three terms are measured as gross changes, therefore a number below 1 indicates falling costs and a number above 1 indicates rising costs.

Cost productivity change is the product of the change in best practice and the change in inefficiency:

$$\Delta PROD_{Ct,t+k} \equiv \Delta BESTPR_{Ct,t+k} \times \Delta INEFF_{Ct,t+k}$$

$$= \{\exp[f_{Ct+k}(\overline{X}_{Ct})] / \{\exp[f_{Ct}(\overline{X}_{Ct})]\} \times \{\exp[\ln \overline{u}_{Ct+k}) / \exp[\ln \overline{u}_{Ct})]\} \qquad (7)$$

This study employs a standard translog functional form.[9] Our specification of the cost function is:

$$\begin{aligned} \ln TC = \quad & a_0 + \sum_{i=1}^{3} a_i \ln y_i + \sum_{j=1}^{3} b_j \ln w_j + \\ & + 1/2 \left[\sum_{i=1}^{3} \sum_{j=1}^{3} d_{ij} \ln y_i \ln y_j + \sum_{i=1}^{3} \sum_{j=1}^{3} g_{ij} \ln w_i \ln w_j \right] + \qquad (8) \\ & + \sum_{i=1}^{3} \sum_{j=1}^{3} r_{ij} \ln y_i \ln w_j + \ln u_C \ln e_C \end{aligned}$$

where TC is a measure of the costs of production, comprising operating costs and interest paid on deposits; the y_i $(i = 1, 2, 3)$ are output quantities; the w_i $(j = 1, 2, 3)$ are input prices;

[9] Berger and Mester (1997a) found that both the translog and the Fourier-flexible functional form, which is a global approximation that includes a standard translog plus Fourier trigonometric terms, yielded essentially the same average level and dispersion of measured efficiency, and both ranked the individual banks in almost the same order.

and the standard symmetry and linear restrictions apply.[10]

In accordance with the assumed constraint of linear homogeneity in prices, TC, w_1 and w_2 are normalised by the price of capital, w_3. The $\ln u_c$ term denotes an inefficiency factor that may raise costs above the best practice level and ε_c denotes random error. The various efficiency measurement techniques differ in how they distinguish the inefficiency term from the random error term. In this study, we use the distribution free method (Berger, 1993) that assumes there is core inefficiency for each firm over time that is distinguished from random error. The method assumes that core inefficiency is persistent over time, while random error tends to average out over time.

Finally, in order to be able to decompose the productivity change into the change in best practice and change in inefficiency (see equation 6 above), we use a version of the thick frontier approach (see Berger and Humphrey 1991) so that banks with residuals in the "best" 25% in each country (lowest cost residuals) are assumed to be best practice for that year. We then estimate best practice functions using OLS on the most efficient quartile of banks.[11]

3.3 Data and Inputs and Outputs Definition

Our data set is primarily drawn from BankScope and includes annual information for a balanced panel of over 2000 European banks between 1994 and 2000. The sample comprises only large banks (total assets > Euro 450 million) from the largest European banking markets: France (357 banks), Germany (518 banks), Italy (413 banks), Spain (448

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[10] Standard symmetry implies that: $d_{ij} = d_{ji}$ and $g_{ij} = g_{ji}$, where $(i = 1, 2)$ and $(j = 1, 2, 3)$, and the following linear restrictions on (7) are necessary and sufficient for linear homogeneity in factor prices: $\sum_{j=1}^{3} b_j = 1$; $\sum^{3} g_{ij} = 0$ and $\sum_{j=1}^{3} r_{ij} = 0$. We exclude factor share equations, which embody restrictions imposed by Shephard's Lemma or Hotelling's Lemma, because these would impose the undesirable assumption of no allocative inefficiencies [see, for example, Berger and Mester (1997a,b)].

banks) and United Kingdom (350 banks). Subsidiaries of foreign banks; specialised financial institutions and central institutions as well as all banks particular to a certain country (for example, special credit institutions in Italy, finance companies in France and official credit institutions in Spain) were excluded from the sample. As in Stiroh (2000) the sample comprises only continuously operating institutions, to avoid the impact of entry and exit and so as to focus on the behaviour of a core of large European banks during the 1990s. Estimations are carried out on individual countries.

