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A comparative study of efficiency in European banking.

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A Comparative Study of Efficiency in European Banking

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Abstract

This thesis investigates whether there has been an improvement and convergence of productive efficiency across European banking markets since the creation of the Single Internal Market: it examines the main European banking systems between 1993 and 1997 and estimates the efficiency characteristics of these markets by employing non-parametric estimation techniques, in the form of Data Envelopment Analysis (DEA) and the Free Disposal Hull (FDH) approach. In addition, this study also evaluates the productivity change across banking markets employing the Malmquist Productivity Index (MPI). Using efficiency measures derived from DEA estimation, it also evaluates the determinants of European bank efficiency using the Tobit regression model approach. Finally, this thesis extends the established literature on modelling the determinants of bank efficiency by recognising the problem of the inherent dependency of DEA efficiency scores when used in regression analysis. To overcome the dependency problem, a bootstrapping technique is applied. Overall, the results suggest that since the EU's Single Market Programme there has been a small improvement in bank efficiency levels, although there is little evidence to suggest that these have converged. The results also suggest that inference on the determinants of bank efficiency drawn from non-bootstrapped regression analysis may be biased and misleading.

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List of Acronyms

ATMs	Automatic Teller Machines
C/I	Cost-to-Income Ratio
CES	Constant Elasticity of Substitution
CDs	Certificates of Deposit
CRS	Constant Returns to Scale
DEA	Data Envelopment Analysis
DFA	Distribution Free Approach
DMU	Decision Making Unit
EC	European Commission
ECB	European Central Bank
ECU	European Currency Unit
EEA	European Economic Area
EEC	European Economic Community
EFTA	European Free Trade Association
EFTPOS	Electronic Funds Transfer at Point-of-Sale
EMI	European Monetary Institute
EMS	European Monetary System
EMU	European Monetary Union
EPSCE	Expansion Path Scale Economies
EPSUB	Expansion Path Subadditivity
ERM	Exchange Rate Mechanism
ESCB	European System of Central Banks
EU	European Union
FCA	Functional Cost Analysis

FDH	Free Disposal Hull
GDP	Gross Domestic Product
IBCA	International Bank Credit Analysis
ICSD	International Central Securities Depository
IT	Information Technology
M&As	Mergers and Acquisitions
MPI	Malmquist Productivity Index
NDRS	Non Decreasing Returns to Scale
NIRS	Non Increasing Returns to Scale
OECD	Organisation for Economic Co-operation and Development
OLS	Ordinary Least Squares
PACEC	Public and Corporate Economic Consultant
PC	Personal Computer
PPP	Purchasing Power Parity
PPS	Production Possibility Set
RAC	Ray Average Cost
ROA	Return on Assets
ROE	Return on Equity
ROAA	Return on Average Assets
ROAE	Return on Average Equity
SE	Scale Efficiency
SEA	Single European Act
S&Ls	Savings and Loans
SFA	Stochastic Frontier Approach
SMEs	Small and Medium Enterprises
SMI	Single Market Integration
SMP	Single Market Program
SUR	Seemingly Unrelated Regression
TE	Technical Efficiency
TFA	Thick Frontier Approach

TFP	Total Factor Productivity
US	United States (of America)
VRS	Variable Returns to Scale

Member States

(In accordance with Community practice, the EU countries are listed using the alphabetical order of the country names in the national languages)

BE	Belgium
DK	Denmark
DE	Germany
GR	Greece
ES	Spain
FR	France
IE	Ireland
IT	Italy
LU	Luxembourg
NL	Netherlands
AT	Austria
PT	Portugal
FI	Finland
SE	Sweden
UK	United Kingdom

1 Background, Aims, Methodology and Structure of the Study

Since the signing of the Treaty of Rome in 1957, European countries have come a long way towards the development of a truly pan-European economic and monetary union. Under the 1957 Treaty, the internal market was viewed as one which allowed "free movement of goods, people and services" and the objective was to transform the segmented national markets into a common single market. The year 1992 marked a significant strengthening of the progression towards an EU-wide market for goods and services with the implementation of the EU Single Market Programme (SMP). One of the major objectives of the EU's 1992 SMP was to facilitate the free movement of goods and services across Member States and to improve economic efficiency.

An integral part of the SMP was directed at harmonising regulations and fostering competition in the banking sector. Up until the mid-1980's there had been little progress in removing barriers to trade in financial services. Typically, European banking systems were characterised by relatively high levels of government controls and restrictions that inhibited competition and maintained a protected banking environment. Interest rate restrictions and capital controls were widespread, and branching restrictions existed in some countries. There were marked differences across banking systems: for instance, the United Kingdom, Germany, Denmark and the Netherlands had comparatively liberal and open banking markets, while regulatory restrictions limited the competitive environment in the remaining EU Member Countries [see European Commission (1997a)].

The EC's 1985 White Paper on the completion of the Single Market and its incorporation in the Single European Act (SEA) of February 1986 constituted an important and renewed commitment by the European Commission towards the liberalisation of EU banking markets. This culminated in the Second Banking Co-ordination Directive, adopted in 1989, together with the two parallel Directives on

Solvency Ratios and Own Funds. This formed a comprehensive framework for regulating all the banking business in the EU. By 1 January 1993 the aforementioned legislation had created the 'largest and most open banking market in the world' by eliminating or lessening existing barriers and by establishing minimum regulatory requirements across EU banking systems.

The process of integration and the accompanying deregulation has embodied an incentive for bank management to focus on improving efficiency, especially given the more competitive banking environment. Efficiency is now considered a critical strategic factor for banks in remaining competitive and a number of recent studies have shown that the most efficient banks have substantial cost and competitive advantages over those with average or below average efficiency [Sinkey (1992); Berger *et al.* (1993); Gardener (1995); Molyneux *et al.* (1996)]. However, despite the extensive literature recently generated on this issue, most of these studies relate to the US banking system, while European empirical research, with some exceptions, is comparatively scarce. In addition, although there have been a number of international comparisons of banks' efficiency [see Berg *et al.* (1993); Fecher and Pestieau (1993); Berg *et al.* (1995); Bergendhal (1995); Pastor, Pérez and Quesada (1995); Allen and Rai (1996); Pastor, Lozano and Pastor (1997); European Commission (1997a); Dietsch and Weill (1998)], the need for further research in this area has been highlighted by a recent survey undertaken by Berger and Humphrey (1997). This need is particularly pressing in the light of relevant changes in the regulation of financial systems, especially in Europe, where structural deregulation (that is, reducing or lessening banking structural and conduct rules) has been a major feature of the EU's Single Market Programme and of the evolution of the European Monetary Union (EMU).

1.1 Aims of the Study

This thesis aims to investigate whether the productive efficiency of the European banking systems has improved since the creation of the Single Market Programme. It examines the main European banking markets between 1993 and 1997 in order to investigate whether there has been an increase and a convergence of efficiency levels following the process of legislative harmonisation. Non-parametric estimation techniques, in the form of Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) approaches, are applied to evaluate the relative efficiency of European banking. In addition, the productivity change across banking markets is calculated using the Malmquist Productivity Index (MPI). This thesis also evaluates the determinants of European bank efficiency by using the Tobit regression model approach to investigate the influence of various country-specific and environmental factors on bank efficiency. Finally, this thesis extends the established literature on the determinants of bank efficiency by taking into account the problem of the inherent dependency of DEA efficiency scores when used in regression analysis. To overcome the dependency problem a bootstrapping technique is applied.

The main question we aim to answer is:

⇒ In a productive context, has large European bank productive efficiency improved and converged since the creation of the SMP?

The above question leads to the following set of sub-questions:

⇒ What is meant by productive efficiency for banks?

⇒ What does theory and the relevant empirical literature tell us about the nature, meaning and determinants of bank productive efficiency?

⇒ How might bank productive efficiency best be evaluated?

⇒ How might we compare bank productive efficiency cross-country and over time?

⇒ Are European banks' productive efficiency estimates consistent with standard measures of performance?

⇒ What are the main determinants of European bank efficiency?

1.2 Methodological Issues

One of the main problems faced by researchers investigating banks' cost efficiency relates to difficulties in the definition and measurement of the concept of bank output, mainly as a result of the nature and functions of financial intermediaries. The most debated issue regards the role of deposits: on the one hand, it is argued that they are an input to the production process (*intermediation and asset approach*); on the other hand, it is suggested that deposits are an output (*production approach*), involving the creation of value added, and for which customers bear an opportunity cost (*value added approach, user cost approach*). Even today, there is no all-encompassing theory of the banking firm; in particular, there is no agreement on the explicit definition and measurement of banks' inputs and outputs. Berger and Humphrey (1997) pointed out that, although there is no 'perfect approach', the intermediation approach may be more appropriate for evaluating entire financial institutions. Following the modern empirical literature [see, among others, Molyneux *et al.* (1996); Mester (1996)], the empirical analysis presented in this thesis uses the intermediation approach, which views financial institutions as mediators between the supply and the demand of funds. The main consequence of the intermediation approach is that deposits are considered as inputs, and interest on deposits is a component of total costs, together with labour and capital.

The techniques employed in this study to estimate the productive efficiency of the main European banking systems are non-parametric: they include the Data Envelopment Analysis (DEA) and its relative, the Free Disposal Hull (FDH). The DEA efficiency estimates are also used with panel data in order to analyse the variation of productive efficiency over time. Following the lead of Färe *et al.* (1994) and Grifell-Tatjé and Lovell

(1995a) we use DEA estimates to construct a MPI of productivity change, which enables us to track productivity growth or decline during the length of time under investigation.

Efficiency estimates are also compared to standard measures of performance (ROE, ROAA, and Cost/Income ratio) to test for consistency. Efficiency measures should be positively correlated with standard non-frontier measures of performance. As pointed out by Bauer *et al.* (1997), positive correlation with these measures would give evidence that the frontier measures are not simply artificial products.

Although the basic DEA models have been improved in a number of ways in recent years [see Lovell (1993) and Seiford (1996)], one of the main criticisms faced by researchers using non-parametric methods is the difficulty of drawing statistical inference. The more recent literature, however, has sought ways to overcome this problem [see Grosskopf (1996)]. One of the first tools employed to this end was regression analysis. The basic idea of what has become known as the "Two-Step" procedure is to treat the efficiency scores as data or indices and use linear regression to explain the variation of these efficiency scores. The first improvement to this model has come with the attempt to account for the fact that efficiency scores are censored [Lovell, Walters and Wood (1995)]; as a result, a model that accounted for the fact that the dependent variable was limited became preferred to OLS.

A new conceptual issue has recently been raised by Xue and Harker (1999): they point out that efficiency scores generated by DEA models are clearly dependent on each other in the statistical sense. The reason for dependency is the well-known fact that the DEA efficiency score is a relative efficiency index, not an absolute efficiency index. Because of the presence of the inherent dependency among efficiency scores, one basic model assumption required by regression analysis, independence within the sample, is violated. As a result, the conventional procedure, followed in the literature, is invalid. Xue and Harker (1999) propose a bootstrap method to overcome this problem. This study implements a 'Three-Step' approach, which can be summarised as follows:

1. Run the DEA model to calculate the DEA efficiency scores;
2. Fit a Tobit regression model in which the DEA efficiency score is the dependent variable to investigate the determinants of bank efficiency;

3. Substitute the conventional estimators of the Tobit regression coefficient estimates, with the bootstrap estimators for the standard errors of these estimates, to account for the problem of inherent dependency arising when DEA scores are used in regression analysis.

1.3 Data Sources

The banking systems studied in this thesis are those of: France, Germany, Italy, Spain and the United Kingdom. The choice of countries is based as much on their relative economic weight inside the EU as on the size of their respective banking sectors. The time span considered is from 1993 to 1997, that is the period following the implementation of the Single Market Programme (SMP).

A sample of 750 banks from the above countries (the largest 150 banks by asset size in each respective country) was drawn from the London-based International Bank Credit Analysis IBCA 'Bankscope' database. Subsidiaries of foreign banks, the specialised financial institutions and the central institutions were excluded. Furthermore, given the need for comparable data from different countries, 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 removed from the sample. The result is a pooled sample of 530 banks. The data were extracted from non-consolidated income statement and balance sheet data corresponding to the years 1993-97. All data are reported in ECU as the reference currency; they are in real 1997 terms and have been converted using individual country GDP deflators[1].

In the present international setting, the need for comparable data from different countries imposes strong restrictions on variables we are able to use, not least because of the various accounting criteria used in the five countries under investigation. In order to

[1] To convert values in local currencies into a common currency we may use either the official exchange rate or the purchasing power parity (PPP) rate as computed by the OECD; the two approaches appear to yield very similar results [Berg *et al.* (1993)].

minimise possible bias arising from different accounting practices, the broad definition of variables as presented by IBCA Bankscope is chosen.

1.4 Structure Plan

The structure of this thesis is as follows:

- Chapter 2 offers an overview of the major changes in European banking, with a particular focus on EU banking regulation. Regulatory developments have been an important factor shaping the structure of European banking markets. The harmonisation of banking and other financial services legislation as part of the EU's Single Market Programme (SMP) and the advent of the European Economic and Monetary Union (EMU) has helped reduce the barriers to cross-border trade in banking services, thus promoting greater competition. The first part of Chapter 2 examines the moves towards a single market for financial products in the EU and offers a detailed review of the relevant legislation that led to the SMP and to EMU. The second part of the chapter outlines the other forces of change, with particular focus on technology. An understanding of these revolutionary changes in the EU banking markets is fundamental to the analysis of productive efficiency of European banking systems over the period 1993-1997, which constitutes the main aim of this study.
- Existing forces of change are putting European banks under increasing pressure to restructure. The main aim of Chapter 3 is to outline how these factors have altered European banking markets. Following a brief overview of the European economy during the 1990s, the chapter analyses the structure and performance characteristics of EU banking markets over the last decade. European banks seem to have responded to the challenges of the increased competition during the 1990s through three main strategic responses: *i)* they

have attempted to cut cost and improve efficiency by reducing excess capacity (in particular by reducing the size of their branch network and staffing levels); *ii)* they have aimed to improve the quality and broaden the range of products and services supplied to customers; and finally *iii)* many have engaged in mergers and acquisitions activities, as well as forging strategic alliances and co-operation agreements. Given these developments and the new challenges posed by further technological developments as well as EMU, it is important to investigate the cost characteristics of the main EU banking systems so as to evaluate the potential efficiency implications and opportunities arising from developments in the European banking industry.

- In recent years, the study of financial firm efficiency has become an increasingly important area. Berger and Humphrey (1997), for example, review 130 efficiency studies and outline how this work is useful for informing government policy and evaluating the managerial performance of financial institutions. This literature has focused mainly on frontier efficiency, that is the empirical estimation of how close financial institutions are to a 'best practice' frontier. The existent literature employs five major different efficiency techniques: *i)* Non-parametric Frontiers: Data Envelopment Analysis (DEA), Free Disposal Hull (FDH), and related frontier approaches, some of which take the form of Malmquist Productivity Indices (MPI) and *ii)* Parametric Frontiers, including the Stochastic Frontier Approach (SFA), Distribution-Free Approach (DFA), and Thick Frontier Approach (TFA). These approaches differ in the assumptions they make regarding the shape of the efficient frontier, the existence of random error and, if random error is allowed, the distributional assumptions imposed on the inefficiencies and random error in order to disentangle one from each other. The main aim of Chapter 4 is to review the financial institution efficiency literature; the first part of this chapter introduces the issue of cost economies in banking and the related problems of defining banks' production processes. This helps the researcher to understand the choice of the variables employed in the empirical literature. The latter part of the chapter provides a review of bank efficiency studies, with a particular focus on international comparisons, which are particularly relevant for the empirical analysis carried out in this thesis.

- Chapter 5 describes the data sample and illustrates in some detail the methodological approaches followed in the empirical analysis. In particular, it focuses on the use of non-parametric deterministic approaches to the evaluation of productive efficiency (DEA and FDH) and technological change (MPI). The last part of the chapter discusses the most recent literature on the issue of statistical inference in non-parametric studies, focusing on the so-called 'Two-Step' approach and the bootstrap method. Finally, it identifies the 'Three-Step' approach for the analysis of the determinants of efficiency in European banking, which will be implemented in the empirical analysis.
- Chapter 6 presents the main findings of the empirical analysis. The results of the empirical investigation are organised as follows: Section 1 presents the FDH and DEA efficiency estimates. Scale efficiency scores are also reported. Moreover, Malmquist Productivity Indices, which identify productivity growth or decline in the European banking markets between 1993 and 1997, are presented. Consistency tests of the efficiency scores over time and with standard non-frontier measures of performance are also presented in Section 6.2. The determinants of European bank efficiency are investigated in Section 6.3. Overall, the results suggest that since the implementation of the EU's Single Market Programme there has been a small improvement in bank efficiency levels, although there is little evidence to suggest that these have converged. The results also suggest that inference on the determinants of bank efficiency drawn from non-bootstrapped regression analysis may be biased and misleading.
- Finally, Chapter 7 presents the conclusions and the limitations of this study.

2 Changes in European Banking

In recent years banking structures and strategies have been involved in a fundamental process of change. At the beginning of the 1990s there had been a great deal of study and speculation on the forces of change in European banking [see, among others, Gardener and Molyneux (1990); Canals (1993); Arthur Andersen (1993)]. The Arthur Andersen (1993) survey of senior bankers and others concerned with European banking and financial markets found that regulatory developments, competition and technology were generally felt to be the three most important forces of change likely to affect the structure of financial markets in most EU countries. More recent studies, however, seem to conclude that the effects to date on corporate and retail banking have been limited. McCauley and White (1997, p.2) note that: 'it is surprising, in light of all these forces of change, how little impact they have had to date on the structure of the European financial industry, which continues to be basically 'national' in the provision of corporate and retail banking services'. They attempt to put forward some explanations, identifying some 'forces resisting change' that have acted to maintain the competitive *status quo*. Some of these forces have their roots in time-specific circumstances, others are institutional in nature, while others are cultural. Nonetheless, it is a widespread belief that the banking sector in Europe may now be about to enter a period of increased competition [McCauley and White (1997); White (1998); De Bandt (1999)]. Some important forces of change, principally identified as changes in technology, the evolving role of the state, demographic pressures, a growing concern for shareholders value and the introduction of the Euro are affecting financial business everywhere. In addition, globalisation, securitisation, and growing competition from both non-bank financial intermediaries and unregulated non-banks can be seen as manifestations of underlying and more fundamental forces of change (White, 1998).

Developments in technology, in particular in computing and telecommunications, can be considered perhaps the most fundamental force for change in the financial sector over the past decade[1]. These developments have led to the creation of new financial products and a great expansion in the means to deliver them. Remote banking is currently offered by at least all the major banks throughout the EU. Most of the standard retail banking services are already offered via automated teller machines (ATMs) and telephone banking. In addition, the provision of financial services on the Internet is also beginning to expand rapidly [European Central Bank (ECB)(1999a)]. Lower-priced computers, further advances in technology, greater familiarity and increased confidence in the security of the technology are expected to accelerate these trends (White, 1998).

While some of these forces of change (e.g. technology, demographic trends, globalisation, securitisation) are affecting banking developments worldwide, some other forces are distinctively European. The advent of the European Economic and Monetary Union (EMU) and the introduction of the Euro are considered to be likely to act in the medium and long term as a catalyst to reinforce the already existing forces of change [McCauley and White (1997); White (1998); De Bandt (1999); ECB (1999a)]. In particular, EMU is expected to reinforce the pressure for the reduction of existing excess capacity, to put profitability under pressure and to lead to increased internationalisation and geographical diversification, also outside EMU, as well as to increased conglomeration and mergers and acquisitions (ECB, 1999a). EMU can also be seen as an extension of the legislative change in European markets and a further step in the direction of European economic and financial integration (De Bandt, 1999). Regulatory developments have been an important factor shaping the structure of European banking markets.

[1] The pace of technological developments has certainly exceeded even the more optimistic expectations at the beginning of the 1990s. In fact, the scenario that emerged form the Arthur Andersen (1993) survey saw technology lagging behind regulatory developments and competition as the most important forces of change likely to affect the structure of financial markets in EU countries.

The harmonisation of banking and other financial services legislation as part of the EU's Single Market Programme (SMP) and the advent of EMU has helped reducing the barriers to cross-border trade in banking services, thus promoting greater competition. EU deregulation has also facilitated the environment in which technology and other bank strategic drivers have become operationally more important (European Commission, 1997a). The first part of this chapter examines the moves towards a single market for financial service in the EU. It briefly outlines the background to the SMP (Section 2.1) and offers a detailed review of the relevant legislation that led to the SMP (Section 2.2) and to EMU (Section 2.3). The second part of the chapter outlines the other forces of change (Section 2.4) with a particular focus on technology (Section 2.4.1). An understanding of these revolutionary changes in the EU banking markets is fundamental to the analysis of productive efficiency of European banking systems over the period 1993-1997, which constitute the main aim of this study.

2.1 The European Single Market

The completion of the Single Market Programme (SMP) among the European Union Member States has already had a profound effect on businesses and industry throughout Europe, not least among the financial service industries of the different Member States. A survey undertaken by the European Commission in 1996 states that the Community legislation in the Single Market area has, taken as a whole, created the basic conditions for free movement and economic efficiency. 'Although it is still too early for many Single Market measures to have taken full effect, there is evidence of positive, albeit preliminary effects of the Single Market in triggering the expected reinforcement of integration, competition, economic performance and benefits for the consumers' [European Commission (1996a)][2].

[2] 'The Impact and Effectiveness of the Single Market', Communication from the Commission to the European Parliament and Council, 1996, p. 4.

This section examines the background to the European Union; particular focus will be given to the legislation passed by the European Commission in order to remove barriers to free trade, in particular those related to the banking industry and to the securities business. It then introduces some attempts to assess the impact and effectiveness of the Single Market.

2.1.1 The European Union

The European Community was originally founded in 1957 by six States - Belgium, France, Germany, Italy, Luxembourg and the Netherlands - which were joined by Denmark, Ireland and the United Kingdom in 1973, Greece in 1981 and Spain and Portugal in 1986. In 1990, the new East German *Länder* were incorporated.

In 1992, the Member States decided to form a European Union (EU), which was enlarged in 1995 to include Austria, Finland and Sweden. The EU today embraces more than 370 million people. The Maastricht Treaty, agreed in December 1991 and enforced in November 1993, is an important landmark in the development of Europe. However, the road which brought Europe from the original Treaty of Rome in 1957 to the creation of the Union was not an easy one, many conflicting issues have emerged over the years. As the community enlarged, it became increasingly clear that many physical and technical barriers remained to prevent the free movement of goods, services and people. The EC 1985 White Paper on the completion of the single market and its incorporation in the Single European Act (SEA) of February 1986 constituted an important and renewed commitment to the original Treaty of Rome. Table 2.1 illustrates the moves towards a single market in the European Union.

Table 2.1: Towards the European Union

Dates	European Developments
1957	The Treaties of Rome were signed on 25 March by the 'Six', Belgium, France, West Germany, Netherlands, Luxembourg and Italy, creating the European Economic Community and Euratom. They came into force on 1 January 1958.
1972	Accession of Denmark, Ireland and the United Kingdom. Signed 2 January 1972; came into force 1 January 1973.
1979	Accession of Greece. Signed 28 May 1979; came into force 1 January 1981.
1985	Accession of Portugal and Spain. Signed 12 June 1985; came into force 1 January 1986.
1986	The Single Act signed 17 and 28 February 1986; came into force 1 July 1987. Established the Single Market from 1 January 1993.
1990	The newly unified Germany was incorporated as a single market state in the Community on 3 October 1990. On 1 July 1990 monetary union between the two states of Germany was begun. Full political reunion took place on 3 October 1990.
1991	European Economic Area, EC plus EFTA minus Switzerland and Liechtenstein formed. Signed October 1991; came into force 1 January 1994. Liechtenstein joined EEA in 1995.
1991	Maastricht agreement on Treaty on Union signed. The Treaty was initialled in February 1992 and after delays in ratification by national parliaments during 1992, came into force 1 November 1993.
1995	Accession of Austria, Finland and Sweden. Agreed March 1994; came into force on 1 January 1995. (Norway's referendum rejected membership).

Source*:* Adapted from Goodman (1996), p.43.

The legal basis of the European Union has become exceedingly complex and there is a strong case to be made for a completely new treaty to simplify the overlapping Treaties of Paris, Rome, Maastricht and the Single European Act, together with assorted other legislation.

The process of making decisions in the European Union is a complicated one. Procedures differ according to subject and type of measure. Broadly speaking, the Council and the Commission may make Regulations, issue Directives, take Decisions, make Recommendations or deliver Opinions.

Regulations are directly applicable in full to all Member States and their citizens and do not need to be approved by national parliaments. If there is any conflict with existing national law, these Regulations take precedence. Directives are also binding on all Member States in connection with the results to be achieved and when they are to be achieved. However, the means by which the results are achieved are left to the individual national governments. Moreover, Directives themselves do not have any legal standing in the Member States but have to be implemented by the national legislation. Failure to implement particular provisions may result in action taken against the country concerned. Decisions are the normal means by which the Community orders something to be done in an individual case. These decisions are legally binding, but only on the particular governments, companies or individuals to whom they are addressed. If they impose financial obligations, they are enforceable in the Member courts. Recommendations and Opinions are also types of legislation, which are not legally binding, but which merely state the view of the institution that issues them. Although the legislative power of the Union lies with the Council, it delegates some of this power to the Commission. Any delegation usually carries routine and technical matters and is subject to the advice and assistance of committees composed of people from each Member State (Dixon, 1993; Goodman, 1996).

2.2 A Single Market for Financial Services

As it has been noted in the previous section, since the signing of the Treaty of Rome in 1957, European countries have come a long way towards the development of pan-European unification and not only from an economic and monetary point of view. According to the 1957 Treaty, the internal market was to allow "free movement of goods, person and services" and its main objective was to transform the segmented national markets into a common single market. The first major target was to form a customs union; the 'Six' agreed to remove customs or tariffs barriers between them and to impose a common external tariff on imports from non-member countries. The right of establishment and the freedom to provide services throughout the Community were specifically laid out in the Treaty of Rome's directions for the internal market; however, far more progress was made in dismantling barriers to trade within the EC than was made in removing barriers to the free provision of services (Dixon, 1993).

Up until the mid-1980s there had been little progress in removing barriers to trade in financial services. Typically, European banking systems were characterised by relatively high levels of government controls and restrictions that inhibited competition and maintained a protected banking environment. Interest rate restrictions and capital controls were widespread, and branching restrictions existed in some countries. There were marked differences across banking systems: for instance, the United Kingdom, Germany, Denmark and the Netherlands had comparatively liberal and open banking markets, while regulatory restrictions limited the competitive environment in the remaining EU Member Countries [see European Commission (1997a)].

The EC's 1985 White Paper on the completion of the Single Market and its incorporation in the Single European Act (SEA) of February 1986 constituted an important and renewed commitment by the European Commission towards the liberalisation of the EU banking market. This culminated in the Second Banking Co-ordination Directive, adopted in 1989, together with the two parallel Directives on Solvency Ratios and Own Funds. These formed a comprehensive framework for regulating all banking business in the EU. By 1 January 1993 the aforementioned legislation had created the 'largest and most open banking market in the world' by eliminating or lessening existing barriers and by establishing minimum regulatory requirements across EU banking systems.

In presenting and discussing the legislation underpinning the SMP, a taxonomic and analytical perspective is provided by grouping banking-specific regulation into those that mainly influence the structure of the sector, the conduct and behaviour of banking firms. This approach, followed by Vesala (1993) and Gual and Neven (1993), is helpful in indicating the broad objectives of banking regulation and the nature of the impacts expected from legislative changes [European Commission (1997a)]. Nevertheless, different Directives can often not be uniquely assigned to one category and there may be significant interdependence between the various influences arising from different Directives.

Table 2.2: Classification of the Methods of Banking Regulation

Regulations influencing the structure	Regulations influencing the conduct	Regulations influencing Prudential concerns
▪ Functional separation of institutions ▪ Entry restrictions ▪ Discriminatory rules against foreign banks (and investors) ▪ Liberalisation of capital movements	▪ Regulation of banks' deposit and lending rates[1] ▪ Regulations of fees and commissions[1] ▪ Credit quotas[1] ▪ Branching limitations ▪ Reserve requirements[1] ▪ Money laundering	▪ Deposit insurance ▪ Discount window (lender-of-the-last-resort)[1] ▪ Minimum capital requirements ▪ Solvency ratios ▪ Ownership restrictions ▪ Restrictions on asset concentration (large exposures) ▪ Information disclosure requirements

[1]These issues have no direct relevance to EU banking regulation in the framework of the SMP but are certainly influential.
Source: Adapted from Vesala (1993); Gual and Neven (1993).

2.2.1 EU Banking Regulation

As previously pointed out, from 1 January 1993 the EU legislation created the 'largest and most open banking market in the world', by eliminating or lessening existing barriers and by introducing the single financial market. This section provides an overview of the relevant EU banking legislation. Table 2.3 lists the main legislative acts enacted by the EU. However, it is very important to stress the existence of lags and leads between the enactment of the legislation by the EU and the actual implementation of the legislation by a Member State.

Table 2.3: EU Banking Regulation

EU Enactment	Measure	Implementation Deadline
73/183/EEC	Self-employed activities	01/01/1975[a]
77/780/EEC	First Banking Directive	15/12/1979
83/350/EEC	Supervision of credit institutions on a consolidated basis	01/01/1985
86/635/EEC	Annual Accounts of banks and other financial institutions	31/12/1990
87/62/EEC	Monitoring of large exposures	not compulsory[b]
87/63/EEC	Deposit-Guarantee Schemes	not compulsory[b]
89/117/EEC	Accounting documents of branches of foreign credit and financial institutions	01/01/1991
89/299/EEC	Own funds	01/01/1991
89/646/EEC	Second Banking Directive	01/01/1993
89/647/EEC	Solvency ratios	01/01/1991
90/109/EEC	Transparency of banking conditions relating to cross-border financial transaction	not compulsory[b]
91/308/EEC	Money laundering	01/01/1993
91/633/EEC	Own funds	01/01/1991
92/16/EEC	Own funds	01/01/1993
92/30/EEC	Supervision of credit institutions on a consolidated basis	01/01/1993
92/121//EEC	Monitoring of large exposures: new standards	01/01/1994
93/6/EEC	Capital adequacy of investment firms and credit institutions	01/07/1995
94/15/ECC	Deposit-Guarantee Schemes	01/07/1995

[a] Except for the derogation in respect of the Netherlands
[b] No deadline as this is only a Recommendation
Source: Adapted from http:// www.europa.eu.int (1998)

The First Banking Directive (Right of Establishment and Freedom to Provide Services)

The Council Directive No. 780 of 12 December 1977 was concerned with the co-ordination of laws, regulations and administrative provisions relating to the taking up and pursuit of the business of credit institutions. It defined a credit institution as an undertaking whose business is to receive deposits of repayable funds from the public and grant credits for its own account. The Directive established the minimum requirements for the authorisation and supervision of banking institutions and represented the first step towards the principle of supervision in the country of origin ('home country control'). The Directive required Members States to have a system for authorisation of new banking entities based on two principal criteria:

- to have adequate capital;
- to be directed by at least two people of good repute and experience.

If a credit institution met these requirements, it gained a basic right of establishment. This allowed banks which had their head offices in one Member State to set up branches in the other Member States.

It is common opinion [Dixon (1993); Canals (1993); Molyneux *et al.* (1996)] that this Directive was a useful first step, but it did not create a free internal market. For instance, although banks within the EC possessed a basic right to extend their activities to other countries of the Community, in practice substantial disparities between national regulations remained (for example, limitations on the number of branches or the capital requirements new branches had to satisfy, which existed in certain countries, such as Spain and Italy). As Molyneux *et al.* (1996) pointed out, while setting up the ground rules, the First Banking Directive left much detail open to interpretation, and a more precise Directive was obviously needed for the freeing up of the cross border provision of banking services.

The Directives on Consolidated Supervision

The Council Directive No. 350/1983 on Consolidated Supervision dealt with the supervision of consolidated accounts and the harmonisation of rules relating to annual accounts of banks. This Directive laid down that where one institution owned more than 25% of another, the two should be supervised together, on a consolidated basis. Therefore, the Directive extended the supervision of individual banks to banking groups, covering their domestic and foreign affiliates and their cumulated overall credit risk (Molyneux *et al.*, 1996). However, as Dixon (1993) pointed out, although helpful, this Directive did not represent the removal of any major barrier to business.

The Council Directive No. 30 of 6 April 1992 replaced the 1983 Directive and provided a coherent framework for supervising all credit institutions on a consolidated basis. In particular, consolidated supervision should be applied not only to credit institutions with another credit institutions as a parent company, but also to those which are subsidiary undertakings of a financial institution.

The 1985 White Paper

The 1985 White Paper on the Completion of the Internal Market, drawn up by Lord Cockfield at the request of the EU Council of Ministers, represented by far the most important progress towards the liberalisation of banking services across Europe. The White Paper contained a list of measures that had to be adopted before 1992 so that 'people, goods, capital and services' could freely circulate in the EU. It established the guidelines for a single banking licence, home country control and mutual recognition. The Commission's approach was to produce legislation that guaranteed minimum standards in the areas of financial stability and prudential practice of financial institutions. Moreover, it attempted to identify the measures to be taken to remove all physical, technical and fiscal barrier among the Member States by the end of 1992 and the timetable to adopt them (Molyneux *et al.*, 1996).

In February 1986 Member States signed the Single European Act (SEA), establishing year-end 1992 as the limiting date for the achievement of an integrated European market in goods, services and capital and setting in motion a two-phase programme for complete and unconditional liberalisation of capital movements (Steinherr, 1992).

Directive on the Annual Accounts and Consolidated Accounts of Banks and other Financial Institutions

The Council Directive No. 635 of 8 December 1986 was designed to adapt the provisions of the Fourth Company Directive on Annual Accounts and Seventh Company Directive on Consolidated Accounts to the peculiarities of the banking sector. It provided for harmonised standards throughout the Community with regard to annual and consolidated accounts for credit institutions.

The Second Banking Co-ordination Directive (Right of Establishment and Freedom to Provide Services)

The Second Banking Co-ordination Directive, adopted in 1989 for implementation by the beginning of 1993, represents by far the most important piece of Community legislation on the removal of barriers to free the provision of banking services. As pointed out by the European Commission (1997a), the Second Banking Directive provided a comprehensive framework for the regulation of the EU banking sector and addressed many of the problems left unresolved by the First Banking Directive.

The Directive's importance in removing barriers derives from several major leading changes. In particular, this legislation:

- established conditions for the free provision of banking services by adopting the principle of 'mutual recognition' of a single banking licence;
- established the principle of 'home country' control;
- harmonised key supervisory standards relating to minimum capital requirements, requirements with regard to major shareholders of the credit institutions and bank limitations to participation in the non-financial sector;
- abolished requirements for branches to maintain a minimum level of endowment capital.

By far the most important aspect of the Second Banking Directive was the provision for a 'single banking licence'. This allowed any credit institution, authorised to act in a Member State, automatically to set up branches or to supply cross-border services in all the other Member States, without having to obtain further authorisation from each state. An appendix to the Directive lists a wide range of services for which this licence would be valid. The scope of the Second Banking Directive is summarised in table 2.4:

Table 2.4: Services Credit Institutions are allowed to Offer under the Second Banking Directive

- Deposit-taking and other forms of borrowing
- Lending (consumer credit, mortgages, factoring, trade finance)
- Financial leasing
- Money transmission services
- Issuing and administrating means of payment (credit cards, travellers' cheques, and bankers' drafts)
- Guarantees and commitments
- Trading for own account or for account of customers in:

(i) money market instruments (cheques, bills, CDs, etc);
(ii) foreign exchange;
(iii) financial futures and options;
(iv) exchange and interest rate instruments;
(v) securities.

- Participation in share issues and the provision of services related to such issues
- Money broking
- Portfolio management and advice
- Safekeeping of securities
- Credit reference services
- Safe custody

Source: Second Banking Co-ordination Directive, *Official Journal of the European Communities*, No. 386/13, 30/12/1989.

The above list of activities is very wide-ranging, taking account of realities of the financial markets and the progressive breakdown of traditional demarcation lines between commercial and investment bank. Moreover, the Directive provided for the periodic review and updating of the list, to take account of future developments in banking services.

The principle of home country control, which had been first put forward by the 1985 White Paper, implied that the EU Member State that had granted a banking licence to a certain institution, was also responsible for the supervision of its activities in the EU, wherever the institution operated. However, host countries would have the primary responsibility for supervising liquidity and exclusive responsibility for implementing monetary policy. Moreover, host country authorities would also have the power to supervise banking solvency in relation to the securities business. Host country rules on the way in which banking services are provided were also to apply, although these rules could not be used to discriminate against foreign institutions and had to be 'justified on the grounds of the public good' (Articles, 19 (4), 21 and 21(5)). However, because of the uncertainty surrounding various interpretations of the 'general good', in 1995 the Commission issued a draft for consultation with a view to clarifying the position

(European Commission, 1997a).

In order to prevent increased competition and the principle of home country control resulting in lower standards of supervision, the Second Directive included provisions to harmonise some essential supervisory standards, especially those related to minimum capital standards for the authorisation and continuation of banking business; the control of major shareholders and banks' participation in the non-banking sector; proper accounting and control mechanisms and standards on own funds, solvency ratios and deposit protection legislation. In addition, the Directive greatly strengthened co-operation between the banking authorities of different Member States.

The other major way in which the Directive helped to remove barriers to banking throughout the EU was by abolishing the requirement for branches to maintain a minimum level of capital. This had presented an obstacle to free establishment of branches in other countries, because of the huge and often unnecessary costs it imposed to banks.

Finally, the Directive also allowed for reciprocal access to the single market for banks from non-EU countries; subsidiaries of non-EU banks set up in Europe were to be considered EU undertakings and, therefore, benefit from the Directive's provision for freedom of establishment and cross border activities. This part of the Directive attracted attention and controversy and it provoked a great deal of opposition on the basis of the fear that non-EU banks would be denied access to the European market and, even worse, the fear that this, in turn, would have reduced access for EU banks in third countries. Because of the strength of feelings against the initial 'reciprocity provisions', the Commission toned them down into effective market access, comparable to that which the third country's bank receive in the Community market.

Dixon (1993) pointed out that, although the Directive did not succeed in removing all the regulatory barriers to a free market in banking services, it went a long way towards establishing an open market and reducing bureaucracy.

A final provision in the Second Banking Directive stated that the concepts of mutual recognition and home country control could only come into effect if two other Directives, the Own Funds and the Solvency Ratio Directives, were implemented at the same time.

The Own Funds Directives

The Own Funds Directive, issued by the Commission in September 1986 and adopted in April 1989 (Council Directive No. 299 of 17 April 1989), became effective in January 1993. It was then amended by Directive 16/1992, also to be implemented by January 1993.

The Own Funds Directives defined what was meant by 'capital' for banks and the definition given was basically the same as the Bank for International Settlement or 'Basle' requirements[3] (Gardener and Molyneux, 1990). By harmonising the definitions of Own Funds for all credit institutions in the EU, it improved the comparability of prudential ratios of EU banks. The definition included all elements that make up institutions' own funds in the different Member States, and used a two-tier classification by dividing them into 'internal' and 'external' elements. 'Internal elements' or 'Original own funds' (which can be also identified as 'Tier 1 capital' in the Basle regime) are those which are at the bank's free disposal and which can absorb any losses (Dixon, 1993). They can be classified in five main subgroups, as shown in table 2.5.

Table 2.5: Own Funds Directive Definition of Capital

- Paid-up capital and share premium account, but excluding the institution's holding of its own shares;
- Reserves, including legal reserves and accumulated retained profits;
- Revaluation reserves;
- Funds which are at the bank's free disposal in order to cover normal business risks, where there is evidence of their existence in the internal accounts and where their amount is determined by the management, verified by independent auditors and made known to the competent supervisory authorities,
- Securities of indeterminate duration and other similar instruments if they fulfil certain specified conditions.

Source: Council Directive 89/299/EEC, *Official Journal of the European Communities* No L 124/16, 5/5/89.

[3] Committee on Bank Regulations and Supervisory Practices (1988), '*International Convergence of Capital Measurement and Capital Standards*' (Basle, BIS).

'External elements' or 'Additional own funds' (which can be also identified as 'Tier 2 capital' in the Basle regime) were defined as those which are placed at the disposal of a credit institution but are not fully owned or controlled by it, or put at its disposal for a limited period only. The Directives did not provide a detailed list of these elements.

Dixon (1993) states that the definitions in these Directives are of minimum prudence; each Member State is free to apply stricter criteria or not including some of the elements listed in its own regulations.

The Solvency Ratio Directive

The Solvency Ratio Directive (Council Directive No. 646 of 18 December 1989) established a uniform minimum solvency ratio for all EU credit institutions, using the capital defined in the Own Funds Directives as numerator. The solvency ratio of the Directive expresses own funds as a proportion of risk-adjusted assets and off-balance sheet transactions. This denominator is found by assigning different degrees of risk to each class of assets and off-balance sheet items and then multiplying this risk weighting and totalling these risks adjusted values. It is generally accepted that this risk-adjusted approach to measuring institutions' solvency is the most flexible and appropriate one, since simpler ratios do not distinguish between different degrees of risk (Dixon, 1993).

In order to assign risk weights, the Directive grouped borrowers into broad categories (for example, central banks, central governments, credit institutions) each of which are associated with a specific risk-weighting (for example, 0%, 10%, 20%, 50% or 100%, according to a list included in the Directive). Moreover, the Directive constrained the own funds of a credit institution to at least 8% of its risk-weighted assets.

Molyneux *et al.* (1996) pointed out that the capital adequacy requirements established by this Directive are perfectly in line with the Bank for International Settlement (BIS)(1988) proposals, for example, both regimes have similar categories of risk classification and identical risk weightings.

The Money Laundering Directive

The Council Directive No. 308 of 10 June 1991, enforced in January 1993, was introduced with the aim of preventing EU financial markets from being used for laundering money derived from criminal activities; it was clearly seen as a device for increasing stability and confidence in the financial system. Money laundering refers to 'the international handling of property knowing it to come from the commission of a serious crime, in particular drug related offences, organised crime and terrorism. The offence also extends to the concealment or aiding and abetting of money laundering'[4].

The Directive provided a list of measures, such as the identification of customers and beneficial owners, the retention of documentary evidence and records of transactions, the disclosure to the competent authorities of suspect transactions and the obligation to introduce staff training programmes and internal control procedures, with which banks and other financial institutions have to comply.

The Large Exposure Directive

The Council Directive No. 121 of 21 December 1992, enforced in January 1994, on monitoring and controlling large exposures of credit institutions aimed at regulating risks concentration and to ensure uniformity in their treatment between Member States.

The Directive defined a large exposure to a single customer, or to a group of connected customers, to be 10% or more of own funds of the credit institution; as soon as the exposure reaches this threshold, it has to be reported to the competent authorities. Moreover, the Directive stated that the total amount of large exposures should not exceed 800% of own funds.

[4] *Official Journal of the European Communities*, No. L 166/77, of 28 June 1991.

The Deposit Guarantee Schemes Directive

The Council Directive No. 19 of 30 May 1994, enforced in July 1995, on the Deposit Guarantee Schemes was designed to increase the confidence and stability of financial systems by ensuring that EU depositors are covered by deposit-insurance compensation schemes in case of bank insolvency. According to the Directive, all credit institutions are required to be a member of a deposit guarantee scheme operating in the country of their incorporation. In addition, the Directive introduced the home country rule, according to which the deposits taken by the EU-based credit institutions in other Member States through branches should be covered by the system operating in the country of the head office. In addition, it laid down provisions on the minimum harmonisation of the extent and level of coverage (at least 20,000 Euro) as well as the procedure for compensating the depositors of a credit institution whose operations are suspended and whose deposits become unavailable (European Commission, 1997a).

EU Regulation on Transactions in Securities

Since the late 1970s, the European Commission has also issued a series of important Directives in order to achieve the creation of single securities market. Table 2.6 lists the relevant regulation on transaction in securities.

Table 2.6: EU Regulation on Transactions in Securities

EU Enactment	Measure	Implementation Deadline
79/279/EEC	Conditions for the admission of securities to Stock-Exchange listing	08/03/1981[a]
82/121/EEC	Information to be published by companies the shares of which are listed on a Stock-Exchange	30/06/1983
82/148/EEC	Conditions for the admissions of securities to Stock-Exchange listing	06/03/1982
85/611/EEC	Investments: collective investment undertakings (UCITS)	01/10/1989[b]
88/220/EEC	Investments: special measures for certain investments by UCITS	01/10/1989[b]
88/627/EEC	Information on major holdings	01/01/1991
89/298/EEC	Prospectus for public offerings of securities	17/04/1991
89/592/EEC	The regulation of insider trading	01/06/1992
93/6/EEC	Capital Adequacy of Investment Firms and Credit Institutions	
93/22/EEC	Investment services	01/07/1995
94/18/EEC	Listing particulars to be published for the admission of securities to official Stock-Exchange listing	no deadline set

[a] except for derogation
[b] 01/04/1992 for Greece and Portugal
Source: Adapted from http:// www.europa.eu.int (1998).

All of the above legislation aimed at creating a single market for financial services, by allowing banks and other financial firms to operate with a 'single licence' throughout Europe, subject only to the home country control. It is necessary to point out, however, that the timing of the introduction of the EU legislation differed across countries. Tables 2.7 and 2.8 illustrate the timing of legislative implementation of some of the main EU Directives previously illustrated.

Table 2.7: Implementation of Banking Legislation

Directives	BE	DK	IE	FR	DE	GR	NL	IT	LU	PT	ES	UK
183/1973/EEC	1983	1974	1977	1975	1976	1986		1975	1975	1992	1987	1976
780/1977/EEC	1993	1980	1989	1980	1978	1985	1978	1985	1981	1992	1987	1979
350/1983/EEC	1985	1985	1985	1984	1986	1986	1986	1986	1986	1986	1985	1979
635/1986/EEC	1992	1990	1992	1991	1992	1994	1993	1992	1992	1992	1991	1994
117/1989/EEC	1992	1990	1992	1991	1992	1994	1992	1992	1992	1992	1993	1993
299/1989/EEC + 16/1992/EEC	1994	1990	1991	1990	1992	1992	1991	1993	1992	1993	1993	1992
646/1989/EEC	1994	1991	1992	1992	1992	1992	1992	1992	1993	1992	1994	1993
647/1989/EEC	1994	1990	1991	1991	1992	1992	1991	1993	1993	1992	1993	1992
308/1991/EEC	1995	1993	1995	1992	1993	1993	1994	1993	1993	1993	1993	1993
121/1992/EEC	1994	1993	1994	1993	1995	1994	1993	1994	1993	1992	1993	1993
15/1994/EC	1994		1995	1995	1995	1995	1995			1995		1995

Source: European Commission (1997a) p.12.