Choosing the appropriate definition of bank output is a relevant issue for research into banks' cost efficiency. The approach to output definition used in this study is a variation of the *intermediation approach*, which was originally developed by Sealey and Lindley (1977) and posits that total loans and securities are outputs, whereas deposits along with labour and capital are inputs. Specifically, as shown in Table 1, the input variables used in this study are: the average cost of labour (personnel expenses/total assets)[12]; deposits (interest expenses/customer and short-term funding) and capital (total capital expenses/total fixed assets). The output variables capture both the traditional lending activity of banks (total loans) and the growing non-lending activities (securities). In addition, we also include the nominal value of banks' off-balance sheet items as a third output as contingent liabilities such as letters of credit, derivatives and other types of non-traditional activities are becoming increasingly important in European and global banking[13].

<Table 1>

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[11] As in Berger and Mester (2001) we assume that the residuals represent random error and not differences in efficiency.

[12] We use personnel expenses to total assets as our indicator of unit labour costs because there was substantial missing data for staff numbers for many banks in our sample.

[13] On the importance of including the OBS items as one of the major outputs of banks in the US see for

Table 1 shows substantial variation in the financial characteristics of the sample banks. Spanish and Italian banks have, on average, the smallest balance sheets in our sample and among the lowest level of off-balance sheet activity. Staff costs are the lowest in the UK, whereas interest costs appear to be highest in Italy. On average, the UK and French banks in our sample are substantially larger than those in the other countries under study. Although not shown in the Table, the nominal value of off-balance sheet (OBS) items stood at a lower level in 2000 than compared with 1994 for all the systems under study.

4. Results

4.1 Malmquist TFP Estimates

Following Färe et al. (1994) the Malmquist (output-oriented) TFP change index has been calculated. A value of the index greater than one indicates positive TFP growth while a value less than one indicates TFP decline over the period. Productivity change is then decomposed into Technological Change (TC), and Technical Efficiency Change (TEC), where TFP = TC x TEC. An improvement in TC is considered as a shift in the best practice frontier, whereas an improvement in TEC is the "catch up" term. The Technical Efficiency Change (TEC) is further decomposed into the scale change (SE) and pure efficiency change (TE) components TEC = TE x SE. The value of the decomposition is that it attempts to provide information on the sources of the overall productivity change in the banking sectors of the main EU countries.

Productivity change estimates are summarised below. The annual entries in each column in Tables 2 are geometric means of results for individual banks and the period results reported in the last row for each country are geometric means of the annual geometric means.

<Table 2>

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example Rogers (1998) and Stiroh (2000).

Overall, the results seem to indicate productivity growth for all countries under analysis, particularly from Spanish (+9.5%) and Italian banks (+8.9%). Productivity growth has been more modest for French, German and British banks (+1.8%; 0.6% and 0.1% respectively). From an analysis of the decomposition of the Malmquist TFP, productivity growth in the Italian and Spanish banking systems seem to have been brought about mainly by a positive technological change (+10.5% and +9.2% respectively). Although it is difficult to precisely explain the substantial shift in the best practice frontiers in these banking systems between 1996 and 1999, it is may be related to the greater level of domestic market consolidation and restructuring that occurred in Italy and Spain compared with the other countries under study[14]. In addition, whereas Spanish banks seem to have been able to exploit also some catching up effect, their Italian counterparts display a decreasing trend in the efficiency change component over the 1990s (-1.5%).

The results relative to the British banking sectors show a slight improvement in the TFP index with an overall increase in productivity of about 0.1%. This productivity growth seems to have been brought about by improvements in efficiency (+1.4%) rather than a positive technological change, although the results of the yearly averages indicate a reverse trend in the early part of the 1990s. The picture that emerges is an almost constant rate of productivity change, resulting from a decline in more recent years in the performance of the best practice institutions.

Productivity growth seems to have been brought about by technological change for French banks (+3.1%), which display also a deterioration in the cost efficiency levels (-1.3%). On the

[14] According to the ECB (2000) the five-firm concentration ratio for Italy and Spain increased to 9.5% and 5.6%, respectively between 1997 and mid-1999, substantially higher than in Germany (2.7% increases) and the UK (-0.7%). No figures were available for France.

other hand, an interesting feature for German banks is the catching up with best practice institutions and the positive scale efficiency change (+3.1% and 0.05% respectively). All the other European countries under analysis, with the exception of the UK, display negative scale efficiency change, thus highlighting that some “wasted expenditure” is accounted for by uneconomical scale size of French, Spanish and Italian banks.