Table 2.8: Implementation of Transactions in Securities Legislation

Directives	BE	DK	IE	FR	DE	GR	NL	IT	LU	PT	ES	UK
627/1988/EEC	1993	1991	1991	1990		1992	1991	1992	1992	1991	1991	1993
611/1985/EEC	1991	1990	1989	1989	1990	1993	1990	1992	1988		1993	1989
592/1989/EEC	1991	1992	1990	1990		1992	1992	1991	1991	1990	1991	1994
298/1989/EEC	1991	1991	1992	1992	1990	1992	1992	1992	1990	1992	1993	1991
279/1979/EEC	1993	1983		1986	1986	1985	1991	1987	1985	1991	1990	1989
220/1988/EEC	1991	1990	1989	1989	1990	1993	1990	1992	1988		1990	1989
121/1982/EEC	1993	1990		1983	1986		1992	1987		1991	1993	1986

Source: http://www.europa.eu.int (1998)

The following section reviews two main studies that have attempted to evaluate the impact and effectiveness of the single market.

2.2.2 The Impact of the Single Market Programme

During the past decade, a number of studies have tried to estimate the potential welfare gains which could possibly result from the completion of the single EU market for financial services. The Cecchini/Price Waterhouse (1988) study was the first and most important critical work to analyse comparative competitive conditions across EU banking and financial systems.

2.2.2.1 The Cecchini/Price Waterhouse Report

The Cecchini studies main objective was to estimate the economic impact of 1992 on the financial sectors in selected European countries (the Benelux countries, France, Italy, Spain, UK and Germany), under the assumption that the law of one price prevailed, that is the hypothesis that after 1992 EU prices would move downwards, towards some uniform level for each financial product and service and therefore bring about economic gains from the EU integration. The main assumption was that the SMP would induce a series of integration effects that would promote the efficiency and competitiveness of EU firms through two channels: increased market size and heightened levels of competition.

Cecchini considered deregulation as a kind of supply-side shock to the system, in consequence of which price reductions and output increases stimulate demand, which in turn leads to further price and output increases. To quantify the effects of regulations, the Report utilised a wide range of approaches, including the following:

- comparative prices of specific products/services;
- value added/output ratios;
- survey data on net margins;
- indirect measures of impact of specific regulations;
- a case study on the impact of deregulation.

The main results of the Cecchini/Price Waterhouse Report indicate that gains in consumer surplus would occur in each country. The overall increase in consumer surplus for the European economy due to the single financial market was estimated to be between 11 billion and 33 billion ECU (between £7.7 billion and £23.1 billion). The integration of the banking sector was estimated to account for between 8 billion and 22 billion ECU. It was suggested that up to one third of the total economic gains from the entire SMP during the first six years after 1992 would come directly or indirectly from the deregulation of the financial services sectors. The Report emphasised that the figures indicated possible benefit to consumers and not the impact on economic activity, as the effect of redistribution between different producers and different countries were not taken into account.

Cecchini envisaged that the productive effects of greater competition from the elimination of barriers to trade, would be to eliminate economic rents (the margin of excess profits or wage rates that result from market protection), reduce X-inefficiencies and allow firms to gain the benefits of economies from restructuring (scale and scope economies). Within this vision, Cecchini also envisaged a substantial increase in both cross-border trade and cross-border mergers and acquisitions in banking, as banks sought to exploit economies of scale and scope (European Commission, 1997a, p. 27).

A number of criticisms, however, have been made about the findings of the Cecchini/Price Waterhouse Report. It has been argued that the results are both over-optimistic and unreliable. Gardener and Teppett (1995), for example, pointed out that the calculation of economic gains excluded the case where prices of some financial products are hypothesised to rise. They also pointed out that the estimated economic gains are overstated because the findings downgrade estimates of the hypothesised losses in producers' surplus. Dixon (1993) criticised the report on the grounds that some of its assumptions seem to be arbitrary in the extreme. For example, it was assumed that the potential price fall in a completely liberalised market would equal the average of the lowest four prices observed. Even though there are economic arguments to support the assumption that the prices will fall, it seems to be guesswork to assume by how much. Llewellyn (1992) noted that there are many factors other than lack of competition or financial regulation that might account for price differences. He also argued that liberalisation does not necessarily increase competition enough to force price equalisation and does not itself guarantee that competitive conditions will be equalised between EU Member States. Because of economic reasons, such as entry costs and scale constraints, banking and financial markets could remain partially segmented even without formal controls, regulations barriers or imposed entry restrictions.

Nevertheless, Molyneux *et al.* (1996, p.46) stated that despite the limitations and the major data problems associated with such an analysis, the Cecchini/Price Waterhouse study was 'an heroic attempt' to include both international trade theory and industrial organisation theory in a static framework, in order to provide at least a first step towards attempting to evaluate the benefits and costs of financial sector integration.

2.2.2.2 The impact of the Single Market on Credit Institutions and Banking (European Commission)

Almost ten years after the publication of the Cecchini/Price Waterhouse findings, another major study attempted to assess the impact of the SMP on the performance and strategic reactions of the banking and credit sectors and to evaluate the effectiveness of the SMP in creating a single market for banking and credit services. The 1997 European

Commission Report on the impact of the Single Market on credit institutions and banking was part of a series of 39 studies commissioned by the European Commission from independent consultants to present an overall analysis of the effectiveness of the measures taken in the creation of the Single Market[5]. In undertaking this study, a suitable conceptual framework was developed and a programme of empirical research specifically aimed at disentangling the effects of the SMP from other factors influencing the EU banking and credit systems was designed. Moreover, the study attempted to take into consideration bankers' perceptions on the impact of the SMP.

While the aforementioned Cecchini/Price Waterhouse study adopted the perspective of modelling a post-SPM scenario conforming to some idealised model which was then compared with the situation pertaining prior to deregulation (*ex-ante* study), the approach adopted by the European Commission (1997a) study was to compare what had happened since the SMP with an assessment of what would have happened without the SMP (*ex-post* study). The main problem associated with this kind of approach consists in the identification of the counterfactual or *anti-monde*. In this respect, the period 1980-86 has been used as a kind of broad benchmark in order to assess the impact of the SMP. The major empirical problem of the research relates to the attempts to disentangle the SMP effects from other factors which have influenced banks and credit institutions during the period under observation.

In order to carry out the analysis, six pieces of empirical research were undertaken:

- a review of both published and unpublished research;
- an assessment of the content, timing and implementation of EU Directives and national legislative changes and an assessment of remaining barriers to Single Market Integration;
- a major postal survey of banking and credit organisations in each country of the EU;
- a case study of a bank in each of the Member States;
- an econometric analysis of relevant time series data and cross-section data relating to economies of scale and scope, X-inefficiency, productive efficiency and prices;
- an analysis of the results of a Eurostat survey.

[5] The project was directed by B. Moore (Cambridge University and PACEC) in collaboration with E.P.M. Gardener and P. Molyneux (Institute of European Finance, University of Wales, Bangor).

While each of these methodologies is subject to various weaknesses and limitations, the authors' attempts to use a diverse approach may have helped to minimise the individual drawbacks and to build up a detailed overall picture of the impact of the SMP.

This study found evidence that the EU banking market has become much more competitive and market-oriented during the past decade. Increased bank emphasis on productive efficiency, greater strategic priority towards internal capital allocation and risk management and awareness of shareholders value concepts are the main arguments put forward to identify the strategic changes in banks' behaviour. The approximate strategic reaction of many EU banks to the SMP has been defensive, stimulating domestic mergers and acquisitions, especially in countries where the banking system was previously less exposed to competition. Evidence from various case studies suggests that a key impact of the EU legislation has been to focus banks more on efficiency issues. Another interesting result is the fact that, despite competition intensifying in all EU banking and credit markets, the prices of bank products appeared largely unresponsive to these increasingly competitive conditions. Moreover, the review found little evidence of either a generalised bank product price convergence or a respective specific SMP influence on any bank product price convergence that was detected during the review.

The Report found mixed evidence on the impact of the SMP on the internationalisation of banking and credit markets; on the other hand, it found solid evidence of the increase of cross-border mergers and acquisitions. Moreover, according to the findings, the level of employment in the banking and credit sectors has generally fallen post-SMP and there is also evidence of a significant decline in the number of banks in most EU countries. The econometric results relative to the estimation of scale, scope and X-efficiencies do not allow, if not tentatively, to assess the impact of the SMP. 'Although the econometric tests found that X-inefficiencies declined in all bank size categories for the majority of EU countries, it is not possible to attribute this decline solely to the impact of the SMP' (European Commission, 1997a, p. 136)[6].

[6] The econometric results of the European Commission (1997a) Report are reviewed in Chapter 4.

This study constitutes an important piece of European research, some of the econometric work had not been undertaken on such a scale in European banking and this, together with the postal survey and the case studies, provided a detailed insight into EU banking market post-SMP. Nevertheless the study notes that, when addressing the issue of the impact of the SMP on European banking, it is very difficult to disentangle EU legislation effects from those related to a wide range of factors, for example, to technological developments and changes in the macroeconomic environment.

2.2.2.3 Forces Restraining Change

As reviewed in Section 2.2, the Single Market Programme has substantially changed the regulatory framework in which European financial institutions operate and changed bankers' expectations and strategies. It should be noted, however, that while cross-border barriers in European financial markets have been dismantled, other forces have acted to maintain the competitive *status quo* (White, 1998, pp. 13-16). Basically, these forces can be identified as:

- time-specific
- institutional
- cultural

Most of the relevant changes highlighted so far are of relatively recent origin and the industry has not had very many years to react to these deregulatory initiatives. It is reasonable to expect that their influence may grow as time passes. However, within national countries, there have been a number of institutional impediments restricting change in the financial sector. As noted by White (1998) the institutional impediments to international competition, especially in continental Europe, remain quite substantial. The legal, tax, regulatory and supervisory frameworks within which financial institutions have to operate continue to differ in significant ways across the various EU Member States. Moreover, different accounting standards, reporting procedures and employment practices also work in the same direction. One of the most important impediments to change is related to labour laws in Europe, which provide significant protection to workers against job shedding. Many of these differences have been allowed to remain given the existence of an 'opt-out' clause in the Second Banking Directive, which can be invoked in the interests of the 'general good'. In other words, EU national governments have been left a device to assert national law over EU legislation. The European Commission (1997a) cited the mortgage sector as an example of a sector which has benefited from the 'general good' opt-out provision. In fact, mortgage credit law in Belgium and all consumer law in France have been classified as being part of the 'general good'; therefore, cross-border mortgage loans have been void on this basis, on the ground that free provision of mortgage services would not be in the general interest of Member State institutions. According to the European Commission (1997a) there is some evidence that the 'general good opt-out', because of the uncertainty which it gives rise to, can create barriers to cross-border activity.

A postal survey undertaken by the European Commission[7] and organised and carried out by country experts showed that the following barriers are believed to be relatively important impediments to trade in EU banking services:

- costs associated with entering new geographical markets
- social barriers
- legal hindrances
- national taxation regime
- domestic governments anti-competitive measures
- collusion between domestic banks
- capital requirements.

The aforementioned concerns reflect the perception of a continuing cultural bias in most countries towards their own citizens and institutions. Different national languages, different national practices and simple inertia on the part of the consumers are other factors impeding cross-border competition that could prove difficult to overcome.

[7] European Commission (1997a), pp.128-129.

However limited to date the effect of deregulation on international competition in banking may have been, the introduction of the Euro seems likely to be a catalyst for change going well beyond the cost of transition to a single currency. According to McCauley and White (1997) it seems probable that the Euro will play an important role in stimulating the growth of a much larger and more liquid securities market in Europe. This could be a significant new source of competitive pressure for banking firms providing traditional forms of intermediated credit in Europe. The introduction of a single currency also removes a major barrier to cross-border EU trading in banking services.

The following section, therefore, summarises the main features of the European Economic and Monetary Union (EMU) and its possible effects on the EU banking systems.

2.3 European Economic and Monetary Union (EMU)

For more than three decades, the European vision has included the objective of achieving a single currency for Europe. The original proposals set out in the 1972 Werner report foresaw monetary union by 1980; however, the 1970s oil shock and the worldwide move to floating exchange rates delayed implementation.

More recently, a single currency has been seen as a necessary element in order to complete the European Union's single market. Without such a reform, exchange rate fluctuations and the costs and inefficiencies, which result from trading between different currencies, created major barriers to cross border trade and investment within Europe. The decision to complete the single market, with the signing of the Single European Act in 1986, lent new force to the belief that a closely integrated group of economies would have much more to gain from lack of exchange rate fluctuations than from occasional exchange rate realignments. The European Monetary System (EMS) and its Exchange Rate Mechanism (ERM), which aimed to control exchange rate movements among Member State currencies, were only ever seen as staging posts on the way to the total elimination of exchange rate fluctuations - which would only be fully achieved through the establishment of a single currency and a single monetary policy.

It was against this background that the Council of Ministers asked Jacques Delors (the then President of the European Commission) to chair a committee to propose concrete stages leading towards full monetary union. The Delors report appeared in April 1989 and its three stage progression towards economic and monetary union (EMU) was subsequently enshrined in the Maastricht Treaty in 1991.

The Maastricht Treaty, which amended and supplemented the 1957 Treaty of Rome, proved to be highly controversial in a number of Member States - not least because of its provisions on EMU. Indeed, it was only agreed by the Heads of Government of the Member States after Denmark and the UK had negotiated their "opt-outs" from the obligation to proceed towards a single currency. Subsequent ratification by Member States proved equally controversial. Nevertheless, the Treaty finally came into force on 1 November 1993 and created an obligation for all the thirteen Member States without an opt-out to merge their currencies into a single currency if they met four macroeconomic criteria - relating to inflation, exchange rate stability, long term interest rates and government debt.

The Treaty contemplated a range of dates for the launch of the single currency. Had a majority of the Member States met the Maastricht criteria at the end of 1996, the Council of the European Union would have set a date for the start of EMU soon thereafter. When the Maastricht Treaty was drafted there was every expectation that a majority would be in economic shape by the end of 1996. In the event, the recession of the early and mid 1990s intervened. As a result, the start date was postponed to the last date expressly contemplated in the Treaty - 1 January 1999. For this start date, there was no requirement that a majority of Member States met the Maastricht criteria. Any two or more Member States, which met the criteria on the basis of their 1997 figures, were obligated, under the terms of the Treaty, to go ahead.

Table 2.9: Key Elements of EMU Timetable

March 1998	Commission and European Monetary Institute (EMI) produced reports on Member State compliance with Maastricht criteria
May 1998	• Participating Member States chosen • Announcement of bilateral conversion rates between participating currencies • Article 1091(4) Regulation adopted
June 1998	• European Central Bank established
31 December 1998 to 3 January 1999	Conversion Weekend • Redenomination of domestic government debt of participating Member States • Stock exchanges of participating Member States move to Euro • ICSDs move to Euro operations
1 January 1999	Launch of single currency and start of transitional period: • irrevocable locking of conversion rates • Euro becomes currency of participating Member States • national currency units become denominations of the Euro • ECU obligations converted into Euro obligations at 1:1 conversion rate • European Central Bank takes over control of monetary policy for Euro zone • New issues of government debt issued in Euro
31 December 2001	• End of transitional period • Obligations denominated in national currency units redenominated into Euro
1 January 2002	Euro banknotes and coins introduced
30 June 2002	Latest date on which national banknotes and coins cease to be legal tender

Source: http://www.cliffordchance.com/library/publications/emu_legal/section1.html (1999)

The decision as to which Member States qualified for the single currency in 1999 was made by a qualified, or weighted, majority vote of the Council on the basis of reports by the European Commission and the European Monetary Institute (EMI) submitted in March 1998. Following the opinion of the European Parliament delivered on 2 May 1998, the Council decided on 3 May 1998 that Belgium, Germany, Spain, France, Ireland, Italy, Luxembourg, the Netherlands, Austria, Portugal and Finland fulfilled the necessary conditions for the adoption of the single currency[8].

[8] Council Decision 98/317/EC of 3 May 1998 in Accordance with Article 109j(4) of the Treaty (OJ L 139, 11.5.1998, p. 30).

Greece did not satisfy the conditions while Sweden failed to fulfil the condition with respect to Exchange Rate Mechanism (ERM) membership and lacked sufficient independence of its central bank. Denmark and the UK exercised their "opt-outs" from proceeding in 1999.

Once the participating Member States were chosen, the only one key step that remained was the fixing of the irrevocable conversion rates. On 1 January 1999, the Euro became the official currency of 11 Member States of the European Union with a fixed conversion rate against their national currencies. Although Euro notes and coins will not appear until 1 January 2002, the new currency can be used by consumers, retailers, companies of all kinds and public administrations from 1 January 1999 in the form of "written money" - that is, by means of cheques, travellers' cheques, bank transfers, credit cards and electronic purses. The irrevocably fixed conversion rates between the Euro and the currencies of the Member States adopting the Euro are as follows[9]:

Table 2.10: Conversion Rates for EMU currencies

Country	Exchange rate
Belgium	40.3399 BEF
Germany	1.95583 DEM
Spain	166.386 ESP
France	6.55957 FRF
Ireland	0.787564 IEP
Luxembourg	40.3399 LUF
Netherlands	2.20371 NLG
Austria	13.7603 ATS
Finland	5.94573 FIM
Italy	1936.27 ITL
Portugal	200.482 PTE

Source: OJ L 359, Volume 41, 31/12/1998.

[9] Council Regulation (EC) No 2866/98 of 31 December 1998 on the conversion rates between the Euro and the currencies of the Member States adopting the Euro (OJ L 359, Volume 41, 31/12/1998).

2.3.1 Possible Effects of EMU on the EU Banking Systems

The advent of European Economic and Monetary Union (EMU) create new opportunities and challenges for financial institutions in Europe. There has recently been a great deal of study and speculation about the possible effects of EMU on EU banking systems [McCauley and White (1997); De Bandt (1999); ECB (1999a)]. The European Central Bank recently issued a report[10] which addresses this issue. The main findings of this report are that EMU is likely to act in the medium and long term as a catalyst to reinforce already prevailing trends in the EU banking systems. In particular, EMU is expected to reinforce the pressure for the reduction of existing excess capacity, to put profitability under pressure and to lead to increased internationalisation and geographical diversification, also outside EMU, as well as to increased conglomeration and mergers and acquisitions. Overall competition in banking within the Euro area is likely to increase considerably.

The ECB Report (1999a, p. 1) classifies the challenges EMU is likely to bring about according to the timing of the impact on the banking systems:

a) in the short term, the revenue and cost implications of the transition to the Euro, together with the possible protracted nature of the Asian and Russian crisis, the possible further spillover effects of developments in Latin America and other emerging markets might represent a dangerous combination for the EU banking systems.
b) in the medium term, the negative effects of the structural adjustment process in the EU banking systems could be concentrated in strategically unfavourably placed banks that may not cope with the risks and difficulties associated with adaptation to that process.

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[10] The report has been prepared in the context of the task of Eurosystem to contribute to the smooth conduct of policies followed by competent authorities in the field of banking supervision and financial stability (Article 105 (5) of the Treaty establishing the European Community) and draws on the contribution provided by the banking supervisory authorities of EU countries.

c) in the longer term, the adjustment process should result in a stronger and fitter banking sector and generate customer gains due to increased competition. In addition, the transition to a stable monetary environment should bring positive effects to the EU banking systems.

The ECB report (1999a, pp. 3-6) attempts to assess the effects of EMU on:

a) banking activities;
b) banking structure
c) banks' strategies;
d) banking risks.

The main findings of the report can be summarised as follow:

a) Effects of EMU on banking activities

The establishment of EMU is expected[11] to affect banking activities in different ways. The main negative consequence of EMU is the reduction in foreign exchange activity of currencies replaced by the Euro, together with the possible establishment of a low interest rate environment which would induce retail banking customers to seek alternative investments to bank deposits. On the positive side, lending business could be favoured by the positive macroeconomic environment brought about by EMU while the introduction of the Euro and the single monetary policy will possibly favour the setting-up of deep and liquid integrated money and capital markets. This latter could, in turn, generate growth but also trigger further competition in this area.

[11] For the ECB (1999a) Report, a large number of EU banks of various size were interviewed between mid-1997 and mid-1998 in order to investigate banks' own assessment of the effects of the EMU on the different banking activities.

b) Effects of EMU on banking structure

EMU is expected to reinforce the current tendency in EU banking systems towards a reduction of excess capacity[12]. In particular, branch networks and staffing levels, given the marked differences across countries, are expected to be reduced, thus enabling banks to achieve efficiency gains. In addition, EMU is also likely to speed up the process of disintermediation that is already under way across EU banking systems.

c) Effects of EMU on banks' strategies

European bankers believe that the establishment of EMU will create a more competitive environment and put further pressure on banks' profitability. The main strategic response to these challenges relate to:

- improvements in services and procedures concerning the quality of services, staff and information technology (IT); risk management and internal control systems; cost-cutting and efficiency improvements;
- changes in product ranges and development of alternative sources of income;
- mergers, strategic alliances and co-operation agreements, undertaken with a view to cost efficiency improvements, product diversification, new distribution channels and geographical expansion.

d) Effects of EMU on banking risks

On the one hand, the positive macroeconomic effects of EMU are expected to mitigate credit risk in the Euro area. On the other hand, several factors exist that may cause an increase in credit risk. One major possibility is that small and medium sized enterprises (SMEs) may not be strategically prepared to face the changes regarding EMU, with possible spillover effects on the banking system. In addition, if competition pressures increase, banks may shift their business towards more profitable but more risky business. Market risk is expected to decrease, especially with regard to foreign exchange and

[12] In a market where competitive conditions prevail and there is freedom of entry for new firms, we have excess capacity when there exists at least one firm attaining a lower level of profits than the "normal" one, i.e. the minimum required in order to stay on the market [Inzerillo *et al.* (1999)].

interest rate risk. However, banks could seek to replace a part of their lost foreign exchange business with new or increased involvement in non-EMU markets, with the possibility of increased country risk.

Liquidity risk is likely to decrease, because of deeper and more liquid markets in the Euro area. Legal risks and operational risks may become relevant in the short term, because of the new regulatory environment and the necessary system adaptation for the transition to the Euro.

To summarise, according to the ECB (1999a) report EMU will certainly have a major impact on the EU banking systems; however, it is important to point out that European banks are experiencing a restructuring phase also in response to worldwide trends affecting the industry. Advances in technology and the growth of institutional investors and securities markets are among the most important causes of this pattern. Section 2.4 investigates some of these trends.

2.4 Forces Generating Change

Financial liberalisation has certainly been one of the most important developments shaping the EU banking systems over the past decade. As reviewed in previous Sections, the process of liberalisation has made extensive progress in the EU, together with the establishment of harmonised EU regulatory framework and the liberalisation of capital movements. In addition, deregulation of the EU banking sector has contributed to create a business environment where operational efficiency and technology implementation play an important role in shaping banks' strategies.

2.4.1 Technological Change and its Effects on the EU Banking Systems

Information technology (IT) developments affect all aspects of banking and can be regarded as one of the main driving forces for change in the sector. Technology can also be used as an important strategic tool for banks to safeguard long-term competitiveness, cost-efficiency and improve their profitability.

IT affects banking in two main ways (ECB, 1999b, p.8):

1. it contributes to the reduction of the costs associated with the management of information (collection, storage, processing and transmission) by replacing paper-based and labour-intensive methods with automated processes;
2. it modifies the ways in which customers have access to banks' services and products, mainly through automated channels (remote banking).

The 'first wave' of IT developments started in the 1960s and 1970s and it implied significant changes in the banking industry, mainly through the centralisation and outsourcing of the related functions, generating important cost savings. The 'second wave' of technological developments, where customers are increasingly serviced through automated channels, has intensified more recently. These newer developments can further reduce banks' costs, but also have important effects on banking structure and can change the competitive environment for banks. The Banking Supervision Committee of the European System of Central Banks (ESCB) has recently presented a report which describes the extent to which these developments have taken place in the EU and investigates the banks' strategic adaptation and risks related to technological progress as well as relevant regulatory issues (ECB, 1999b).

'Remote banking' refers to the provision of banking services without face-to-face contact between the bank employee and the customer (ECB, 1999b). The key feature is that remote banking services represent complementary or even substitute services for those traditionally provided at branch offices.

It is important to correctly define[13] the services that form part of remote banking:

- kiosk (or self-)banking, where the customer uses multi-purpose ATMs installed by the bank, which may also use an interactive television to link the customer to a bank clerk in case guidance is needed;
- telephone banking, where the telephone is used as a message carrier to enable person-to-person or tone or voice activated communication between the bank and the customer;
- PC banking, where a telephone network or the Internet is used as data-message carrier and the customer uses a PC and a modem and is either given some home banking[14] software by the bank (online PC banking) or uses software directly available on the Internet (Internet banking).

Remote banking is already considered as a part of the basic retail banking service; it is currently offered by at least all major banks as well as niche banks throughout the EU as part of an overall distribution strategy. However, the intensity with which banks have promoted various remote banking 'models' differs significantly from one country to another, mainly depending on telecommunications infrastructure and other such conditions particular to individual countries (ECB, 1999b). Until now, major emphasis has been placed on developing ATM and telephone-based services, while PC banking has started only more recently, although most major banks have established Web sites for information purposes. Internet and interactive TV banking are also expected to have high growth potential, incorporating increasingly sophisticated products.

[13] These definitions are those used by the European Central Bank (1999b).

[14] In its Glossary, the ECB (1999c) defines '*home banking services*' as services which a retail customer of a financial institution can access using a telephone, television set, terminal or personal computer as a telecommunications link to the institution's computer centre. Therefore, home banking is part of remote banking.

As the majority of banks have no direct influence on technological developments, their main objective is to adapt to the use of the new technologies in their production and distribution channels. Technological developments based on remote banking can potentially determine substantial changes in the nature of banking competition for two main reasons. On the demand side, customers have the possibility of easily accessing and obtaining information on banking products and services offered by different banks and, therefore, of making comparisons. On the supply side, the barriers to entry into the retail market are lowered since a large branch network is no longer necessary to reach a 'critical mass' of customers. This means that small banks or niche institutions can also become competitive in this area.

Against the background of strategic opportunities and challenges offered by technological developments, it should be noted that EU banks are currently using IT resources mainly to manage operational needs, although they are expected to broaden the use of remote banking in the near future (ECB, 1999b).

IT developments affect the overall risk profile of banks. Strategically, banks run the risk of investing in IT resources that could quickly become outdated. Legal risk is related to the uncertainty surrounding the applicable laws and regulations on a number of aspects relating to technology (e.g. the legal status of remote banking, validity and proof of transactions, the respect of customers' privacy). Operational risk can increase because banks could tend not to upgrade their systems of internal control to cope with the new operational environment. Finally, the possibility of systemic risk may increase since technology increasingly links bank to each other through alliances and joint ventures, standardisation and the possibility of using similar software and hardware. As a consequence, technological developments in banking also have important consequences for prudential regulation and supervision.

2.4.2 Other Forces of Change

Other important forces of change in European banking include the changing role of the state, demographic change and the increasing demands of shareholders. In addition, 'underlying' forces of change such as globalisation, securitisation and increased competition from non-bank financial intermediaries are likely to have an even deeper impact on EU banking as well as banking systems worldwide. The remainder of this chapter deals with these issues.

At the end of the 1980s, the share of bank intermediation attributable to public sector banks was still high in most the European countries except for the United Kingdom, Denmark, Ireland and the Netherlands[15]. However, the role of the state in European banking was beginning to change; in countries such as Italy, France and Spain, where state ownership was substantial, relevant steps were taken in the direction to reduce direct state ownership within the banking sector[16].

The changing role of the state can be seen also with respect to demographic changes. The reliance on state pension schemes in Europe is increasingly being seen as unsustainable, given the ageing of the population. As pointed out by White (1998, p. 7), this demographic trend, together with continuing increases in national income and wealth, should force banks to shift their marketing emphasis from financial products directed to the young poor (consumer credit and mortgages) to asset management services of the old rich, taking into account the fact that these latter are likely to be both more knowledgeable and more demanding customers.

The increasing demands of shareholders have also forced bank management to promote adding shareholders value as a major strategic objective. Traditionally shareholder value pressures have been most intense in the United Kingdom (and in the

[15] Gardener and Molyneux (1990, p.21).

[16] For example, in Italy Law 474/1994 laid down rules designed to speed up privatisations. By the end of 1998, the share of total assets attributable to banks or groups in which the majority interest is held by foundations, local authorities or the state has fallen to 20 per cent, compared with 68 per cent at the end of 1992. In addition, out of 70 savings and pledge banks, 39 are still more that 50 per cent controlled by their foundations, but they only account for 8.6 per cent of the banking system's total assets (Bank of Italy, Annual Report, 1998).

US). This has forced bank decision-makers to be more aggressive on cost-cutting, undertaking share buybacks and demutualising of mutually owned financial firms[17]. There are now signs that continental European countries are increasingly aware of these issues and that corporate culture is beginning to change [European Commission (1997a); White (1998)].

The globalisation of trade in financial services can also be seen as a by-product of the underlying forces described above. Technological advances and lower communications costs make a global reach more practical, while deregulation has opened up new markets. In the European context, the practical implication is that continental markets may become more contestable, not only to other continental banks also having a universal banking character, but also to institutions incorporated in English-speaking countries and operating continent-wide with a 'single passport'. Securitisation and the associated growth of non-bank financial intermediaries (e.g. life insurance companies, pension funds, mutual funds) are another by-product of the aforementioned forces of change and are likely to pose another significant challenge to European banks. Moreover, increasing competition from other institutions constitute another strategic challenge[18]. A final point to keep in mind relates to the importance of the interactions among the different forces of change, which may lead to dynamic processes that may be difficult both to predict and control (White, 1998).

2.5 Conclusions

During the past decade, banking structures and strategies have been involved in a fundamental process of change. At the beginning of the 1990s regulatory developments, competition and technology were generally felt to be the three most important forces of change likely to affect the structure of financial markets in most EU countries.

The Single Market Programme, implemented in 1993, has substantially changed the

[17] In the UK there has been almost total demutualisation of traditional building societies.

[18] For example, in the UK, retail institutions such as Sainsbury, Marks and Spencer and Tesco are already taking deposits as well as making loans to their retail customers.

regulatory environment for financial institutions within the EU. However, there is evidence [European Commission (1997a); White (1998)] that the effectiveness of the SMP is being constrained to varying degrees by possible sluggishness in companies' responses to the apparent opportunities afforded by the single market and also by the persistence of a range of barriers influencing their behaviour. Nonetheless, it is a widespread view that the banking sector in Europe may be about to enter a period of increased competition [McCauley and White (1997); White (1998); De Bandt (1999)].

Some important forces of change including: technological developments, the declining role of the state, demographic pressures, the increasing strategic emphasis on shareholder value and the introduction of the Euro are continuing to transform European banking.

In addition, globalisation, securitisation, and growing competition from non-bank financial intermediaries and other firms are increasing competition in the financial services industry.

Possibly the most important impact of the implementation of the SMP has been to help shape the environment in which banks and financial institutions operate, creating freer markets and more open competition in the EU financial sector. As deregulation-induced changes, together with technology and market developments, release increased competitive pressure, the need for banks and financial institutions to improve their efficiency arises.

The following chapter provides an overview of the market structure, structural developments and performance characteristics of selected EU banking markets in order to provide a framework for the following analysis of cost efficiency in European banking.

3 Recent Changes and Structural Developments in European Banking Systems

Existing forces of change are putting European banks under increasing pressure to restructure. The strategic response of EU banks has been to focus on reorganising in three main areas. First, many banks have sought to improve their services and procedures. This has involved both the development of better quality services, staff and IT combined with attempts to reduce costs and improve overall efficiency. The ultimate objective is to enhance profitability and therefore increase shareholder value. Secondly, the EU Second Banking Directive legislated for a universal banking model and this has enabled many banks to expand their product range into insurance (*bancassurance*), asset management and investment banking. The SMP has also fostered further geographical expansion. Finally, increased competitive pressure and the wider opportunities afforded under EMU have facilitated the growth of mergers and acquisitions (M&As) activities, strategic alliances and co-operative agreements. The aims of such developments are to improve cost efficiency, enhance diversification opportunities and build new distribution channels.

The main aim of this chapter is to outline how these factors have altered European banking markets. Section 3.1 offers a brief overview of the European economy during the 1990s. Sections 3.2 and 3.3 illustrate, respectively, the structure and performance characteristics of EU banking systems over the last decade. Section 3.4 is the conclusions.

3.1 European Economy: a Brief Overview

The European economy went through four distinct phases during the 1990s, which can be identified as follows[1]:

1. 1990-93: overheating and recession;
2. mid-1994 to mid-1995: soundly based recovery;
3. mid-1995 to mid-1996: abrupt slowdown and extended growth pause;
4. mid-1996 to 1998: progressively strengthening upturn.

Since the mid-1980s, economic integration and the convergence of economic policies have led to cycles in the European Union becoming increasingly synchronised. This trend, which was temporarily interrupted in 1990 and 1991 following German unification, has since grown stronger, leading to the emergence of a real European cycle (European Commission, 1997b). Table 3.1 illustrates the main European macroeconomic indicators in each EU Member State.

Table 3.1: European Macroeconomic Indicators

	Real GDP Growth (% per years)				Unemployment Rate (% of civilian labour forces)				Inflation Rate (% change)			
	1995	1996	1997	1998[a]	1995	1996	1997	1998[a]	1995	1996	1997	1998[a]
AT	1.8	1.0	1.6	2.5	3.8	4.2	4.5	4.6	2.3	2.0	1.9	2.0
BE	1.9	1.4	2.2	2.7	9.9	9.9	9.9	9.8	1.6	2.0	2.1	2.0
DE	1.9	1.4	2.2	2.8	8.2	9.0	9.1	8.7	1.9	1.8	1.7	1.8
DK	2.8	2.1	3.1	3.0	7.1	6.2	6.0	5.7	2.1	2.0	2.4	2.7
ES	2.8	2.1	2.7	3.2	22.9	22.0	21.5	20.7	4.7	3.6	2.9	2.7
FI	4.2	2.3	3.7	3.1	17.2	16.0	14.9	14.2	0.2	0.9	1.6	2.0
FR	2.2	1.1	2.1	2.7	11.5	12.3	12.4	11.9	1.7	1.9	1.4	1.4
GR	2.0	2.4	2.5	2.8	9.1	9.1	9.0	9.0	9.3	8.5	6.9	5.8
IR	10.7	7.8	5.8	5.2	12.4	12.5	12.0	11.7	2.0	2.0	2.2	2.6
IT	3.0	0.8	1.4	2.6	11.9	12.1	12.3	12.1	5.8	3.9	2.9	2.6
LU	3.4	2.3	2.8	3.8	2.9	3.1	3.0	2.9	2.0	1.7	2.1	2.1
NL	2.1	2.5	2.8	3.0	7.3	6.8	6.3	5.8	0.9	1.9	2.0	2.0
PT	2.3	2.5	2.8	3.2	7.3	7.3	7.1	6.8	4.2	3.3	3.0	2.9
SE	3.0	1.7	2.1	2.5	9.2	9.8	9.4	9.0	2.7	1.7	2.3	2.6
UK	2.4	2.3	3.0	3.0	8.8	8.3	7.8	7.4	2.6	2.5	2.4	2.5
EU	2.4	1.6	2.3	2.8	10.9	10.9	10.8	10.4	3.0	2.6	2.2	2.2

[a]Economic Estimates
Source: European Commission, Annual Economic Report for 1997.

[1] European Commission (1997b).

During the past few years, the output in the EU has shown an increasing trend. Moreover, despite the disappointing job performance of the EU as a whole, a number of Member States have achieved a considerable reduction in unemployment over the last two to three years and the unemployment rate has fallen in the United Kingdom, Netherlands, Spain, Ireland and Finland. Member States have also made encouraging progress towards price stability in recent years. Average inflation (as measured by the private consumption deflator) in the EU decelerated to 2.2% in 1997 and inflation dispersion among Member States narrowed significantly. Moreover, EMU is expected to create a zone of stable macroeconomic conditions, with low inflation, low interest rates and the Euro, as a stable currency, is expected to stimulate growth and investments and also the demand for credit. Nevertheless, the EU is not fully insulated against global asset price movements. Continued fallout from the Russian crisis, the protracted difficulties in the Japanese banking sector and the potential spillover effects of these crises are still major sources of concern.

3.2 The Structure of EU Banking Systems

Gardener and Molyneux (1990) defined the study of structural developments in European banking as an examination of the changes in the size, numbers and comparative significance of banks and other financial institutions within a financial banking system as well as embracing those institutional changes which alter the ways in which financial services are demanded, used, developed and delivered.

During the past decade, common trends and changes have influenced the structure of EU banking systems. Nevertheless, it is important to point out that there still exist some differences between continental banking systems and the so-called British model. In continental Europe, traditional bank lending is of significantly greater importance than in English-speaking countries, where capital market finance is more important. These differences imply a greater reliance on capital markets in English-speaking countries and a greater reliance on relationship banking in continental

Europe[2]. As noted by White (1998), should European financial structures become more and more similar to the Anglo-Saxon model, the degree of adjustment required from continental European banks would certainly be large. As discussed in the previous chapter, there are many forces pointing in this direction. The structure of EU banking systems has altered considerably during the 1990s mostly in reaction to the EU deregulation process. In most countries the number of banks has declined, primarily as a consequence of a wave of mergers and acquisitions.

Table 3.2: Number of Credit Institutions in the EU

	1980	1990	1997	% change 1980-1990	% change 1990-1997
AT	1,595	1,210	995	-24.1%	-17.8%
BE	176	157	134	-10.8%	-14.6%
DK	197	124	100	-37.1%	-19.4%
FI	669	529	371	-20.9%	-29.9%
FR	2,105[a]	2,027	1,299	-3.7%	-35.9%
DE	5,356	4,720	3,578	-11.9%	-24.2%
GR	34	39	54	14.7%	38.5%
IT	1,156	1,156	935	0.0%	-19.1%
NL	81[a]	111	90	37.0%	-18.9%
PT	-	260	235	-	-9.6%
ES	695[a]	696	416	0.1%	-40.2%
SE	779[a]	704	242	-9.6%	-65.6%
UK	-	564[b]	551	-	-2.3%
EU	**12,256[a]**	**11,958**	**9,285**	**-2.4%**	**-22.4%**

[a]1985 data; [b]1995 data
Source: Adapted from European Central Bank (1999a).

From table 3.2 it is possible to see an overall reduction in the number of credit institutions at the EU level, the only exception being Greece. In some countries this process started as early as the 1980s (Austria, Belgium, Finland, Denmark), although it has become even more evident during the 1990s. The same trend is also apparent across different types of banks, including the mutual savings and co-operative banks as well as for domestic commercial banks (European Commission, 1997a, p. 68).

[2] See, among others, Revell (1987) and Davis (1996) for an analysis of the differences of the two banking models.

Nevertheless, there still remain a large number of banks operating in Europe, as illustrated in Table 3.2. Table 3.3 presents some indicators of bank capacity, offering an overview of the size characteristics of European banking markets.

Table 3.3: Some Indicators of Banking Capacity

	Number of branches (per 1,000 inhabitants)			Number of ATMs (per 1,000 inhabitants)			Number of staff (per 1,000 inhabitants)		
	1990	1997	% change	1990	1997	% change	1990	1997	% change
AT	0.58	0.58	0.0%	0.20	0.53	165.0%	9.86	9.43	-4.4%
BE	0.90	0.72	-20.0%	0.08	0.49	512.5%	7.94	7.57	-4.7%
DK	0.58	0.42	-27.6%	0.04	0.24	500.0%	10.60	8.10	-23.6%
FI	0.58	0.32	-44.8%	0.57	0.45	-21.1%	10.15	5.21	-48.7%
FR	0.45	0.44	-2.2%	0.26	0.42	61.5%	7.63	6.89	-9.7%
DE	0.63	0.57	-9.5%	0.18	0.50	177.8%	11.10	9.16	-17.5%
GR	0.19	0.24	26.3%	0.02	0.15	650.0%	4.61	5.25	13.9%
IT	0.31	0.44	41.9%	0.17	0.44	158.8%	5.92	6.00	1.4%
NL	0.58	0.42	-27.6%	0.18	0.38	111.1%	7.86	7.19	-8.5%
PT	0.20	0.41	105.0%	0.06	0.52	766.7%	6.20	5.97	-3.7%
ES	0.83	0.97	16.9%	0.46	0.88	91.3%	6.22	6.29	1.1%
SE	0.38	0.29	-23.7%	0.25	0.27	8.0%	5.32	4.93	-7.3%
UK	0.35	0.32	-8.6%	0.28	0.38	35.7%	8.98	9.07	1.0%
EU	**0.51**	**0.48**	**-5.9%**	**0.20**	**0.44**	**120.0%**	**9.94**	**9.73**	**-2.1%**

Source: Adapted from European Central Bank (1999a).

With regards to the number of branches, it is possible to observe an overall reduction at the EU level, but different national patterns are apparent. In most countries the number of branches fell, consistently with the rationalisation associated with the consolidation movement. In other countries, however, such as Greece, Italy, Spain and Portugal, the number of branches has increased. This can be explained by the fact that in these countries branch restrictions existed up to until the early 1990s. The number of ATMs increased substantially in all EU countries during the 1990s. However, there are still significant differences with regard to the extent to which ATMs have penetrated in individual countries. Banking employment has stagnated or declined over the past few years in the majority of EU systems, the only exception being the UK. Overall, as described from the indicators in table 3.3, there has been a considerable reduction in the level of capacity in EU banking systems. This trend is expected to increase owing to the establishment of EMU.

Other useful indicators of banking sector depth or sophistication are relative measures, such as the importance of banks' assets in relation to GDP. Table 3.4 illustrates the total assets of EU credit institutions as a percentage of GDP and the percentage change over the past decades.

Table 3.4: Total Assets of Credit Institutions as a percentage of GDP

	1980[a]	1990	1997	% change 1980-1990	% change 1990-1997
AT	182.98	228.80	238.38	25.0%	4.2%
BE	174.80	260.80	294.17	49.2%	12.8%
DK	178.00	240.00	220.00	34.8%	-8.3%
FI	76.08	147.37	113.35	93.7%	-23.1%
FR	101.00	216.00	244.60	113.9%	13.2%
DE	166.74	220.24	255.82	32.1%	16.2%
GR	72.82	93.62	102.03	28.6%	9.0%
IT	122.40	133.30	155.40	8.9%	16.6%
NL	116.00	190.00	227.00	63.8%	19.5%
PT	117.00	127.00	220.00	8.5%	73.2%
ES	103.77	166.20	183.23	60.2%	10.2%
SE	152.00	215.00	213.00	41.4%	-0.9%
UK	193.58	227.88	327.60	17.7%	43.8%
EU	**177.24**	**206.86**	**244.23**	**16.7%**	**18.1%**

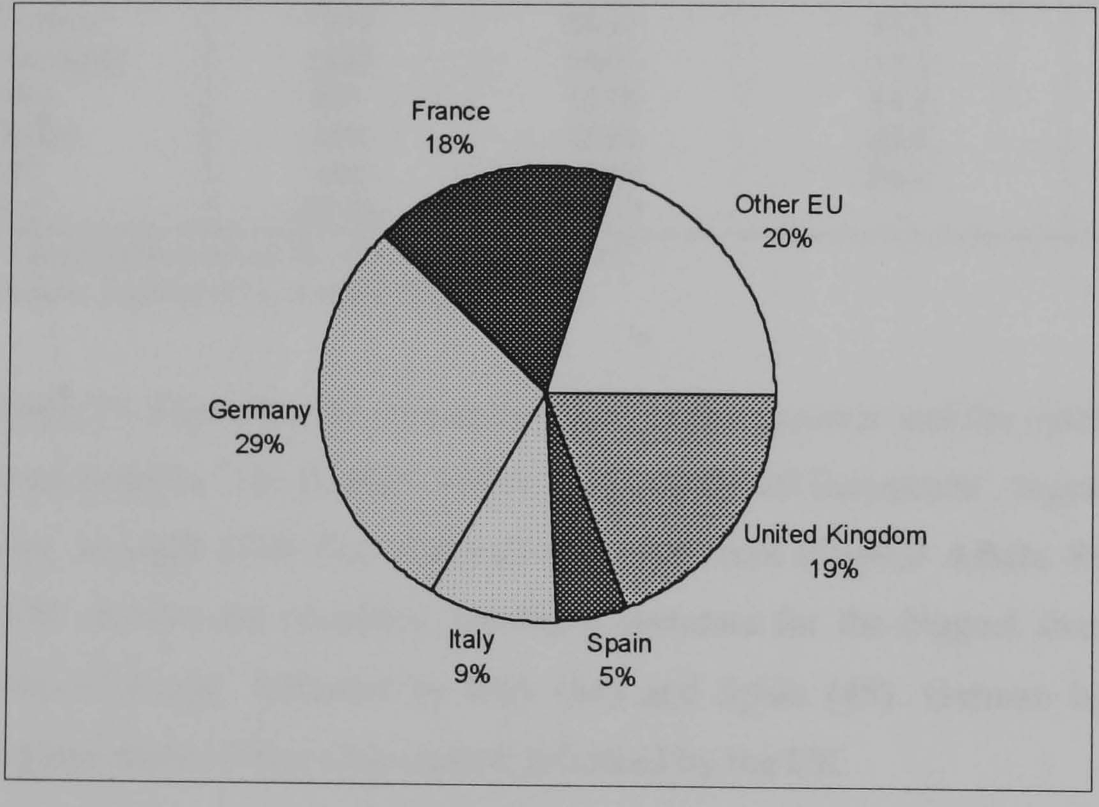
[a] For 1980, the data refer to the first available year.
Source: ECB (1999a)

From this table it is possible to note that banking intermediation has been growing steadily over time in most countries, with few exceptions (Finland, Sweden and Denmark)[3]. On the other hand, recent figures (1995-1997) indicate that the relative importance of credit institutions (in terms of assets) has decreased compared with the assets of institutional investors (mainly investment funds and pension funds) in the majority of Member States (ECB, 1999a).

[3] It is necessary to note that Scandinavian countries experienced a banking crisis at the beginning of the 1990s and underwent a major restructuring of their banking systems.