Overall, despite the indication of TFP growth for all countries in the sample over the 1990s, the analysis of the decomposition of the TFP index into its technological change (TC) and technical efficiency change (TEC) components highlights different trends. Whereas there seem to have been considerable technological changes over the 1990s (although with a decreasing trend in all countries, except the UK, at the end of the decade), little seems to have changed in terms of cost efficiency. Despite the gains achieved by best practice institutions, there has been little catching up effect on the part of the remaining institutions. This may suggest that only best practice banks, so far, have been able to take advantage from the opportunities offered by the different forces of changes in the European banking sector.

4.2 Productivity Estimates from a Decomposition of Cost Changes

Table 3 reports the total changes in costs over time (ΔTOTAL) and the decomposition of these total changes into their ΔPROD, ΔBUSCOND, ΔBESTPR and ΔINEFF components for our sample of European banks. The rows in the table give annualised measures for the entire period 1994-00 with 1994 serving as a base year. The analysis of the productivity change for UK banking sector using the parametric method could not be carried out due to the lack of sufficient data on off-balance sheet items (y_3 in equation 7 above).

<Table 3>

Over the entire 1994-2000 interval the cost of the average bank (ΔTOTAL) increased for France at an annual rate of 3.2%. We used the average-practice cost function (estimated using all banks) to decompose cost changes; this suggest that cost productivity declined by the same amount (3.2%) while business conditions do not appear to affect costs over the period (ΔBUSCOND=1). The results for Germany show that cost of the average bank increased at an annual rate of 2.4% and cost productivity declined by 2.2% over 1994-00. Also, changes in business conditions increased costs over all years (ΔBUSCOND>1).

In Italy and Spain the total cost of the average bank fell at annual rates of 4.3% and 2.1% respectively. For both countries this has resulted in a significant improvement in productivity over 1994-2000 (+3.8% in Italy and +2.3% in Spain). However, in Italy business conditions as a whole reduced costs over all years (ΔBUSCOND<1).

As shown in equation 6 above, cost productivity change can be decomposed into change best practice and change in inefficiency[15]. Results from such decomposition can be summarised as follows. In France, using the best-practice cost function (i.e., using the "best" 25% of banks for each year) results suggest that if we consider the whole 1994-00 interval, an unfavourable shift in best practice has occurred (-2.7%) and inefficiency has increased only slightly (+0.5%). In Germany results indicate that inefficiency has decreased slightly, while the change in best practice was similar to that experienced by the French banking sector (-2.7%). In Italy, best practice banks display a significant improvement (5.8%), whereas efficiency worsened by 2.1%. Finally, in the Spanish banking sector both efficiency levels and best

[15] As Berger and Mester (2001) pointed out, there is no consensus as to the best way to estimate the best practice frontier. Because of this uncertainty, the decomposition of ÄPROD into ÄINEFF and ÄBESTPR should be considered less accurate than the decomposition of ÄTOTAL into the impact of changing business conditions and changes in productivity. We estimate best practice using OLS on the 25% most efficient banks. Specifically, we used the best 26 banks in each year for France; the best 37 in Germany, 30 in Italy, 32 in Spain.

practice improved by approximately 0.5% and 1.9% respectively over the period.

4.3 Productivity Change: A Comparison of parametric and non-parametric approaches

Figure 1 below illustrates the trends of TFP change and cost productivity between 1994 and 2000.

<Figure 1>

Overall, the results of both parametric and non-parametric estimations suggest a clear productivity growth in the Italian and Spanish banking sectors, whereas results are mixed for French and German banking sectors. As we noted earlier, the strong improvements in the Italian and Spanish banking sectors between 1996/7 and 1998/9 may have been a consequence of the substantial domestic consolidation that took place in these banking systems over this period. It is possible to note that the favourable trend of productivity growth seem to end towards the end of the decade, when results for all countries under investigation converge towards productivity decline, according to the trend highlighted both by the Malmquist index and the cost parametric approach.

< Figure 2>

A comparison of the trends of the components of the Malmquist Total Factor Productivity index, technological change (TC) and efficiency change (TEC) and the trends of the change in best practice (ΔBESTPR) and change in inefficiency (ΔINEFF) for the countries under study are shown in Figure 2. ΔBESTPR in the econometric approach is analogous to technological change (TC) for the Malmquist estimates (improvement or deterioration of the best practice firms); and ΔINEFF in the parametric model can be compared with technical efficiency change (TEC) for the Malmquist estimates (convergence towards or divergence from best practice on part of the remaining firms). It is important to point out that, although the decomposition of total productivity change in the two approaches attempts to identify the sources of overall productivity, the different underlying hypothesis of the parametric and non-parametric approaches would lead us to expect comparable results only in the overall trend. As pointed out by Färe *et al*. (1994), different methodologies could produce similar results only in a world without inefficiency.

It can be seen that the competing methodologies yield similar estimates in terms of improvements in best practice for Italian, Spanish and German banks as the trends in ΔBESTPR and TC appear to mirror each other. For French banks the decomposition according to the two methodologies also identify the same trends for best practice banks (apart for 1995/96) although the variation and level of these changes appears to be more marked using the parametric decomposition (for example see the 1996/7 and 1999/2000 estimates)[16]. In terms of divergence in best practice (ΔINEFF from the parametric model compared with TEC from the non-parametric decomposition) there appears to be less consistency in the findings. For instance, in the case of Spain the two approaches only yield similar findings for 1994/5 and 1995/96 – as such it is by no means certain whether there has been greater divergence from best practice or not in Spanish banking from 1996 onwards.

[16] In addition, the two approaches also reveal conflicting overall findings for the 1994/2000 period for France with the parametric approach suggesting a decline in best practice over the study period and the non-parametric method an improvement.

Other conflicting results in terms of divergence from best practice are also found in Germany (1995/6 and 1998/9), Italy (1994/5 and 1995/6) and in France (1995/6)[17].

Overall, while the magnitude and direction of the productivity decomposition may vary in certain cases both methodologies generally tend to identify similar trends. Both parametric and non-parametric approaches appear to indicate a decreasing trend in the performance of best practice banks in all countries under analysis at the end of the 1990s. Furthermore, despite some differences in the yearly averages of the total productivity components between the two approaches, overall they seem to indicate that there has been little catching up effect on the part of the remaining institutions during the 1990s.

6. Conclusions

This paper examines the productivity change in European banking during the 1990s by comparing parametric and non-parametric approaches. The findings of both parametric and non-parametric estimations suggest a clear productivity growth in the Italian and Spanish banking sectors, whereas results are mixed for the French and German banking sectors. We tentatively suggest that this productivity growth might have been related to the substantial consolidation and restructuring that occurred in the Italian and Spanish banking systems especially over the 1996 to 1999 period. On the other hand, in the French and German banking systems there is little evidence of productivity growth according to the parametric estimation while non-parametric estimates indicate a small average total factor productivity (TFP) growth. Both approaches however consistently identify those systems that have benefited most (and least) from productivity change during the 1990's. The results also suggest

[17] Having said this, however, both methodologies reveal that over the whole study period 1994/2000 there has been a general improvement in best practice.

that (where found) productivity growth has mainly been brought about by improvements in the performance of best practice banks and there does not appear to have been ‘catch-up’ by non best-practice institutions. Finally, both approaches reveal a decreasing trend in the performance of best practice banks in all countries under analysis at the end of the 1990s. Overall, we find that the competing methodologies do not yield markedly different results in terms of identifying the broad trends and sources of productivity growth. Our results concur with Mukherjee et al’s, (2001) findings for US banking, that is, changes in best practice drive productivity growth in European banking and this is likely to have been influenced by substantial consolidation and restructuring activity particularly in the Italian and Spanish systems.