Figure 3.1 shows that using total banking sector assets as a size measure, the German, British and French banking systems are by far the largest in the EU, followed by the Italian and Spanish banking markets. Specifically, in 1998, the total assets of the banking sectors of France, Germany, Italy, Spain and the UK amounted to $16,530 billion, representing nearly 80% of the total assets of the European Union as a whole (Banca d'Italia, Annual Report, 1998). The size of the respective banking sectors of the above mentioned countries, together with considerations of their relative economic weight inside the EU, motivated the decision to concentrate on such countries in the following analysis of efficiency in banking.

Figure 3.1: Relative Asset Size of EU Banking Systems



Source: Banca d'Italia, Annual Report (1998).

To evaluate the level of market concentration within EU banking systems, the proportion of the banking and credit sector controlled by the five largest players is often considered. Measured in terms of total assets, a five-firm concentration ratio is commonly employed as measure of market structure. In the majority of industrialised countries, a high level of market concentration appears to be evident, such that a small core of banks account for a relatively large proportion of total banking sector assets.

The European Commission (1997a, p.76) study reports that in every EU country between 1979 and 1995, apart from France, Greece and Luxembourg, the five-firm asset concentration ratio increased.

As can be seen from the five-firm concentration ratios (table 3.5) at the end of 1997, the top five German, British and French banking groups each accounted for more than 10% of the total EU banking market, while the first five EU banking groups accounted for as much as 17.1% of the total EU banking system.

Table 3.5: Market Concentration and Size of main EU Banking Sectors (1998)

	Number of banks	Total Assets (billion $)	Concentration % of total national market (5-firm)	Concentration % of total EU market (5-firm)
France	1210	3641	40.3	12.4
Germany	3424	5981	17.0	13.7
Italy	921	1879	24.6	5.3
Spain	396	1060	43.6	3.4
UK	464	3969	28.0	10.6
EU	8779	20717	-	17.1

[a] Concentration measures refer to the end of 1997.
Source: Bank of Italy, Annual Report (1998).

Table 3.6 illustrates the concentration of banking power and the number of banks which were listed in '*The Banker*' (1998, p.52) 'Top 500 Europeans', together with their asset size, strength (Tier One Capital) and soundness (Capital Assets Ratio) at the end of 1997. Across the countries, Germany accounts for the biggest share of the Top 500, with 97 banks, followed by Italy (85) and Spain (45). German banks also hold the highest share of Tier One capital, followed by the UK.

Table 3.6: Top 500 European Banks (1997)

	Number of banks in Top 500	Total Assets (million $)	Tier One Capital (million $)	Capital Assets Ratio (average)
France	21	2,410,557	95,197	7.66
Germany	97	4,493,850	123,764	3.73
Italy	85	1,462,303	74,114	7.37
Spain	45	826,391	46,090	6.83
UK	36	2,459,604	114,082	9.91

Source: *The Banker*, September 1998.

Overall, EU banking markets are in most cases characterised by a declining number of banks, although most systems still have a large number of small local and regional banks, with a wide branching network. On the other hand, market concentration is increasing and this consolidation trend is likely to continue, especially with the advent of EMU.

3.2.1 Internationalisation of the EU Banking Sectors

The opening of the EU banking market has provided domestic banks and other financial services firms with an opportunity to expand their activities abroad, but also forced them to face increased foreign competition in their domestic market place. As Molyneux *et al.* (1996) note, the important element in the process of financial deregulation has been the opening-up of the EU banking systems to domestic as well as foreign competition. This move has been significant in shaping the current state of the European financial market place. The degree of internationalisation of the EU banking system can be seen from two basic perspectives: inward and outward internationalisation. According to the ECB (1999a, pp. 20-21) we can define inward internationalisation as the number and assets of banks' branches and subsidiaries from the European Economic Area (EEA) and third countries in a given EU country and outward internationalisation as the number and assets of branches and subsidiaries from a given EU country in the EEA and third countries. Table 3.7 illustrates the degree of inward internationalisation of EU banking systems while the degree of outward internationalisation is shown in table 3.8.

Table 3.7: Inward Internationalisation

	Number of Branches				Number of Subsidiaries				Percentage of change	
	EEA		Third Countries		EEA		Third Countries		Total Branches	Total Subsidiaries
	1995	1997	1995	1997	1995	1997	1995	1997	1995-1997	1995-1997
AT	5	6	2	2	20	20	10	11	14.3%	3.3%
BE	20	25	16	15	20	16	18	15	11.1%	-18.4%
DK	11	14	-	-	-	-	-	-	27.3%	-
FI	8	9	-	-	-	-	-	-	12.5%	-
FR	46	46	44	43	119	118	101	98	-1.1%	-1.8%
DE	36	46	33	31	32	31	56	45	11.6%	-13.6%
GR	14	14	8	9	4	3	3	3	4.5%	-14.3%
IT	32	36	20	17	3	4	3	4	1.9%	33.3%
IE	11	18	4	3	16	21	5	7	4.0%	33.3%
LU	61	61	7	7	104	97	44	46	0.0%	3.4%
NL	14	11	11	11	7	8	20	19	-12.0%	0.0%
PT	6	11	2	2	5	6	3	3	62.5%	12.5%
ES	34	33	23	20	20	21	6	6	-7.0%	3.8%
SE	9	14	2	3	-	-	-	1	54.5%	-
UK	102	106	153	149	25	18	112	114	0.0%	-3.6%
EU	**409**	**450**	**325**	**312**	**375**	**363**	**381**	**372**	**3.8%**	**-2.8%**

Source: Adapted from ECB (1999a).

The overall level of inward internationalisation in EU banking is relatively low (except in the UK and Luxembourg). The number of foreign branches and subsidiaries vary considerably within the EU and it is possible to note a clear bias towards branches from EEA countries (again, with the exception of the UK). On the other hand, it is not possible to detect a bias towards EEA or third countries in the number of subsidiaries from foreign countries.

Table 3.8: Outward Internationalisation

	Number of Branches				Number of Subsidiaries				Percentage of Change	
	EEA		Third Countries		EEA		Third Countries		Total Branches	Total Subsidiaries
	1995	1997	1995	1997	1995	1997	1995	1997	1995-1997	1995-1997
AT	7	10	9	12	6	7	3	52	37.5%	51.3%
BE	20	20	16	26	22	23	14	15	27.8%	5.6%
DK	12	7	6	6	4	5	2	2	27.8%	16.7%
FI	3	4	6	6	1	1	5	3	11.1%	-33.3%
FR	70	76	125	-	163	-	117	-	-	-
DE	75	82	81	83	76	79	41	52	5.8%	12.0%
GR	4	5	4	4	4	4	2	4	12.5%	33.3%
IT	59	53	52	49	28	27	26	29	-8.1%	3.7%
PT	16	18	22	24	11	15	25	34	10.5%	36.1%
ES	83	69	40	35	11	10	52	66	-15.4%	20.6%
SE	12	12	10	13	6	4	4	3	13.6%	-30.0%

Source: Adapted from ECB (1999a).

The overall number of branches and subsidiaries opened by EU banks in foreign countries has increased in recent years in almost all countries. It is possible to note the relatively higher number of subsidiaries in third countries of Austrian and Spanish banks, mainly due to their efforts of diversification in Eastern Europe and South America respectively.

Overall, the EU banking systems seem to have adopted an important role as international lenders: EU banks lending to emerging, transitional or developing countries amounted to 57% of all international banks' lending, compared with 14% for Japan and 12% for the United Stated. As can be seen from table 3.9, EU banks hold the majority of claims to emerging Asian countries and a relatively high share in lending to Eastern Europe and South America. These data reflect the internationalisation trend in European banking.

Table 3.9: Exposure of Industrialised Countries Banks towards Emerging, Transitional and Developing Countries (1998, million US $)

	EU Banks	Japanese Banks	US Banks	Others
Asia[1]	152,674	114,745	29,440	10,973
Eastern Europe	106,231	4,148	12,402	10,973
Latin America	167,118	14,784	64,183	49,627
Middle East	32,547	3,037	5,267	16,445
Africa	43,437	2,314	4,847	7,698
All emerging, transitional and developing countries	**513,613**	**122,827**	**109,308**	**157,324**

[1] Excluding Hong Kong, Singapore and Japan.
Source: Adapted from BIS International Banking Statistics (November 1998).

3.2.2 Mergers and Acquisitions Activities

Financial integration within Europe has also been generating incentives for EU banks to increase their activities in international markets and to develop a broader network of connections among financial institutions, both at the domestic and cross-border level. In addition, the breakdown in traditional sector barriers as well as the widespread privatisation process has created a further incentive towards the merger and acquisition process observed in Europe in recent years. The EU's Second Banking Directive has helped promote this trend because it provides a legislative framework for banks to undertake universal banking activities. In addition, the traditional separation between commercial banking, insurance, investment banking, brokerage and asset management, which characterised many national markets, no longer exists in Europe; as a consequence, competition in the financial services industry has intensified. The increasing recourse to information and communications technologies is likely to incentive further this trend. The rapid growth of new financial services providers, such as asset-financing firms (factoring and leasing), credit card operators, consumer finance firms, together with the growth of Internet financial services, are putting banks under an ever increasing competitive pressure.

In general, M&A activities can be driven by a series of interrelated factors, as set out below (European Commission, 1997, p.58):

1. survival – intensified competition and greater market contestability put pressure on individual operators to merge to secure economies of scale and scope, capture other synergies or facilitate rationalisation, cost-cutting or the implementation of other efficiency-improving measures;
2. opportunities to increase profitability through efficiency gains – mergers or acquisitions provides, at least potentially, opportunities to improve profitability by securing economies of scale and scope, realising synergies and facilitating rationalisation;
3. market entry – merger or acquisition may afford opportunities for individual operators to secure a foothold in other, perhaps new, EU markets or different market segments;
4. defensive strategies – growth pursued through merger or acquisition provides a deterrent against takeover;
5. pursuit of managerial objectives – the desire to merge or acquire other banks or credit institutions may stem from the pursuit of managerial objectives not linked to profitability or shareholders wealth maximisation. These objectives may include prestige, growth, executive remuneration and so on;

6. opportunities to raise profitability by increasing market power – by increasing market share, individual operators may increase the degree of market power they enjoy to the extent that they are able to earn abnormal profits and capture economic rents.

Mergers and acquisitions involving all sizes of institutions have been taking place in most EU countries, especially in Italy[4]. In other countries, such as Germany and France this trend has been more recent. Moreover, most recent merger and acquisition activity has been between domestic banks. This can be seen as an effort to increase market power at the domestic level and, consequently, increasing their relative size at a European level. There has also been a trend towards M&As involving domestic banks and non-banking providers of financial services, in particular insurance companies (bancassurance).

Another reason explaining the consolidation trend in Europe relates the 'national interest' argument. This viewpoint suggests that some mergers between large banks have been motivated by the threat of foreign acquisition of a market leader. This view has recently found wide support, especially in France and Italy. Various commentators argue that 'core banks' or 'national leaders' have to have a critical size to be competitive, typically meaning that an asset size of at least \$ 150 to \$ 200 billion would be enough to have a reasonable European presence and to be immune from hostile take-over (Molyneux, 1999, p.33).

[4] See Banca d'Italia (1998), Annual Report.

Table 3.10: Number of Domestic Mergers and Acquisitions

	Total from 1995 to first quarter 1998				
	mergers	**full acquisitions**	**majority acquisitions**	**total acquisitions**	**total M&As**
AT	62	3	1	4	66
BE	17	8	0	8	25
DK	5	0	0	0	5
ES	1	1	3	4	5
FI	17	1	1	2	19
FR	0	6	0	6	6
GR	3	1	7	8	11
IE	0	3	0	3	3
IT	29	93	67	160	189
LU	6	1	0	1	7
NL	1	6	2	8	9
PT	0	5	6	11	11
SE	2	2	0	2	4
UK**	1	0	0	42	43
Total*	**144**	**130**	**87**	**259**	**403**

*excluding DE;
**domestic and cross-border M&As included
Source: Adapted from ECB (1999a). (N.B.: Indicative list only)

Cross-border M&As in banking have been less common in the EU. Cultural differences with regard to management style and strategic goals, together with legal and fiscal difficulties, are possibly among the main obstacles to their relative unimportance. Table 3.11 illustrates some recent trends in cross-border M&As in Europe. From the table it is possible to note that most cross-border mergers and acquisitions have been taking place within the European Economic Area (EEA), with the noticeable exception of Spain, where cross-border acquisitions of 28 Latin American banks have been reported since 1995.

Table 3.11: Number of Cross-border Mergers and Acquisitions

	total from 1995 to first quarter 1998					
	intra-EEA mergers	**of which within EU**	**intra-EEA acquisitions**	**3rd country mergers**	**3rd country acquisitions**	**total cross-border M&As**
AT	1	1	0	0	1	2
BE	1	1	2	0	1	4
DK	0	0	1	0	0	1
ES	0	0	0	0	28	28
FI	0	0	0	0	1	1
FR	1	1	0	0	0	1
IE	0	0	8	0	7	15
IT	0	0	0	0	8	8
LU	0	0	1	0	1	2
NL	0	0	6	0	12	18
PT	0	0	1	0	2	3
SE	2	2	1	0	0	3
Total	**5**	**5**	**20**	**0**	**61**	**86**

Source: Adapted from ECB (1999a). (N.B.: Indicative list only).

Another important aspect associated with the increase in M&As activity in recent years has been the important role played by technology. Technological developments affect banking activities in two main ways: on the one hand, the growing cost of IT has increased the necessary size for banks to operate; on the other hand, recent developments in remote banking have made the conduct of joint banking activities easier. The next section investigates the current involvement of EU banks in remote banking and the new strategic challenges posed by technological progress.

3.2.3 Technological Developments and Bank Strategies

The application of new technology has advanced considerably in all EU countries. There are large potential benefits to be achieved in many areas of banking business, as new technology enables banks to obtain additional marketing capabilities, a better knowledge of the needs of their customers and offer the potential for significantly reduced costs. With greater access to customer information banks will be able to provide tailor-made products and services to an increasingly segmented market.

Overall, the new opportunities afforded by new technological developments are likely to result in a more competitive, efficient and customer oriented banking environment.

Remote banking is already regarded as part of an overall distribution strategy in retail banking and it is currently offered by at least all major EU banks. Overall, EU banks' involvement in remote banking can be summarised as follows[5]:

- major institutions offer 'traditional' remote banking services (kiosk and telephone banking) and have started to offer a growing number of on-line PC banking and Internet banking services;
- some small-sized specialised banks operate without branches exclusively via remote banking channels. In most cases these banks are subsidiaries of existing banking groups;
- innovative new institutions are setting up business in the Internet, also covering traditional banking activities. This activity is often promoted by large to medium-sized banks.

The intensity with which banks have promoted various remote banking 'models' differs significantly from one country to another. Until now, the major emphasis has been placed on developing ATMs and telephone based services; the focus has been on submitting account balance information, providing money transmission services and securities transactions, collecting loans applications and providing information in general. Table 3.12 shows the type of banking services currently offered via traditional branches and remote channels. However, it is necessary to keep in mind that the specific services may vary considerably from one country to another.

[5] European Central Bank (1999b), p. 10.

Table 3.12: Banking Services Offered via Branches and Remote Channels

Channels / Services	Branches	ATMs	Telephone		PC Banking	
			person-to-person	tone or voice-activated	On-line PC Banking	Internet Banking
Cash withdrawals	YES	YES	NO	NO	NO	NO
Loading of prepaid cards	NO	YES	YES	YES	YES	YES
Loading of network money	NO	NO	NO[1]	NO[1]	YES	YES
General information on bank products and market developments	YES	YES	YES	YES	YES	YES
Account balance information	YES	YES	YES	YES	YES	YES
Money transfer	YES	YES	YES	YES	YES	YES
Direct debits and standing orders	YES	YES	YES	YES	YES	YES
Credit and debit card requests	YES	YES	YES	NO	YES	YES
New cheque books orders	YES	YES	YES	YES	YES	YES
Investment advice	YES	NO	YES	NO	YES[2]	YES[2]
Securities transactions	YES	NO	YES	NO	YES	YES
Loans (standardised)	YES	NO	YES	NO	YES	NO[3]
Deposits business	YES	YES	YES	NO	YES	YES
Non standardised banking transactions	YES	NO	NO	NO	NO	NO[3]
Insurance products	YES	NO	YES	NO	YES	YES

[1]Not usually. [2]For standard products. [3]Not yet.
Source: European Central Bank (1999b), p. 12.

According to European Central Bank statistics, the number of ATMs (including cash dispensers and multipurpose ATMs) grew substantially between 1993 and 1997, as can be seen from table 3.13.

Table 3.13: Cash Dispensers and ATMs

	Number of machines per 1,000,000 inhabitants						Number of transactions per capita					
	1993	1994	1995	1996	1997	%change 1993-97	1993	1994	1995	1996	1997	%change 1993-97
BE	280	313	360	414	492	+76%	11	13	14	15	16	+40%
DK	108	142	207	239	253	+134%	-	-	-	-	-	-
DE	308	361	437	459	504	+64%	-	11	13	15	-	-
GR	82	155	129	185	209	+155%	-	4	4	6	6	-
ES	557	600	680	775	863	+55%	12	13	14	15	15	+27%
FR	325	355	393	420	462	+42%	13	14	16	18	20	+51%
IE	220	241	257	290	286	+30%	16	16	18	21	24	+54%
IT	262	321	371	422	444	+69%	3	5	5	6	7	+117%
LU	294	374	456	537	613	+109%	10	10	9	10	10	+5%
NL	292	325	355	373	410	+41%	21	24	27	29	33	+61%
AT	320	381	420	479	533	+67%	7	8	8	9	10	+38%
PT	283	337	372	541	631	+123%	10	12	14	18	21	+120%
FI	591	557	474	448	445	-25%	40	38	39	42	43	+8%
SE	255	260	266	269	268	+5%	28	31	32	34	35	+24%
UK	328	343	358	376	393	+20%	21	23	25	27	30	+41%
***EU* [1)]**	**324**	**363**	**408**	**448**	**488**	**+51%**	**14**	**14**	**16**	**17**	**20**	**+46%**

[1)] Average without countries where data are not available.
Source: Adapted from ECB (1999b).

The growth rate in the use of ATMs has been, on average, around 50% and even higher in some countries, such as Denmark, Greece, Luxembourg and Portugal, reflecting possibly some 'catching up' with other EU countries. However, it is still possible to note considerable differences in the use of ATMs among EU countries.

Telephone banking is already quite common throughout the EU and it is expected to grow even further (ECB, 1999b). In general, the most standardised services are available through this channel (see table 3.12). Most banks involved in this activity offer both call centres and tone or voice-activated telephone banking systems.

At present, the use of PC banking is still significantly lower than telephone or ATMs, but growth is generally expected. As to Internet banking, most major banks have established Web sites for information purposes, whereas interactive Web sites for transaction purposes are just starting to be introduced in most countries on a larger scale. Overall, Internet banking is expected to have the highest future growth potential and market participants already anticipate that it will expand considerably within the next two or three years (ECB, 1999b). It is necessary to point out that the use of PC banking depends to a large extent on the degree of sophistication of telecommunications networks, the level of PC penetration, usage and computer literacy. In the EU, the highest relative number of Internet users is found in Finland (35%), Sweden (33%) Denmark (22%) and the United Kingdom (18%), whereas Greece, Portugal and Italy reported figures of 1%, 2% and 4% respectively (ECB, 1999b).

Turning to the use of electronic payment instruments, in recent years there has been a major replacement of paper-based payment methods by electronic methods. There are still significant difference across EU countries, concerning both the intensity of cash use and the use of traditional and electronic non cash-payment instruments (i.e. cheques, debit and credit cards, retailer cards, direct debits). The more established electronic payment media, such as debit and credit cards used at EFTPOS terminals, is replacing cash and cheques payments[6]. Table 3.14 reports the size of EFTPOS networks and transactions in the EU countries between 1993 and 1997. The growth in EFTPOS terminals was substantial over the years, although the number of transactions per inhabitants in some countries has remained relatively low.

Table 3.14: EFTPOS Terminals

	Number of machines per 1,000,000 inhabitants			Number of transactions per capita			Average value per transaction (ECU)		
	1993	1997	%change 1993-97	1993	1997	%change 1993-97	1993	1997	%change 1993-97
BE	4,255	6,284	48%	16	27	73%	54	58	8%
DK	4,197	11,923	184%	33	58	75%	43	46	8%
DE	345	1,948	475%	1	3	252%	46	65	40%
GR	241	2,831	1,075%	-	1	-	-	74	-
ES	8,287	16,691	101%	6	9	55%	43	48	11%
FR	9,193	9,555	4%	27	39	44%	49	46	-7%
IE	-	1,402	-	-	-	-	-	-	-
IT	1,329	4,869	268%	0	4	946%	104	94	-10%
LU	8,390	11,071	32%	22	45	104%	66	66	0
NL	1,606	7,715	381%	4	31	607%	50	43	-14%
AT	229	1,652	621%	1	3	258%	38	54	41%
PT	2,790	6,022	116%	8	22	188%	32	24	-24%
FI	8,291	10,506	27%	34	51	49%	34	45	34%
SE	3,054	7,778	155%	7	16	121%	57	69	20%
UK	4,640	8,984	94%	-	-	-	-	-	-
EU 1)	**3,836**	**7,146**	**86%**	**9**	**16**	**83%**	**57**	**62**	**8%**

1) Average without countries where data are not available.
Source: ECB (1999b).

[6] According to the ECB (1999c) the term EFTPOS refers to the use of payments cards at a retail location when the payment information is captured by electronic terminals, which are also designed to transmit the information.

The data reported in the table imply that the use of debit and credit cards is quite widespread throughout the EU, particularly in Denmark, France, Luxembourg and Finland, where the number of transactions per capita is relatively higher. The use of electronic money (e-money[7]), on the other hand, has taken off quite slowly, possibly as a consequence of consumer concerns about costs, security, lack of cross-border comparability and the incompleteness of the regulatory framework. Nonetheless, the use of e-money is expected to grow in the near future (ECB, 1999b). Furthermore, banks can help to develop the e-commerce[8] market.

Technological developments offer banks major business opportunities, both on the cost and revenue side. On the cost side, the cost per transaction is expected to decrease[9]. The expected cost reductions are mainly attributable to a lower overall cost of electronic transactions as compared with labour intensive processing. In the short term, however, average labour cost may increase owing to the need for generally more highly qualified staff. Other factors that may entail cost reductions include the realisation of greater scale economies; the rationalisation of the production and distribution structures; the standardisation of banking processes and the cross-selling of non-banking products. In addition to lower costs, the Internet provides banks with an alternative distribution channel, which enables them to offer new services and service access possibilities, hence attracting new potential customers and generating new revenues.

While the development of Internet banking and e-commerce in general is expected to provide substantial opportunities for banks, there also remain a number of important strategic challenges. Internet banking may develop from a supplementary to a core service, so the failure to enter the area successfully may have dramatic implications

[7] When referring to e-money, a distinction is usually drawn between card-based e-money and network e-money. Card-based e-money refers to e-money as stored value on cards or prepaid card products that allow customers to make small value transactions. Network e-money refers to e-money transactions conducted via telecommunications networks, primarily the Internet. This distinction may cease to be relevant as card-based e-money become used for Internet transactions, via chip card reading devices (ECB, 1999b, p.18).

[8] E-commerce can be defined as business activity conducted over the Internet (ECB, 1999b, p.20).