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Table 1 Summary Statistics on Cost, Output Quantities and Input Prices (Pooled Data 1994-00)[a]

		TC	Q1	Q2	Q3	P1	P2	P3
FRANCE	mean	1543.29	9384.46	12296.59	10868.14	0.014	0.060	1.577
	median	324.30	2280.90	2350.10	799.90	0.012	0.049	1.197
	min	120.40	158.70	311.50	13.50	0.001	0.017	0.186
	max	34527.10	177569.50	269369.30	289092.90	0.035	0.342	6.449
	stdev	4004.54	24300.33	32488.29	33598.06	0.006	0.037	1.159
GERMANY	mean	584.92	6018.75	5188.25	1727.24	0.011	0.044	0.848
	median	270.80	3005.65	1951.10	363.70	0.011	0.043	0.435
	min	110.40	542.40	498.90	0.10	0.002	0.023	0.149
	max	15391.70	156541.30	175442.80	67430.40	0.018	0.101	17.333
	stdev	1318.14	12998.40	15752.98	6772.04	0.003	0.011	1.448
ITALY	mean	683.88	5109.17	4134.75	2639.02	0.019	0.066	0.661
	median	225.50	1472.00	1388.50	493.60	0.018	0.067	0.564
	min	56.90	172.90	182.30	26.00	0.008	0.013	0.114
	max	7282.90	57032.30	43729.50	77360.00	0.032	0.208	7.121
	stdev	1222.68	9232.18	7445.60	7680.41	0.004	0.029	0.468
SPAIN	mean	387.42	3596.26	2718.57	429.72	0.016	0.044	0.359
	median	189.90	1874.55	1194.30	126.60	0.016	0.039	0.284
	min	8.70	17.10	24.60	1.00	0.001	0.012	0.085
	max	4680.60	44441.00	31340.30	10834.90	0.189	1.390	2.453
	stdev	631.52	5487.90	4650.05	933.51	0.009	0.066	0.259
UK[b]	mean	1626.37	16478.88	10741.71	43358.89	0.007	0.056	0.548
	median	43.10	587.90	143.90	9036.50	0.007	0.055	0.498
	min	2.90	37.10	3.30	0.00	0.003	0.028	0.133
	max	26047.60	283738.40	197671.40	183492.40	0.018	0.096	2.000
	stdev	4434.96	43585.99	33285.81	54959.76	0.003	0.009	0.255

[a] TC = total costs (€ mil.); Q_1 = total loans (€ mil.); Q_2 = other earning assets (€ mil.); Q_3 = off-balance sheet activities nominal value (€ mil.); P_1 = personnel expenses/total assets; P_2 = interest expenses/total customer deposits; P_3 = other non-interest expenses/total fixed assets.

[b] In the UK, the sample is 50 banks per year (over the 7-year period: 350 banks) of which 6 banks per year have published off-balance sheet activities (over the 7-year period: 42).

Table 2: Malmquist Index Decomposition (Summary of Annual Means)[a,b]

	Years	Pure Technical Efficiency Change (TE)	Scale Efficiency Change (SE)	Technical Efficiency Change (TEC)	Technological Change (TC)	Total Factor Productivity Change (TFP) (M_0)
FRANCE	1994/95	1.046	1.029	1.076	0.903	0.972
	1995/96	0.992	0.946	0.938	1.155	1.084
	1996/97	0.976	0.967	0.944	1.09	1.028
	1997/98	1.005	1.005	1.01	0.989	0.999
	1998/99	0.965	0.968	0.935	1.162	1.086
	1999/00	1.002	1.028	1.03	0.921	0.949
	1994/0	**0.997**	**0.99**	**0.987**	**1.031**	**1.018**
GERMANY	1994/95	1.014	1.03	1.045	0.919	0.96
	1995/96	1.01	1.016	1.027	1.04	1.068
	1996/97	1.018	1.001	1.019	1.017	1.036
	1997/98	1.026	1.006	1.033	0.949	0.98
	1998/99	1.016	0.989	1.005	1.067	1.073
	1999/00	0.991	0.99	0.982	0.947	0.93
	1994/0	**1.013**	**1.005**	**1.018**	**0.988**	**1.006**
ITALY	1994/95	0.987	0.995	0.982	0.965	0.948
	1995/96	0.981	1.014	0.995	1.042	1.037
	1996/97	1.012	1.013	1.025	1.144	1.173
	1997/98	1.006	0.981	0.987	1.211	1.195
	1998/99	0.987	0.981	0.968	1.32	1.278
	1999/00	0.967	0.987	0.954	0.992	0.947
	1994/0	**0.99**	**0.995**	**0.985**	**1.105**	**1.089**
SPAIN	1994/95	1.034	1.006	1.04	0.928	0.965
	1995/96	1.004	1.005	1.009	1.064	1.074
	1996/97	0.988	0.894	0.884	1.408	1.244
	1997/98	1.005	1.095	1.1	1.064	1.17
	1998/99	0.991	1.002	0.993	1.226	1.217
	1999/00	1.009	0.994	1.003	0.934	0.937
	1994/0	**1.005**	**0.998**	**1.003**	**1.092**	**1.095**
UK	1994/95	1.015	1.071	1.087	0.878	0.954
	1995/96	0.994	0.991	0.985	1.073	1.057
	1996/97	0.985	0.975	0.961	1.072	1.029
	1997/98	1.027	1.018	1.045	0.929	0.971
	1998/99	0.998	0.966	0.965	1.071	1.033
	1999/00	1.012	1.034	1.046	0.972	1.017
	1994/0	**1.005**	**1.008**	**1.014**	**0.996**	**1.01**

[a] Note: A number <1 indicates decline; a number >1 indicates growth.

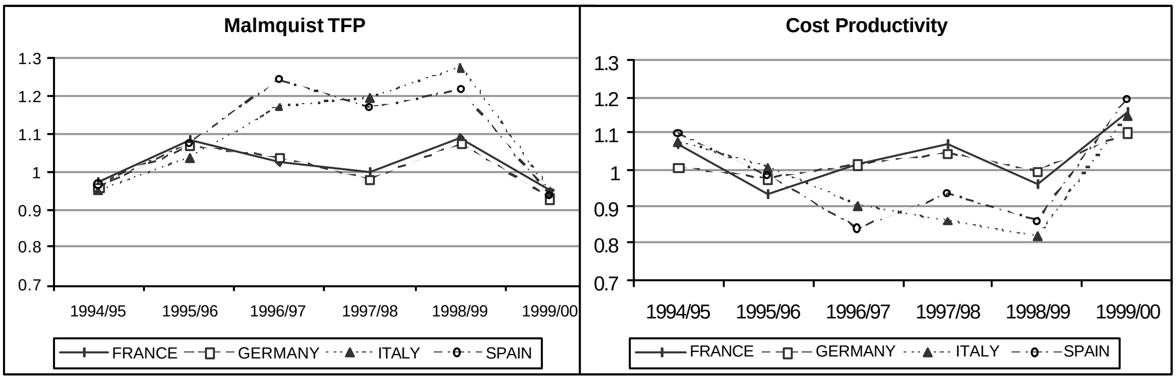
[b] TE x SE = TEC; TEC × TC = TFP.

Table 3 **Measured Gross Changes in Cost: Total Change, Productivity Change, Business Condition Change, Best-Practice Frontier Change and Inefficiency Change [a,b]**

	YEARS	DTOTAL	DPROD	DBUSCOND	DBESTPR	DINEFF
FRANCE	1994/95	1.084	1.069	1.014	1.099	0.972
	1995/96	0.941	0.933	1.008	1.116	0.836
	1996/97	1.022	1.019	1.002	0.651	1.566
	1997/98	1.057	1.071	0.988	1.135	0.943
	1998/99	0.959	0.960	0.999	0.924	1.039
	1999/00	1.146	1.158	0.990	1.400	0.827
	1994/00	**1.032**	**1.032**	**1.000**	**1.027**	**1.005**
GERMANY	1994/95	1.008	1.007	1.001	1.167	0.863
	1995/96	0.976	0.974	1.002	0.814	1.196
	1996/97	1.026	1.013	1.012	1.173	0.863
	1997/98	1.045	1.044	1.000	1.069	0.977
	1998/99	0.996	0.997	0.999	0.926	1.077
	1999/00	1.094	1.100	0.995	1.061	1.037
	1994/00	**1.024**	**1.022**	**1.002**	**1.027**	**0.995**
ITALY	1994/95	1.070	1.076	0.994	1.169	0.920
	1995/96	1.005	1.006	0.999	1.102	0.913
	1996/97	0.902	0.904	0.997	0.920	0.982
	1997/98	0.858	0.862	0.995	0.791	1.089
	1998/99	0.813	0.820	0.991	0.742	1.106
	1999/00	1.139	1.147	0.993	1.005	1.141
	1994/00	**0.957**	**0.962**	**0.995**	**0.942**	**1.021**
SPAIN	1994/95	1.103	1.099	1.004	1.185	0.927
	1995/96	0.981	0.981	1.000	1.143	0.858
	1996/97	0.838	0.838	1.001	0.854	0.981
	1997/98	0.938	0.935	1.003	0.810	1.155
	1998/99	0.863	0.862	1.001	0.899	0.959
	1999/00	1.195	1.191	1.004	1.059	1.125
	1994/00	**0.979**	**0.977**	**1.002**	**0.981**	**0.995**