[9] A study by Booz-Allen and Hamilton estimate that Internet banking transactions are around 90% less costly than through a traditional branch network. ECB (1999b) estimates that the costs of various remote banking transactions range from 1-25% (Internet banking) to 40-71% (telephone banking) of the cost of the transactions handled manually.

for banks future market position and performance. As the global market for financial services become more transparent, customers' loyalty may decline. Furthermore, competition within the banking sector and from non-banking financial institutions may intensify significantly.

Overall, technological developments based on remote banking can determine substantial changes in the structure of the banking industry. According the European Central Bank (ECB, 1999b, p.7), EU banks are expected to:

- experience increased pressure to reduce the number of branches, in order to achieve a balance between physical and remote distribution channels;
- change the overall profile of bank staff in favour of marketing, IT and more sophisticated and value added services;
- intensify outsourcing of IT related activities;
- increase strategic alliances and co-operation agreements between banks on the production and distribution side, in order to achieve efficiency gains and offer customers benefits through widely acceptable payment means;
- increase strategic alliances and joint ventures between banks and IT firms, as well as telecommunication companies to allow the effective application of up to date technology; to optimise research and to lower implementation costs.

Overall, technology is an important strategic tool for banks to safeguard long-term competitiveness, cost efficiency and profitability.

3.3 The Performance of EU Banking Systems

The aim of this section is to evaluate trends in EU bank revenue and performance indicators to see how deregulatory and structural developments have affected the banking environment. Table 3.15 illustrates the trend in interest margin, return on assets and return on equity across EU banking markets between 1993 and 1997.

Table 3.15: Banks' Aggregate Profitability Measures

	Return on Assets			Return on Equity			Net Interest Margin		
	1993	1997	%change 1990-97	1993	1997	%change 1990-97	1993	1997	%change 1990-97
BE	0.4	0.4	0.0	14.1	15.3	0.1	1.4	1.2	-0.2
DK	0.6	1.0	0.7	10.6	15.1	0.4	3.9	2.4	-0.6
DE	0.5	0.5	0.0	13.6	-	-	2.1	-	-
GR	1.0	0.7	-0.3	21.6	-	-	2.2	2.3	0.1
ES	0.3	0.9	2.0	3.8	10.6	1.8	3.9	2.9	-0.3
FR	0.1	0.3	2.0	2.9	7.7	1.7	1.5	1.0	-0.5
IE	-	1.0	-	-	18.4	-	-	1.9	-
IT	0.8	0.3	-0.6	8.8	3.4	-0.6	4.3	3.8	-0.1
LU	0.5	0.5	0.0	19.9	23.0	0.2	0.8	0.7	-0.1
NL	0.7	0.7	0.0	15.9	-	-	1.8	-	-
AT	0.4	0.4	0.0	8.7		-1.0	2.1	-	
PT	0.9	0.8	-0.1	9.2	13.1	0.4	3.7	2.3	-0.6
FI	-1.4	0.8	-1.6	-28.4	15.2	-1.5	2.1	2.1	0.0
SE	0.3	0.7	1.3	5.7	13.0	1.3	3.1	1.8	-0.7
UK	0.7	1.1	0.6	19.3	26.4	0.4	2.8	2.3	-0.2
EU [1)]	**0.4**	**0.5**	**0.3**	**9.0**	**12.2**	**0.4**	**2.5**	**2.3**	**-0.4**

[1)] Average without countries where data are not available.
Source: OECD "Bank profitability" statistics (1993-1997).

Profitability figures show generally improved returns: average Return on Equity (ROE) within the EU banking system increased from 9.0% in 1993 to 12.2% in 1997 while the average Return on Assets (ROA) rose from 0.4 to 0.5 during the same period. According to the European Central Bank (1999a), these improved results were mainly due to the favourable economic conditions.

Table 3.15 also shows the trend in traditional margin based business. Net interest margin indicates the level of return generated on interest earning business and, therefore, a decline in interest margins may indicate an increased competitive pressure on interest related business. As can be seen from table 3.15, interest margins have fallen in the majority of Member States in the period 1993-97. An important influence on interest margins in EU banking markets has been a shift of emphasis to other non-interest income sources of earnings. This trend, indicative of the growth of securitisation, off-balance sheet activity and non-banking product cross-selling opportunities (for example, *bancassurance*) has been witnessed across virtually all the main markets (European Commission, 1997, p. 104). This is reflected in the increase in non-interest income (see Table 3.16) and can also be linked to the downward trends in interest rates, which has contributed to the boosting of capital gains, and strengthened returns from securities trading and underwriting activities in general. Overall, given the increasingly varied and sophisticated demands of banks' customers, non-interest based income is increasingly likely to replace interest earnings on most banks' income statements.

Table 3.16: Non-Interest Income Contribution to Total Income

	Non-Interest Income as a percentage of Total Income					
	1993	1994	1995	1996	1997	%change 1990-97
BE	28.6	26.2	29.2	30.7	37.1	29.7%
DK	20.3	-16.7	32.8	32.1	31.8	56.7%
DE	23.7	19.2	21.0	21.0	-	-
GR	58.2	68.0	52.4	55.5	-	-
ES	25.8	21.5	23.1	26.6	29.2	13.2%
FR	41.6	37.7	45.5	47.0	53.2	27.9%
IE	-	-	29.8	32.1	33.8	-
IT	26.8	22.9	20.2	24.9	29.0	8.2%
LU	39.5	33.0	34.5	38.3	44.1	11.6%
NL	33.7	28.7	33.3	35.9	-	-
AT	27.9	28.7	39.4	41.0	-	-
PT	24.0	22.1	24.0	31.1	33.4	39.2%
FI	58.0	46.8	43.2	49.5	45.6	-21.4%
SE	52.4	35.7	35.0	41.6	48.6	-7.3%
UK	44.5	43.2	42.9	38.5	38.8	-12.8%
EU [1]	**32.8**	**28.1**	**31.4**	**32.5**	**34.8**	**6.1%**

Average without countries where data are not available.
Source: OECD "Bank profitability" statistics (1993 –1997).

While trends in the sources of bank income can be characterised as a fall in interest margins compensated by an increase in non-interest income, the trend in cost levels are less clear-cut. The usual measure for bank efficiency is the cost-income ratio. This measure can be influenced both by endogenous and exogenous factors. Adverse economic conditions affect the cost-income ratio in the sense that banks do not have total control over their income streams whilst restrictive labour laws in many continental European countries hinder staff reduction and productivity improvements on the cost side. In addition, while the trend towards consolidation is expected to alleviate over capacity, put more pressure on bank management to improve efficiency and realise cost savings, M&As activities may add costs in the short term. Table 3.17 shows that in the majority of countries the general trend in bank efficiency has been downwards. This can be explained because, *inter alia*, banks are seeking quality business against a background of improving risk controls and enhanced efficiency (Molyneux, 1999, p. 14). The improved cost performance of Scandinavian banks can be seen mainly as a consequence of the forced reorganisation following the banking crises of the early 1990s.

Table 3.17: Cost to Income Ratio

	Cost to Income Ratio					
	1993	**1994**	**1995**	**1996**	**1997**	**%change 1990-97**
BE	67.9	71.7	67.6	65.7	63.9	-5.9%
DK	51.1	72.5	54.0	56.9	59.2	15.9%
DE	62.4	60.8	63.8	63.8	-	-
GR	62.7	59.5	64.3	68.1	68.1	8.6%
ES	59.7	59.7	63.2	62.2	61.4	2.8%
FR	64.7	71.3	65.6	69.9	68.7	6.2%
IE	-	-	59.3	57.6	58.3	
IT	61.2	68.8	68.2	67.1	69.0	12.7%
LU	38.0	44.8	46.5	46.5	43.3	13.9%
NL	66.6	67.1	67.3	67.3	-	-
AT	63.5	65.1	69.5	69.1	-	
PT	56.2	61.8	64.9	64.3	57.7	2.7%
FI	136.4	139.9	112.2	88.6	73.4	-46.2%
SE	106.5	80.0	71.6	64.3	64.0	-39.9%
UK	63.2	64.1	63.8	62.3	60.9	-3.6%
EU [1)]	64.6	66.3	65.5	65.4	62.9	-2.6%

[1)]Average without countries where data are not available.
Source: OECD "Bank profitability" statistics (1993-1997).

Operating efficiency in the production of the banking system can be defined as employed inputs per unit of output, which corresponds closely to the concept of productivity (Molyneux *et al.*, 1996). Most comparisons of cost efficiency usually use aggregate ratios relating cost to revenue or assets. Although these measures do not account for business mix, the risk profile of a bank nor the quality of services provided, it is these measures which are most frequently drawn up to use cross-country comparisons of bank operating efficiency. Table 3.18 illustrates these efficiency measures for EU banking systems.

Table 3.18: Banks' Aggregate Operating Efficiency Measures

	Staff Costs as a percentage of non-bank deposits			Non-Staff Costs as a percentage of non-bank deposits			Operating expenses as a percentage of non-bank deposits		
	1993	1997	%change 1990-97	1993	1997	%change 1990-97	1993	1997	%change 1990-97
BE	2.3%	1.8%	-5%	1.5%	1.4%	-27%	3.8%	3.2%	-16%
DK	2.6%	2.1%	-19%	1.7%	1.5%	-6%	4.3%	3.6%	-14%
DE	1.9%	1.9%	-5%	1.2%	1.3%	14%	3.2%	3.2%	2%
GR	1.9%	2.5%	18%	0.8%	1.1%	75%	2.8%	3.6%	31%
ES	2.8%	2.4%	-15%	1.7%	1.5%	-11%	4.5%	3.8%	-13%
FR	3.3%	2.5%	-32%	2.7%	2.1%	-35%	6.0%	4.6%	-33%
IE	-	1.8%	-	-	1.4%	-	-	3.2%	-
IT	3.9%	3.1%	-	2.2%	1.8%	-	6.1%	4.9%	-
LU	0.5%	0.7%	16%	0.5%	0.6%	26%	1.0%	1.3%	21%
NL	2.1%	2.4%	21%	1.7%	2.1%	42%	3.9%	4.5%	30%
AT	2.2%	2.3%	0%	1.5%	2.1%	32%	3.8%	4.4%	13%
PT	2.1%	1.9%	-9%	1.7%	1.5%	15%	3.8%	3.5%	0%
FI	1.9%	1.2%	-44%	9.0%	2.8%	-19%	10.9%	3.9%	-28%
SE	1.9%	2.2%	6%	10.1%	2.3%	-43%	12.0%	4.6%	-27%
UK	2.1%	1.6%	-18%	1.7%	1.4%	-10%	3.8%	3.0%	-15%
EU [1)]	**2.3%**	**2.0%**	**-11%**	**2.7%**	**1.7%**	**-10%**	**5.0%**	**3.7%**	**-11%**

[1)] Average without countries where data are not available

NOTE: Operating expenses include all expenses relating to ordinary and regular banking business other than interest expenses, fees and commissions payable and provisions and income or corporate taxes. Staff costs are a part of the operating expenses. Staff costs include salaries and other employee benefits, including transfers to pension reserves.

Source: OECD "Bank profitability" statistics (1993-97).

As can be seen from table 3.18, when we compare average figures over the 1993-1997 period, there seems to be an overall improvement in operating efficiencies. However, large differences among countries still exist. A major component of operating costs relates to staff expenses. Table 3.19 illustrates the trend of staff costs as a percentage of operating expenses, which overall register a slight increase between 1993 and 1997. However, most EU countries (in particular Belgium, Denmark, Austria, Germany and France) appear to have managed to reduce the overall influence of staff costs.

Table 3.19: Staff Costs as a percentage of Operating Expenses

	Staff Costs as a percentage of operating expenses					
	1993	1994	1995	1996	1997	%change 1990-97
BE	61%	61%	61%	60%	57%	-6.6%
DK	61%	62%	61%	60%	59%	-3.3%
DE	61%	61%	60%	59%	59%	-3.3%
GR	69%	70%	70%	69%	69%	0.0%
ES	62%	61%	61%	61%	61%	-1.6%
FR	55%	54%	54%	54%	55%	0.0%
IE	-	-	59%	58%	55%	-
IT	63%	65%	64%	65%	63%	0.0%
LU	51%	53%	51%	50%	50%	-2.0%
NL	55%	55%	55%	54%	54%	-1.8%
AT	59%	59%	53%	53%	53%	-10.2%
PT	56%	56%	56%	54%	56%	0.0%
FI	18%	22%	24%	30%	30%	66.7%
SE	16%	31%	39%	44%	48%	200.0%
UK	55%	56%	56%	55%	55%	0.0%
EU [1]	53%	55%	55%	55%	55%	3.8%

[1] Average without countries where data are not available

NOTE: Operating expenses include all expenses relating to ordinary and regular banking business other than interest expenses, fees and commissions payable and provisions and income or corporate taxes. Staff costs are a part of the operating expenses. Staff costs include salaries and other employee benefits, including transfers to pension reserves.

Source: OECD "Bank profitability" statistics (1993-97).

Overall, the above data on the operating cost and efficiency levels of European banks suggests that many banking systems have generally been slow in achieving cost reductions. It is important to keep in mind, however, that EU banks have had to face 'unexpected' costs relating to the EMU changeover. Moreover, the costs of mergers and acquisitions could also have had an adverse impact on the operating expenses of many credit institutions.

3.4 Conclusions

This chapter provides an overview of the current state of the banking industry in the European Union. Deregulation and financial liberalisation have certainly been among the most important developments shaping EU banking systems. European banks seems to have responded to the challenges of the increased competitive pressure during the 1990s through three main strategic responses: *i)* they have attempted to reduce costs and improve efficiency by reducing excess capacity (in most cases by reducing the size of their branch networks and staffing levels); *ii)* they have aimed to improve the quality and broaden the range of products and services supplied to customers. Over this period, traditional interest margin business has become a less important source of revenue and non-interest income has grown. In general, European bank profitability has also improved during the 1990s; and, finally, *iii)* many have engaged in mergers and acquisitions activities as well as forging strategic alliances and co-operation agreements. Given these developments and the challenges posed by further technological advances as well as EMU, it is important to investigate the cost characteristics of the main EU banking systems, so as to evaluate areas for potential efficiency improvements. The next chapter will present a review of the main issues relating to cost efficiency in banking.

4 Cost Efficiency in Banking

In the present (1999) environment, where the structure of the financial services industries is changing rapidly, it is particularly important to determine the cost and revenue efficiency characteristics of financial institutions. Berger *et al.* (1993, pp.1-2) noted, in this context, that 'if financial institutions are becoming more efficient, then we might expect improved profitability, greater amounts of funds intermediated, better prices and service quality for consumers and greater safety and soundness if some of the efficiency savings are applied towards improving capital buffers that absorb risk. Of course, the converse applies if the evolution results in less efficient intermediaries, with the additional danger of taxpayer-financed bailouts if substantial losses are sustained'. Nevertheless, they added, 'the study of the efficiency of financial institutions has not kept pace with the changes in the financial industry structures which are occurring all around the globe'.

In recent years, however, there has been a growing number of studies on the efficiency of financial institutions. Cooper (1997, p. 170) reckons that the recent flurry of activities directed at evaluating the performance of financial institutions reflects a variety of considerations: *i)* it may have resulted from a 'pent-up demand' arising from inattention, until very recently, in the literature of economics, finance and management; *ii)* the fact that methodologies suited to dealings with these kinds of evaluations have only recently been developed may also have contributed to this state of affairs; *iii)* finally, institutional re-arrangements, such as ongoing programs of liberalisation, as well as banks' failure attributed to managerial inefficiencies have also contributed to interest in the topic.

This recent literature has focused mainly on frontier efficiency, that is the empirical estimation of how close financial institutions are to a 'best practice' frontier. The existing literature employs five major different efficiency techniques. Berger and Humphrey (1997) classified these main techniques as: *i)* Non-parametric Frontiers: Data

Envelopment Analysis (DEA), Free Disposal Hull (FDH), and related frontier approaches, some of which take the form of Malmquist Productivity Indices; and *ii)* Parametric Frontiers: Stochastic Frontier Approach (SFA), Distribution-Free Approach, (DFA), and Thick Frontier Approach (TFA). These approaches differ in the assumptions they make regarding the shape of the efficient frontier, the existence of random error and, if random error is allowed, the distributional assumptions imposed on the inefficiencies and random error in order to disentangle one from the other.

To date, there is a virtual consensus in the literature on the fact that differences in frontier efficiency among financial institutions exceed differences attributable to incorrect scale or scope of output[1]; nevertheless there is still no consensus as to the best method for estimating the best-practice frontier against which relative efficiencies are measured.

A recent paper (Bauer *et al.*, 1997), however, argues that it is not necessary to have a consensus on which is the single best frontier approach for measuring efficiency; instead, they propose a set of 'consistency conditions' that the efficiency measures derived from the various approaches should meet in order to be most useful for regulators or other decision makers. Basically, the efficiency estimates derived from the different approaches should be consistent in their efficiency levels, rankings and identification of best and worse firms, consistent over time and with competitive conditions in the market; finally, they should be consistent with standard non-frontier measures of performance used in the market by banking firms and analysts.

The financial institution efficiency literature is both recent and extensive[2]. The main aim of this chapter is to review this literature, with particular focus on the non-parametric methodologies (DEA and FDH) and Productivity Indices, since these are the methodologies that will be implemented in the empirical part of this thesis. The first part

[1] Berger *et al.* (1993), in their review of scale and scope efficiency studies, highlighted that research suggested that X-inefficiencies accounted for on the order of 20% more of costs in banking, while scale and product mix inefficiencies, when they could be accurately estimated, were usually found to account for less than 5% of costs.

[2] Berger and Humphrey (1997) in their review of 130 studies of financial institution frontier efficiency across 21 countries found that 116 studies were written or published during 1992-1997.

of this chapter introduces the issue of cost economies in banking and the related problems of defining banks' production processes. This helps the researcher to understand the choice of the variables employed in the empirical literature. The latter part of this chapter provides a comparison of bank efficiency studies. The chapter will be structured as follows: Section 4.1 illustrates the issue of banks' production process while Section 4.2 introduces the definitions of efficiency relevant to this study. Section 4.3 reviews the relevant literature on financial institution frontier efficiency and Section 4.4 concludes.

4.1 Banks' Production Process: Measuring Inputs and Outputs

A financial firm is an entity engaged in the production of intermediation services between borrowers and lenders. These services are related directly or indirectly to the financial assets and liabilities held by the firm, such as loans and deposits (Hancock, 1991). The financial services industry can be viewed as the aggregation of all firms that supply financial services and products, and as such it includes industries such as banking, thrift, securities, insurance, real estate, credit union and finance (Sinkey, 1992). 'A bank is an institution whose current operations consist in granting loans and receiving deposits from the public' (Freixas and Rochet, 1997, p.15). This is the kind of definition used by regulators when they decide whether a financial intermediary has to submit to the prevailing prudential regulations for banks.

As for any other institution, the existence of banks is justified by the role they play in the process of resource allocation, and more specifically in the allocation of capital. In order to provide a better understanding of how financial intermediation improves resource allocation, it is necessary to examine the functions that banks perform. Contemporary banking theory classifies these functions into four main categories (Freixas and Rochet, 1997, p.15):

- offering access to a payment system;
- transforming assets;
- managing risk;
- processing information and monitoring borrowers.

Allen and Santomero (1998) argue that many current theories of intermediation[3] are too heavily focused on functions of institutions that are no longer crucial in many developed financial systems. Such theories are often unable to account for those activities that have become the central focus of many institutions, such as risk management and reducing participation costs, which are the costs of learning about effectively using the markets as well as participation in them on a day-to-day basis.

Financial firms provide services rather than readily identifiable physical products and there is no general consensus in the literature as to the precise definition of what banks produce and how this service output can be measured. Unlike the outputs of manufacturing firms, service firms' output cannot be measured by physical quantities; in addition, banks provide a wide range of services. Indeed, one of the major problems in the theory of the financial firm is the specification of appropriate measures of outputs and inputs. The problem is compounded when financial firms, especially commercial banks, are treated as multi-product firms. It is then not only necessary to devise the measurement of output, but also to consider the multi-product characteristics of the financial firm (Molyneux *et al.*, 1996).

Colwell and Davis (1992, p. 5) noted that, at a practical level, the obvious starting point in measuring the sector output is to look at the way it is treated in the *national accounts*. However, they added, most banking studies do not use national accounts measures, but have tended to use a variety of approaches, resulting in the fact that 'measurement techniques have often outpaced the theory of what is to be measured'.

[3] For a survey of the current state of the literature in banking see, among others, Bhattacharya and Thakor (1993).

The earliest cost studies in banking used very simple models that resembled ratio-based analysis. However, each study applied a different indicator of banking output. Some early studies proxied bank services by a single index that combined all services into a unidimensional measure; others measured each bank service separately. In addition, some researchers chose to measure output in terms of bank assets and liabilities by focusing either on only one side of the balance sheet or on both sides at the same time. Some other studies used bank revenues to measure bank output.

Greenbaum (1967) used the dollar market value of services rendered to measure output in an attempt to estimate the real social value of banking services. Gilligan and Smirlock (1984) measured output in dollars, either as demand and time deposits or securities and loans. According to Humphrey (1985), the output produced by a financial institution might be viewed primarily as the number of deposits and loans accounts 'produced' since most banks' operating costs are incurred by the processing of deposits and loans documents as well as by debiting and crediting of deposits and loans accounts.

An alternative view of bank output focuses on the dollars in each account rather than the number of accounts. This view argues that while banks do indeed produce deposits and loans accounts, the production process is more closely associated with the costs incurred per dollar in that account. Kolari and Zardkoohi (1987) used the dollar value of accounts to measure bank output and justified their choice with the following arguments: *i)* banks compete to increase their market share regarding dollar amounts as opposed to the number of accounts; *ii)* the use of the number of accounts as measure of outputs is incorrect, unless all accounts have the same costs; *iii)* as long as banks produce many services, dollar measurement is the only common denominator.

This problem of output definition has persisted since the earliest studies and has continued to present problems to researchers as the empirical banking literature has developed over the last three decades (Molyneux *et al.*, 1996).

Another important problem is that bank outputs are generally defined in terms of stock variables that do not correspond with the fundamental nature of the bank production process. Bank production is a continuous process in which inputs are continuously transformed into a flow of services using existing technology. There are two main approaches to the choice of how to measure the flow of services provided by financial institutions:

- the production approach;
- the intermediation approach.

Under the 'production approach', banks are treated as firms which employ capital and labour to produce different type of deposits and loan accounts. Outputs are best measured by the number and type of transactions or documents processed over a period of time. Unfortunately, such detailed transactions flow data are typically proprietary and not generally available. Therefore, data on the number of deposits or loan accounts serviced, or the number of transactions performed on each type of product is used instead.

Under the 'intermediation approach', banks are thought as primarily intermediating funds between savers and investors. The value of loans and investments are taken as output measures; labour, capital and deposits are generally inputs to the bank's production process. In this approach, deposits are included as a third input along with capital and labour. As a result, operating costs, as well as interest costs, are taken into account in the production process.

According to Berger and Humphrey (1997), neither of these two approaches is perfect because neither fully captures the dual roles of financial institutions as *i)* providing transactions/documents processing services and *ii)* being financial intermediaries that transfer funds from savers to investors. Nevertheless, each of the approaches has some advantages. The 'production approach' may be somewhat better for evaluating the efficiencies of branches of financial institutions, because branches primarily process customers documents for the institution as a whole and branch managers typically have little influence over bank funding and investment decisions. On the other hand, the 'intermediation approach' may be more appropriate for evaluating entire financial institutions because this approach is inclusive of interest expenses, which often account for one-half to two-thirds of total costs. Moreover, the 'intermediation approach' may be superior for evaluating the importance of frontier efficiency to the profitability of financial institutions, since minimisation of total costs, not just production costs, is needed to maximise profits (Berger and Humphrey, 1997).