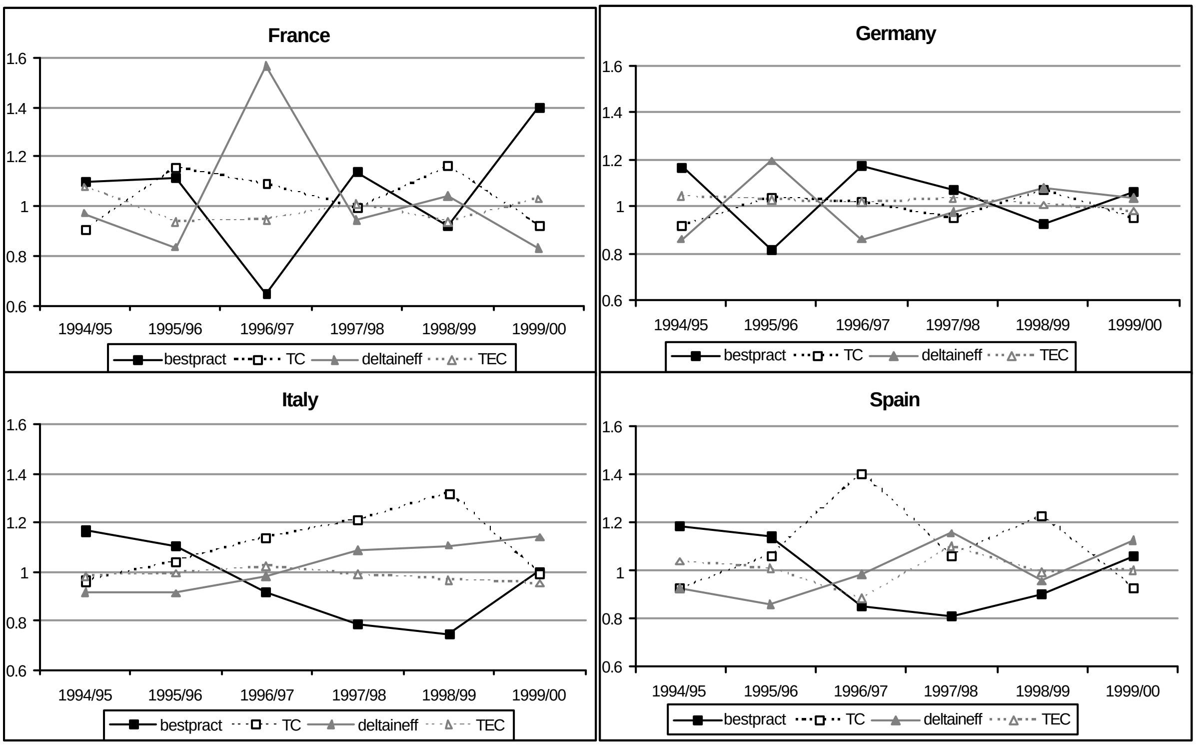
[a] A number >1 indicates an adverse shift toward higher costs; a number <1 indicates a favourable shift.
[b] ΔBUSCOND=ΔTOT/ΔPROD.

Figure 1: Productivity Change trends



Note: For the Malmquist FTP Index, A number <1 indicates decline; a number >1 indicates growth. For the Cost Productivity estimate, a number >1 indicates an adverse shift toward higher costs; a number <1 indicates a favourable shift. We would therefore expect mirror trends in the two graphs.

Figure 2: Decomposition of productivity change



Note: For the Malmquist FTP Index decomposition [technological change (TC) and efficiency change (TEC)], a number <1 indicates decline; a number >1 indicates growth. For the Cost Productivity estimate decomposition [change in best practice (ΔBESTPR) and change in inefficiency (ΔINEFF)], a number >1 indicates an adverse shift toward higher costs; a number <1 indicates a favourable shift. We would therefore expect mirror trends in the two graphs.