In addition to the 'intermediation' and 'production' approaches, other methods of assigning financial goods to input and output categories are:

- the asset approach;
- the value-added approach;
- the user cost approach

Under the 'asset approach' banks are considered only as financial intermediaries between liability holders and those who receive bank funds, and bank outputs are considered to be just loans and other assets (Sealey and Lindley, 1977). Authors like Berger and Humphrey (1990) have strongly criticised this latter approach and favoured instead the so-called 'value added approach', where those factors having substantial added values are employed as important outputs. According to the 'value added' approach, all items on both sides of the balance sheet may be identified as inputs or outputs, according to whether they generate or destroy value. Berger and Humphrey (1992), using information from the Functional Cost Analysis (FCA), found that the items which generate more added value are (demand, savings and time) deposits and loans, so these are considered outputs.

The 'user cost approach' determines whether a final product is an input or an output on the basis of its net contribution to bank revenue. If the financial returns on an asset exceed the opportunity cost of funds or if the financial costs of a liability are less then the opportunity costs of funds, then the instrument is to be considered to be a financial output (Hancock, 1985).

All of these methods substantially agree that loans and other major assets of financial institutions should count as outputs. However, there is no agreement on the role of deposits. Deposits have input characteristics because they are paid for in part by interest payments and the funds raised provide the institution with the raw material of investible funds. On the other hand, deposits have also output characteristics, because they are associated with a substantial amount of liquidity, safekeeping and payment services provided to depositors (Berger and Humphrey, 1997). Some studies (Berger and Humphrey, 1991) resolve this issue by using both the input and output characteristics of deposits (i.e. the interest paid on deposits is counted as part of costs and the rate paid is included as an input price, while the quantities of deposits are counted as outputs). Other studies (Favero e Papi, 1995) have treated deposits as an input and then as an output. The results of these studies suggest that the treatment of deposits can affect the estimates of the analysis.

In general, since it appears that inferences drawn upon results may be affected by how the output is measured, this aspect of model specification assumes particular importance for the researcher.

4.2 Defining Banks' Productive Efficiency

A fundamental decision in measuring financial institution efficiency is which concept of efficiency to use. Although the definitions of efficiency in economics are varied, our concern is primarily with productive efficiency.

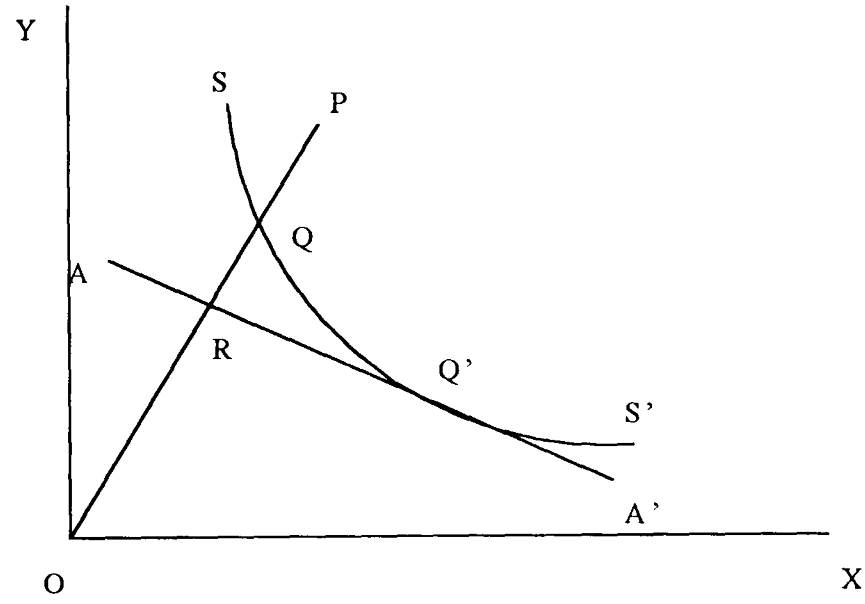
Productive efficiency can be defined as the sum of two components: the purely technical or physical component and the allocative or price component. The purely technical or physical component refers to the ability to avoid waste by producing as much output as input usage allows, or by using as little input as output production allows (Lovell, 1993). Therefore, the analysis of technical efficiency can have an output-augmenting orientation or an input-conserving orientation. The allocative or price component refers to the ability to combine inputs and outputs in optimal proportions in the light of prevailing prices (Lovell, 1993).

Koopmans (1951) provided the following formal definition of technical efficiency: a producer is technically efficient if an increase in any output requires a reduction in at least one other output or an increase in at least one other input, and if a reduction in any input requires an increase in at least one other input or a reduction in at least one other output. Thus, a technically inefficient producer could produce the same outputs with less of at least one input, or could use the same inputs to produce more of at least one output.

Debreu (1951) and Farrell (1957) introduced a measure of technical efficiency. Their measure is defined as one minus the maximum equiproportionate reduction in all inputs that still allows continued production of given output (see Figure 4.1). A score of unity indicates technical efficiency because no equiproportionate input reduction is feasible, and a score of less than unity indicates the severity of technical inefficiency. In some circumstances it is desirable to convert the Debreu-Farrell measure to equiproportionate output expansion with given inputs and this conversion is straightforward (Lovell, 1993).

Figure 4.1: Farrell Measure of Technical Efficiency

An illustration of Farrell measure of technical efficiency (Farrell, 1957, p.245)



...consider, for the sake of simplicity, a firm employing two factors of production to produce a single product, under the conditions of constant return to scale. Suppose that the efficient production frontier is known; that is the output that a perfectly efficient firm could obtain from any given combination of inputs. In the diagram above, the point P represents the inputs of the two factors, per unit of output that the firm is observed to use. The isoquant SS' represents the various combinations of the two factors that a perfectly efficient firm might use to produce unit output. Now, the point Q represents an efficient firm using the two factors in the same ratio as P. It can be seen that it produces the same output as P using only a fraction OQ/OP as much of each factor. It could also be thought of as producing OP/OQ times as much output from the same inputs. It thus seems natural to define OQ/OP as the technical efficiency of the firm P. This ratio...takes the value of unity (or 100 per cent) for a perfectly efficient firm, and will become indefinitely small if the amounts of input per unit output become indefinitely large.

However, one needs also a measure of the extent to which a firm uses the various factors of production in the best proportions, in view of their prices. In the Diagram above, if AA' has a slope equal to the ratio of the best prices of the two factors, Q' and not Q is the optimal method of production; for although both points represent 100 per cent technical efficiency, the cost of production at Q' will only be a fraction OR/OQ of those at Q. It is natural to define this ratio as the price efficiency of Q.

If the observed firm were perfectly efficient, both technically and in respect of their prices, its costs would be a fraction OR/OP of what they in fact are. It is convenient to call this ratio overall efficiency of the firm, and one may note that it is equal to the product of the technical and price efficiencies.

Variation from productive efficiency can be broken down into input and output-induced inefficiencies. Input inefficiency means that, for a given level of output, the firm is not optimally using the factors of production. With respect to outputs, optimal behaviour necessitates production of the level and combination of outputs corresponding to the lowest per unit cost production process (Evanoff and Israilevich, 1991).

While the concept of productive efficiency is rather straightforward, various difficulties arise when attempting to measure it. Essentially, it is necessary to derive the best practice or production frontier, which depicts the maximum performance possible by firms, and compares existing firms with this standard. Ideally, it would compare firm performance with their 'true' frontier. However, the best that can be achieved is an empirical or 'best practice' frontier generated from the empirical data set used by the researcher. It is important to point out that in most practical economic analyses, relative efficiency rather than absolute efficiency is the more appropriate concept.

Berger and Mester (1997) discussed what they consider to be the most important economic efficiency concepts: that is, those with the best economic foundations for analysing the efficiency of financial institutions. They identify: *i)* cost efficiency; *ii)* standard profit efficiency and *iii)* alternative profit efficiency.

Cost efficiency gives a measure of how close a bank's cost is to what a best-practice bank cost would be for producing the same output bundle under the same conditions. Standard profit efficiency measures how close a bank is to producing the maximum possible profit given a particular level of input and output prices. Finally, under the alternative profit efficiency assumptions, efficiency is measured by how close a bank comes to earning maximum profits given its output levels rather than its output prices.

Once the efficiency concepts are selected, the next issue is about how to measure them. The two general approaches used to model this relationship are the parametric or econometric approach and the non-parametric approach: these approaches will be discussed in Section 4.4.

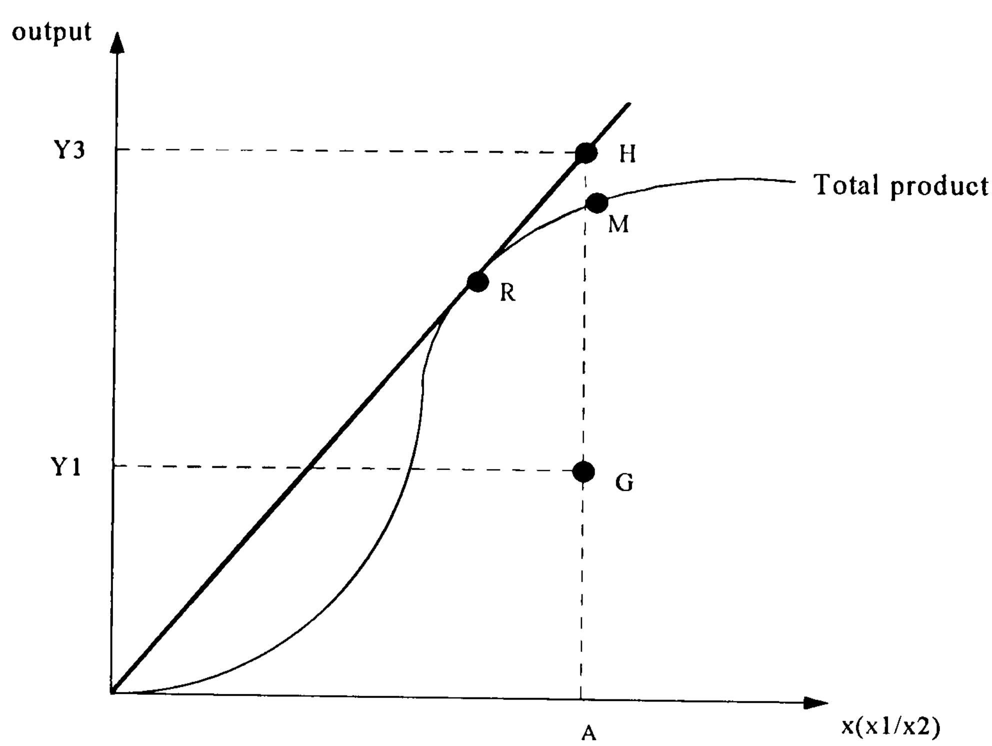
In general, the concept of efficiency has been closely related to the concepts of scale and scope economies. Optimal firm size and product mix are important issues for an industry undergoing a restructuring process as described in Chapter 3. Interest in the subject of scale and scope economies has been recently stimulated by the wave of mergers and acquisitions in Europe. One of the reasons commonly put forward to justify M&As are possible efficiency gains resulting from scale and scope economies. In addition, the application of new technologies in banking entails heavy expenditure, which can often be made profitable only by a sufficient number of transactions. On the other hand, important policy issues include establishing the degree of national consolidation likely to enhance efficiency whilst maintaining competition. Giving the above factors, it is of interest to investigate the issue of scale and scope efficiency in banking.

4.2.1 Scale and Scope Economies

Productive efficiency requires optimising behaviour with respect to outputs as well as inputs. An optimal level of output is possible if economies and diseconomies of scale exist at different output levels. According to Evanoff and Israilevich (1991) economies of scale exist if, over a given range of output, costs per unit decline as output increases. Increases in costs per unit correspond to decreasing returns to scale. A scale efficient firm will produce at the point where there are constant returns to scale; that is, changes in output result in proportionate change in costs. Because it involves the choice of an inefficient level, scale inefficiency is considered a form of technical inefficiency. Therefore, total technical inefficiency includes both pure technical and scale inefficiency; that is inefficient levels of both inputs and outputs.

Graphically, these concepts can be explained by figure 4.2, which considers the case of a one input and one output production process. The assumption of constant returns to scale has been dropped and the production process is now characterised by increasing returns up to point R, constant returns at R and decreasing returns to scale for output levels above R. The firm corresponding to point G in Figure 4.2 is inefficient for two reasons. First, there is pure technical inefficiency resulting from the under-utilisation of inputs: the firm is beneath the total product curve. If inputs are fully utilised, they should produce the higher output level corresponding to point M, that is y_3. Second, there are decreasing returns to scale at the current level of output since the production process is not represented as the linear relationship OH. The output not produced because of scale inefficiency can be measured as HM.

Figure 4.2: The Concept of Technical Efficiency



Source: Evanoff and Israilevich, 1991, p. 15.

The concept of scale economies, or returns to scale, refers to the rate at which output changes as all factor quantities are varied. Therefore, economies of scale are measured by the ratio of the percentage change in output. When a firm expands its scale of operations, economies of scale arise if it reduces the average cost of output, holding all other factors constant. Economies of scale can therefore be defined either in terms of the firm production function or its corresponding cost function, since scale economies are the inverse of increasing returns to scale. Thus, it is said that there are constant costs when the production function presents constant returns to scale, scale economies when the production function presents increasing returns to scale and diseconomies of scale when the production function presents decreasing returns to scale (Molyneux *et al.*, 1996).

The concept of scale economies in a single product firm applies to the behaviour of total costs as output increases, and economies of scale exist if total costs increase less than proportionately than output. The multi-product nature of banks makes analysis and interpretation of returns to scale more complex. When the firm is multi-product, global scale economies are defined relative to a proportionate increase in the production of all outputs, the productive mix being held constant. If the output increases more proportionately than total costs, then economies of scale are said to exist. They can be measured[4] by employing Baumol's (1982) concept of *Ray Average Cost* (RAC), which describes average costs for the multi-product firm without recourse to arbitrary aggregation of all outputs into a single index. Defining RAC as:

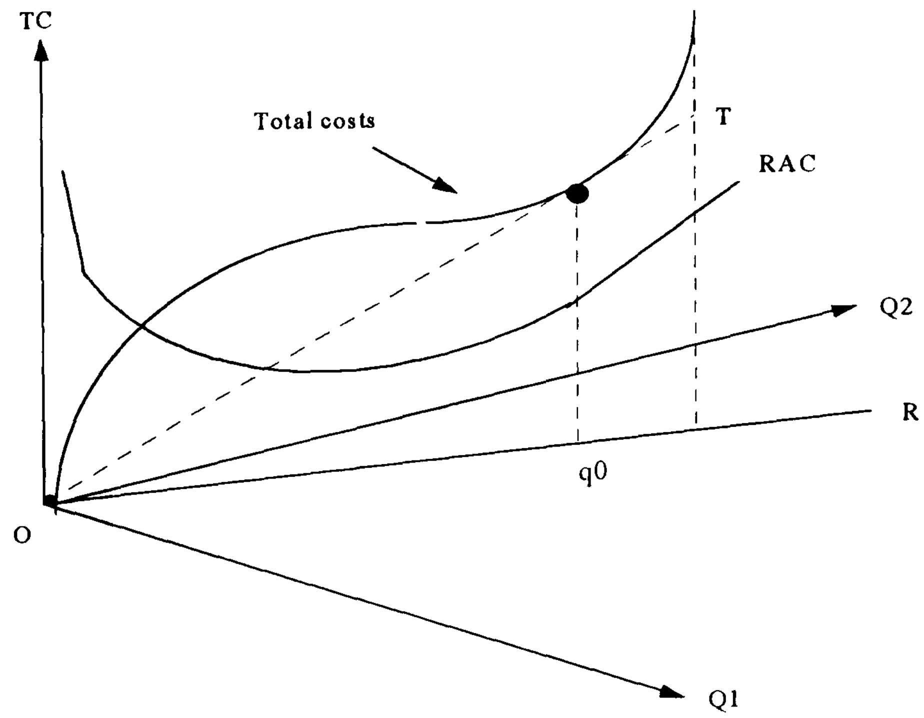
$$\mathrm{RAC} = C(kQ_i)/k \tag{4.1}$$

where Q_i is a vector of outputs, or the unit bundle, for a particular mixture of outputs $(Q_1, \ldots, Q_n)$ and k is the number of units in the bundle such that $Q = kQ_i$, economies of scale are present when RAC is strictly declining, or

$$C(kQ_i)/k < C(tQ_i)/t \qquad \text{for } k > t \tag{4.2}$$

[4] Alternative methodologies of measuring scale economies are illustrated, among others, in Humphrey (1985), Kolari and Zardkoohi (1987), Berger *et al.* (1987), Forestieri (1993), Molyneux *et al.* (1996).

Figure 4.3: Economies of Scale for Multi-Product Firms: the Concept of RAC



Source: Adapted from Baumol, Panzar and Willig, 1988, p. 50.

Figure 4.3 above shows the concept of RAC for a multi-product firm in a three-dimensional diagram. The point of minimum RAC, the output bundle q_0, corresponds to the most efficient scale (size) for the firm producing outputs in the proportion specified by the ray OR. Thus, the degree of scale economies at q_0 is defined as the elasticity of output with respect to cost which is equal to $S_N = 1/(1 + e)$ where e is the elasticity of the relevant average cost curve. This variable (the degree of scale economies) is greater than, less than or equal to one as returns to scale are locally increasing, decreasing or constant and the RAC curve slope is negative, positive or zero, respectively.

The concepts of RAC and multi-product scale economies refer to proportional changes in the quantities in the entire product set. However, a firm could change the production of a single output, holding the production of the other products constant. In order to define analytically product specific economies of scale, it is first necessary to introduce the concept of incremental cost. The incremental cost (IC_i) for product Q_i at a vector of outputs Q^* is the additional cost required to produce $Q_i = Q_i^*$ in place of $Q_i=0$, i.e.:

$$IC_i(Q^*) = C(Q_1^*,\ldots Q_i^*,\ldots Q_n^*) - C(Q_1^*,\ldots Q_{i-1}^*,0,Q_{i+1}^*,\ldots,Q_n^*) \tag{4.3}$$

Then, the degree of scale economies specific to a product is measured by the ratio of the average incremental cost of the products to its marginal cost (Forestieri, 1993).

Humphrey (1985) cautioned about the possible confusion between *Plant (Branch)* and *Firm* scale economies. Scale economies reflect how operating costs are affected as output expands. In the case of unit banks, output can only be expanded by producing more of various banking services at a single office - plant scale economies. On the other hand, in a branch banking organisation, scale economies for one office - plant scale economies – may be quite different from those for the entire organisation or all branches together - firm scale economies. This is because branch banks can expand their output either by adding new services or by adding new branches. Scale economies at the plant or branch level are calculated assuming that the expansion of output occurs with no increase in the number of branches, while scale economies at firm level are calculated assuming that output expansion is accompanied by branch expansion. In the case of banks with a wide branch network, it seems very important to compute both plant and firm scale economies.

Additional cost advantages may result from producing more than one product. The impact of product diversification on banks' cost efficiency is captured both in the notion of cost complementarities and in the notion of economies of scope.

Cost complementarities mean that the marginal cost of producing any product decreases with an increase in the output of any other product. If the cost of joint production is less than the cost resulting from independent production processes, economies of scope are said to exist. Diseconomies of scope exist if the joint production costs are higher than specialised or stand-alone production of the individual product.

Let us consider two outputs, Q1 and Q2 and their separate cost function, $TC(Q_1)$ and $TC(Q_2)$. If the joint cost of producing the two outputs is expressed by $TC(Q_1,Q_2)$, then economies of scope are said to exist if:

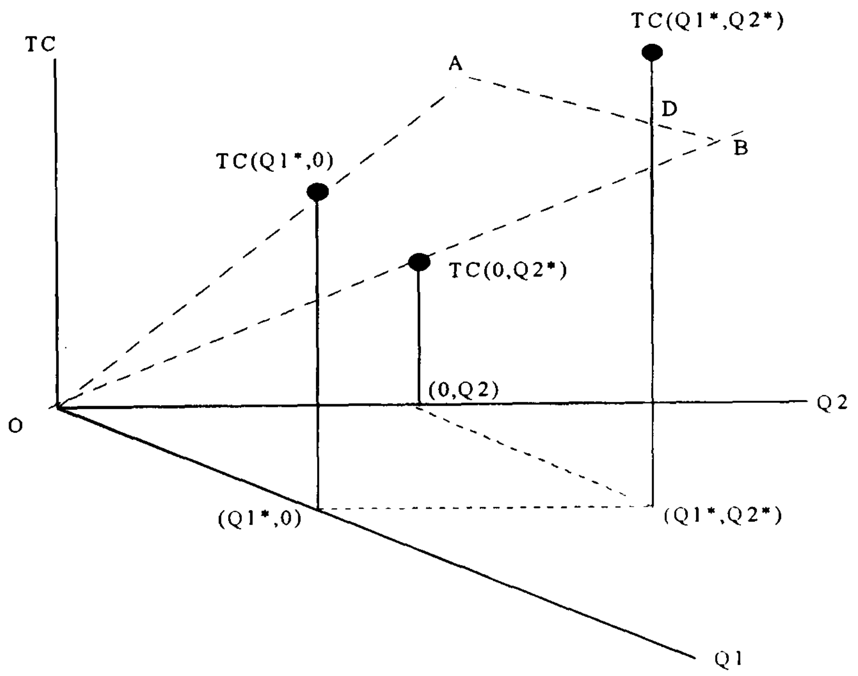
$$TC(Q_1,Q_2) < TC(Q_1) + TC(Q_2) \tag{4.4}$$

If the inequality is reversed, then diseconomies of scope are said to exist.
The degree of economies of scope can be measured as follows:

$$SCOPE = [TC(Q_1) + TC(Q_2) - TC(Q_1,Q_2)]/\ TC(Q_1,Q_2) \tag{4.5}$$

The concept of scope economies is explained graphically in Figure 4.4. This illustrates that the concept of scope economies involves a comparison of $TC(Q_1^*,0) + TC(0, Q_2^*)$, the sum of the heights of the cost surface over the corresponding points on the axes, with $TC(Q_1^*,Q_2^*)$, the height of the cost surface at point (Q_1^*,Q_2^*), which is the vector sum of $(Q_1^*, 0)$ and $(0, Q_2^*)$. If $TC(Q_1^*,Q_2^*)$ lies below the hyperplane OAB which goes through the origin and points $TC(Q_1^*,0)$ and $TC(0, Q_2^*)$, then the condition for scope economies is achieved. Therefore, in Figure 4.4, the height of D, the point on plane OAB above (Q_1^*,Q_2^*), must equal $TC(Q_1^*,0) + TC(0, Q_2^*)$ since the hyperplane is defined by $TC = aQ_1 + bQ_2$ for some constants a,b. Hence $TC(Q_1^*,0) = aQ_1^*$ and $TC(0, Q_2^*) = bQ_2^*$, and $TC(Q_1^*,Q_2^*)$ must be less than $aQ^*_1 + bQ^*_2$ for scope economies to hold (Baumol, Panzar and Willig, 1988).

Figure 4.4: The Concept of Scope Economies



Source: Adapted from Baumol, Panzar and Willig, 1988, p. 72.

Berger *et al.* (1987) developed alternative scale and product mix measures: *Expansion Path Scale Economies* (EPSCE) and *Expansion Path Subadditivity* (EPSUB), which compare the cost effectiveness of firms that differ in both scale and product mix simultaneously. The expansion path measures examine competitive challenges from firms represented in the data, as opposed to the standard ray scale and scope measures, which examine competition from firms that all have the same product mix or firms that all specialise completely. In the same study, Berger *et al.* (1987) identified the potential sources of scope and product mix economies in the following:

(i) Spreading Fixed Costs;

(ii) Information Economies;

(iii) Risk Reduction;

(iv) Consumer Cost Economies.

According to Forestieri (1993, p.70) the hypothesis of the existence of scale and scope economies is usually grounded on considerations that include the following:

(*i*) *Technology* [Revell (1983); Humphrey (1985); Hunter and Timme (1986); Evanoff *et al.* (1991); Landi (1990)];
(*ii*) *Specialised Labour* [Bell and Murphy (1968); Clark (1988); Muldur (1991)];
(*iii*) *Information Economies* [Arrow (1971); Williamson (1975); Berger *et al.* (1987); Shaffer (1991); Humphrey (1991)];
(*iv*) *Strategic and Organisational Flexibility* [Muldur (1990); Berger *et al.* (1987); Gilbert and Steinherr (1989); Litan (1987)];
(*v*) *Demand Side Benefits* [Herring and Santomero (1990)].

The methodology applied in estimating scale and scope efficiency has become increasingly complex. The choice of the functional form for the total cost or production functions reflects the problems in defining the characteristics of bank production process. The Cobb-Douglas, CES (*Constant Elasticity of Substitution)*, Translog, Hybrid Translog and Fourier Flexible functions have all enjoyed prominence. It is beyond the aims of this chapter to analyse the methodological problems associated with estimating scale and scope economies: details on different methodological approaches are reported and reviewed, among others, in Benston *et al.* (1982a), Kolari and Zardkoohi (1987), Berger *et al.* (1987), Forestieri (1993) and Molyneux *et al.* (1996).

4.2.1.1 Scale and Scope Economies: Empirical Evidence in the US Banking Market

This section briefly analyses the main results of studies investigating economies of scale and scope that have been undertaken over the past 30 years. Appendix 1 and 2 summarise the findings. A more detailed literature review can be found in Kolari and

Zardkoohi (1987), Steinherr (1992), Forestieri (1993), and Molyneux *et al.* (1996). Initial attempts to investigating bank costs for banks of different size were relatively simplistic; instead of using econometric methods they relied on accounting data to calculate financial ratios relating bank costs to their output. Kolari and Zardkoohi (1997) categorised these early studies in two groups: (1) studies that measured output in terms of earning assets and (2) studies that used total assets to measure output.

The first major systematic study of bank cost was undertaken by Alhadeff (1954), who compared costs of Californian branch and unit banks of different size for the years 1938-50. Output was measured as the ratio of loans and investments to total assets to reflect the used capacity of the bank. With this measure Alhadeff found that branch banks produced greater output per dollar resources than did unit banks. The evidence of this study suggested that there was increasing returns to scale for large and small banks and constant returns to scale for mid-sized banks. A later study by Horoviz (1963), over the period 1940-60, employed definitions of total costs and output similar to Alhadeff (1954) and reached similar findings: he concluded that scale economies in banking were not large and did not outweigh diseconomies relating to branching.

A major criticism of these early studies related to the use of earning assets as a measure of output, since this measure did not include other assets; this omission tends to exaggerate the average unit cost of large banks. In order to avoid this potential bias, Schweiger and McGee (1961) and Gramley (1962) used total assets as measure of bank output. Schweiger and McGee (1961) found that large banks had a cost advantage over small and medium-sized banks. Gramley (1962) found that average cost decreased as bank size increased and, therefore, larger banks were found to have a cost advantage compared with small banks. Gramley observed that, perhaps, small banks costs were higher simply because they did not work as hard as large banks to control costs.

Two studies by Benston (1965a,b) marked the beginning of a new direction for the bank cost literature. He was the first to employ a Cobb-Douglas cost function to investigate economies of scale in banking. A number of cost studies that considered alternative output definitions, sample and model variables followed. Benston's results indicated that economies of scale were present, but were small for all banking services.

In line with Benston's results, Greenbaum (1967) reviewed the early literature on bank costs and concluded that economies of scale were generally exhausted after banks exceeded $10 million in asset size. Therefore, he concluded that banks with more than $10 million in assets were inefficient because of high overhead unit costs, high transaction costs, and lack of sufficient specialisation and limited diversification. The next major study of economies of scale in the US banking market was undertaken by Bell and Murphy (1968). The variables used by Bell and Murphy were similar to those employed by Benston. They found economies of scale for most bank services; on the other hand, branching operations were found to be more costly than unit bank operations

In the 1970s, research sought to update and extend previous work, by taking into account technology developments and other emerging trends in banking. From these studies, it emerged that although there were economies of scale in banking, they were not sufficient to preclude small and medium-sized banks from viable competition [see, among others, Schweitzer (1972); Murphy (1972); Daniel, Longbrake and Murphy (1973); Kalish and Gilbert (1973); Longbrake and Haslem (1975), Mullineaux (1975, 1979)].

In general, the Cobb-Douglas studies indicated the existence of economies of scale for most services offered by banks. These studies, however, are subject to various limitations: (1) the analysis was undertaken primarily on small banks; (2) the Cobb-Douglas functional form does not allow for a U-shaped cost curve; (3) the cost function is heavily restricted and therefore does not allow for the computation of economies of scope. Benston, Hanweck and Humphrey (1982a, p.435), in their synthesis of the Cobb-Douglas studies, reached the following conclusion: 'A consensus emerges from retrospective research into banking costs that there are constant economies of scale irrespective of the size of the bank'. However, by the end of the 1970s this conclusion began to come under fire, on both theoretical and methodological grounds.

The first study to use the translog function methodology to estimate scale economies was undertaken by Benston, Hanweck and Humphrey (1982b). The introduction of the translog cost function form to measure cost economies has at least two important advantages (Forestieri, 1993): (a) it allows for a U-shaped average cost curve, or at least for a cost curve not uniform for all sizes; (b) it dispenses with the ancillary hypothesis of an input elasticity equal to 1, typical of the Cobb-Douglas form, and from the constraints typical of the CES production function. It is thus possible to check that the estimated cost function is monotonically non-decreasing in input prices and outputs. In other words, the translog functional form appeared to be more suitable to represent the nature of the activity of financial institutions.

The findings of the first application by Benston *et al.* (1982b) indicated that there was evidence of the existence of U-shaped cost curves; that unit banks with more than $50 million in deposits recorded diseconomies of scale while banks in branching states experienced small economies of scale. From Murray and White (1983) onwards, there was an increasing trend for researchers to construct models of financial institutions as multi-product firms in line with the theory of multi-product industries (Baumol *et al.*, 1988). The measurement of scope economies became a key issue in the analysis of the cost structure of the financial industry.

Murray and White (1983) examined the production technology of credit unions in Canada; the study, which followed Sealey and Lindley's (1977) intermediation approach, found that economies of scale existed in most of the credit unions studied. Moreover, the study indicated that large, multi-product credit unions were more cost efficient than small, single-product credit unions.

The introduction of the translog model in empirical research in banking coincided with a reversal of previous results. The great majority of studies from the 1980s, adopting either the production or the intermediation approach and using the translog function, reported the existence of scale economies for a very low level of output ($100 million). The average cost function in these studies tend to be U-shaped, but the optimal size was very small [Benston, Hanweck and Humphrey (1982b); Benston, Berger, Hanweck and Humphrey (1983); Gilligan, Smirlock and Marshall (1984); Berger, Hanweck and Humphrey (1987); Humphrey (1987); Mester (1987)]. All of these studies, however, with the exception of Gilligan *et al.* (1984), pointed out either the lack of evidence or the existence of diseconomies of scope once a very small size is exceeded.

One of the main shortcomings of the standard translog function is its indeterminacy whenever one or more products are produced; the more products are specified and the more differentiated the behaviour of the financial institution, the more it becomes necessary to include in the sector analysis the assumption that one or more outputs equal 0 for at least some firms (Forestieri, 1993). The Box-Cox transformation of a translog cost function (employed by Clark, 1984) or the hybrid translog function (Kolari and Zardkoohi, 1987) can solve this problem. A different, but commonly adopted solution [Benston *et al.* (1983); Kim (1986); Mester (1987); Cossutta *et al.* (1988); Rossi (1991)] consists of assigning arbitrary low, but positive, values to the level of production of each service.

Overall, the results of the translog studies suggested that there were U-shaped average cost curves in the US banking markets; these studies concluded that economies of scale existed, but at relatively low levels of output (between $25 and $200 million in deposit size) and there was no consensus as to the optimal size of the banking firm (Molyneux *et al.*, 1996). It is necessary to point out, however, that until the late 1980s cost studies on the US banking market tended to exclude data on large institutions. The results of studies which used data samples for large US banks [Hunter and Timme (1986); Shaffer and David (1986); Kim (1986); Hunter, Timme and Yang (1990); Noulas, Ray and Miller (1990)] found, in general, that scale economies appeared to exist for much larger institutions. The evidence suggested that scale advantages existed well beyond the $100-200 million in the deposit size range. None of these studies, however, seemed to find evidence of the existence of scope economies.

More recently, the cost efficiency problem, and therefore the problem of estimating scale and scope efficiencies, has been approached using models based either on stochastic or on linear programming techniques [Sherman and Gold (1985); Parkan (1987); Rangan *et al.* (1988); Ferrier and Lovell (1990); Elyasiani and Mehdian (1990b); Tulkens (1990); Vassiloglou and Giolias (1991); Berger and Humphrey (1991); Mester (1993); Cebenoyan *et al.* (1993); Berg *et al.* (1993)]. These 'new' approaches will be analysed in detail in Section 4.4.

4.2.1.2 Scale and Scope Economies: Empirical Evidence in the European Banking Market

Most of the literature on scale and scope economies relates to the US banking market. The first European studies began to appear in the late 1970's [Maes (1975); Lévy-Garboua and Lévy-Garboua (1975); Lévy-Garboua and Renard (1977)]. The earliest European studies examined the French and Italian banking markets and observed substantial economies of scale. Cossutta *et al.* (1988), Lanciotti e Raganelli (1988), Baldini e Landi (1990), Cardani *et al.* (1990), Landi (1990), Conigliani *et al.* (1991) and Conti and Maccarinelli (1992) generally suggested the existence of economies of scale in the Italian banking market, although little evidence has been found on scope economies. These results for French banking were confirmed in later studies [Dietsch (1988, 1993); Martin and Sassenou (1992)]. Casu and Girardone (1998) found evidence that only slight scale economies exist in the Italian banking market and that banking groups show a higher degree of scope economies with respect to individual banks. These results are in line with more recent studies that show strong evidence of scope economies for largest banks across virtually all European banking markets (European Commission, 1997a).

Fanjul and Maravall (1985) and Rodriguez, Alvarez and Gomez (1993) analysed the Spanish banking market and found evidence of both scale and scope economies for medium-sized saving banks and diseconomies of scale and scope for larger institutions.

Gathon and Grosjean (1991) and Pallage (1991) employed a translog cost function to analyse scale and scope economies in the Belgian banking market. Gathon and Grosjean (1991) found decreasing returns to scale for the four big Belgian banks, whose assets are beyond 50 million BF, and increasing returns to scale in all other banks. Pallage (1991) found scale economies for small institutions and diseconomies of scale when size grows, confirming the results achieved by Pacolet (1986). Scope economies were found for the 5 larger Belgian banks.

Cost economies studies in the UK have focused mainly on the building society sector, have used a range of competing methodologies and reported conflicting findings. Gough (1979) and Barnes and Dodd (1983) both estimated linear average cost functions and found no evidence of scale economies for UK building societies for the period 1972-79 and 1970-78, respectively. Cooper (1980) employed a Cobb-Douglas cost function and found evidence of scale economies for building societies with assets size of less than £100 million, and of diseconomies of scale for larger societies. Hardwick (1989, 1990) found evidence of scale economies for relatively smaller building societies and no evidence of scope economies.

McKillop and Glass (1994) employed a hybrid translog cost function to obtain econometric measures of overall and augmented economies of scale, product-specific scale economies and economies of scope. The data were obtained from the 1991 annual returns for a sample of 89 building societies, grouped into three categories – national, regional and local – depending on their consolidated asset size and number of branches. Scale and scope estimates were then calculated for each category of societies as well as the whole industry. Overall, McKillop and Glass (1994) found evidence of significant augmented economies of scale for both national and local societies, but only constant returns to scale for those societies that are regionally based. They found no evidence of economies of scope or cost complementarities.

Drake (1995) used a translog multiproduct cost function which provided for the first empirical test for expense-preference behaviour in UK building societies. The results of this study found no evidence of either scale or scopes economies when expense-preference behaviour is taken into account.

Molyneux *et al.* (1996) adopted a hybrid translog cost function to examine economies of scale and scope in the French, German, Italian and Spanish banking markets. The results indicated noticeable differences in cost characteristics across European banking markets, and scope and scale economies appeared to be evident in each country over a wide range of bank output levels. It also appeared that scale and scope economies would be important in generating economic gains to the EU banking markets under the single market programme.

A study undertaken by the European Commission (1997a) was primarily concerned with assessing the potential gains brought about by the Single Market Programme (SMP). The analysis used balance sheet and income statement data from 1987 to 1994, obtained from the IBCA Bankscope database. The analysis showed that in all countries there was evidence of both economies and diseconomies of scale. The preponderance of increasing returns to scale was found generally with the small banks, particularly in the case of Germany and France. The existence of diseconomies of scale in several size bands suggested that, with the existing distribution of banks and current technology, the opportunities from exploiting economies of scale might be quite limited. According to the study, there was a clear potential for a SMP effect in that substantial economies of scale existed, especially for the small banks in more fragmented banking systems. However, the question whether economies of scale have been realised as a result of the SMP is more problematic, since in most countries the identification of a SMP effect coincided with a recovery of their economies, which raised bank output and precluded the identification of a specific SMP effect. The study found strong evidence of significant and apparently large economies of scope for the biggest banks. These findings lead the authors to the presumption that, given the widening of the product range permitted by the legislative changes under the SMP, evidence on economies of scope are likely to be found.

4.2.2 Limitations of the prior Literature on Scale and Scope Economies in Banking

As summarised in the previous sections, the prior literature on scale efficiency in banking suggests that the average cost curve has a relatively flat U-shape, with medium-sized firms being slightly more efficient than either very large or very small firms (Humphrey, 1990). The primary uncertainty expressed in this literature is the location of the scale efficient point on the cost curve. According to Berger *et al.* (1993), these results suggest that the functional form employed in these studies may not be capable of incorporating the technologies of both large and small banks together in a single model, or that some important factor that varies with bank size may be excluded from the model. McAllister and McManus (1993) showed that the traditional translog cost function specification gives a poor approximation when applied to banks of all sizes, because it forces large and small banks to lie on a symmetric U-shaped ray average cost curve, and disallows other possibilities. Moreover, according to McAllister and McManus, the translog approximation may behave poorly away from the mean product mix, which can create problems in measuring scale efficiencies because large banks tend to have very different product mixes from the average. The solution they proposed consisted of replacing the translog with one of several non-parametric estimation procedures.

Berger *et al.* (1993) identified another potential difficulty in the scale economy literature in the fact that most studies did not use a frontier estimation method. In fact, they note that scale economies theoretically apply only to the efficient frontier, and the use of data from banks off the frontier could confound scale efficiencies with differences in X-efficiency. The term X-efficiency is used to describe all technical and allocative efficiencies of individual firms, as distinguished from scale and scope efficiencies.

The prior literature on scope efficiency seems to be even more problematic. Berger *et al.* (1993) pointed out three major problems: (*i*) there is a problem in applying the translog specification. The translog is insufficiently flexible to describe an industry with increasing returns to scale up to some point and constant returns thereafter, and seems to have difficulties when firms tend to change product mix significantly as they change scale. The translog and the Box-Cox approximation also perform poorly in estimating scope economies because they have trouble with estimations at or near zero output. (*ii*) there are often little or no data on firms that specialise; (*iii*) there are problems associated with evaluating scope economies using data that are not on the frontier. In order to address these limitations, Berger *et al.* (1993) proposed the concept of 'optimal scope economies', based on the profit function instead of the cost function; they include all the revenue effects of output choices as well as the cost effects of input choices, providing at a least partial solution to the aforementioned methodological limitations.

4.3 Recent Approaches to Measuring Banks' Productive Efficiency

As is apparent from the previous sections, scale and scope efficiency have been extensively studied, especially in the context of US financial institutions. However, until recently, little attention has been paid to measuring what appears to be a much more important source of efficiency differences: X-inefficiency or deviations from the efficient frontier. That is, differences in the managerial ability to control cost or maximise revenue. There is a virtual consensus in the literature that differences in frontier efficiency among financial institutions exceed inefficiencies attributable to incorrect scale or scope of output (Berger and Humphrey, 1997). Nevertheless, there is still no consensus on the preferred method for determining the best-practice frontier against which relative efficiencies are measured.

Several different types of approaches have been employed for evaluating the efficiency of financial institutions; these methods primarily differ in the assumptions imposed on the data in terms of the shape of the frontier and the distributional assumptions imposed on the random error (v_i) and possible inefficiency (μ_i). At a broad level, a general distinction emerges between deterministic and stochastic frontiers.

a) Deterministic models:

- every observed point is in the attainable set ψ (no noise, no error in the variables, no major missing values)

- $\varepsilon_i = \mu_i$ where $\mu_i \geq 0$ for all $i = 1,\ldots,n$.

- μ_i is pure inefficiency

The main problem of deterministic models is related to their sensitivity to outliers.

b) Stochastic models

- there might be noise, some observed point might lie outside the attainable set ψ

- $\varepsilon_i = \mu_{i_i} + v_i$ where $\mu_i \geq 0$ for all $i = 1,\ldots,n$.

- μ_i is pure inefficiency and v_i is noise

The main problem of stochastic models relates to the possible difficulty in distinguishing statistical noise from inefficiency.

Both deterministic and stochastic models can be either parametric or non-parametric. The next section will briefly review these alternative methods, focusing on the underlying concepts and assumptions, rather than the technical details of the estimation methods. Some technical details on the non-parametric methodologies will be illustrated in Chapter 5; more in-depth explanations can be found in several comprehensive surveys [see, among others, Banker *et al.* (1989); Bauer (1990); Seiford and Thrall (1990); Aly and Seiford (1993); Greene (1993); Grosskopf (1993); Lovell (1993); Charnes *et al.* (1994)].

4.3.1 Parametric Approaches

There are 3 main parametric frontier approaches[5]:

1) the Stochastic Frontier Approach (SFA)
2) the Distribution Free Approach (DFA)
3) the Thick Frontier Approach (TFA)

The Stochastic Frontier Approach (or Econometric Frontier Approach) specifies a functional form for the cost, profit or production function and allows for random error[6]. It generally assumes that inefficiencies follow an asymmetric half-normal distribution and that random errors follow a symmetric standard normal distribution (Aigner, Lovell and Schmidt, 1977). In other words, the error term is given by $\varepsilon = \mu + v$, where μ represents inefficiency and follows a half-normal distribution. Both the inefficiencies μ and the random error v are assumed to be orthogonal to the input, output or exogenous variables specified in the estimating equation [Ferrier and Lovell (1990); Timme and Yang (1991); Bauer *et al.* (1993)]. The estimated inefficiency of any firm is taken as the conditional mean or mode of the distribution of the inefficiency term, μ, given the observation of the composed error term, ε (Berger and Humphrey, 1997). In practice, however, the half-normal assumption for the distribution of inefficiency seems to be rather inflexible and it presumes that most firms are clustered near full efficiency.

According to Greene (1990), other distributions, such as the truncated normal or the gamma distributions may be more appropriate [Yuengert (1993); Mester (1996); Berger and DeYoung (1997)]. However, allowing for more flexibility in the assumed distribution of the inefficiencies may make it difficult to separate inefficiency from

[5] See Berger et al. (1993), Berger and Humphrey (1997) and Bauer *et al.* (1997) for a review of the different approaches.

[6] See Bauer (1990) for a review of the frontier literature and how different stochastic assumptions can be made.

random error (Berger and Humphrey, 1997). In addition, Bauer *et al.* (1997) argue that any distributional assumptions simply imposed without basis are in fact quite arbitrary and could lead to significant error in estimating individual firm efficiencies.

The Distribution Free Approach (DFA) also specifies a functional form for the frontier, but assumes that the efficiency differences are stable over time, while random error averages over time [Berger (1991,1993); Bauer *et al.* (1993); Berger and Humphrey (1992); Berger *et al.* (1993)]. Unlike the other approaches, a panel data set is required. The estimate of inefficiency for each firm in a data set is determined as the difference between its average residual and the average residual of the firm on the frontier, with some truncation performed to account for the failure of the random error to average out to zero. Another way to apply DFA is to use a fixed effects model, where a dummy variable is specified for each firm in a data set. Inefficiencies are computed as differences in the fixed effect estimates across firms (Lang and Welzel, 1996). With the DFA inefficiency can follow almost any distribution, as long as the inefficiencies are non negative. However, if efficiency is shifting over time due to various exogenous influences (i.e. regulatory reforms, interest rate cycle, or other influences), then DFA describes the average deviation of each firm from the best average-practice frontier, rather than the efficiency at one point in time (Berger and Humphrey, 1997).

The Thick Frontier Approach (TFA) specifies a functional form and assumes that deviations from predicted costs within the lowest average-cost quartile of banks in a size-class represent random error, while deviations in predicted costs between the highest and the lowest quartile represent X-inefficiencies [Berger and Humphrey (1991); Bauer *et al.* (1993); Berger *et al.* (1993)]. This approach imposes no distributional assumptions on either inefficiencies or random error, except to assume that inefficiencies differ between the highest and lowest quartile and that random error exists within these quartiles. The TFA itself does not provide exact point estimates of efficiency for individual firms but provides an estimate of the general overall level of efficiency (Berger and Humphrey, 1997).

SFA, DFA and TFA approaches are intuitively appealing as measures of economic performance, since they are based on keeping costs low for a given set of outputs and input prices over a long period of time and over changes in economic conditions. However, as Berger and Humphrey (1997) have pointed out, at present, the choice between the various parametric models and estimation procedures is based primarily on ease of use and/or the apparent reasonableness of underlying assumptions, rather than on any strong theoretical foundation.

4.3.2 Non-Parametric Approaches

The non-parametric approaches can be identified as Data Envelopment Analysis (DEA) and the Free Disposal Hull (FDH) method.

Data Envelopment Analysis (DEA) is a mathematical programming approach for the construction of production frontiers and the measurement of efficiency relative to the constructed frontiers. DEA is based on a concept of efficiency very similar to the microeconomic one; the main difference is that the DEA production frontier is not determined by some specific functional form, but it is generated from the actual data for the evaluated firms. In other words, the DEA frontier is formed as the piecewise linear combination that connect the set of 'best-practice observations', yielding a convex production possibility set (PPS). As a consequence, the DEA efficiency score for a specific firm (or Decision-Making Unit, DMU) is not defined by an absolute standard, but is defined relative to other firms. This feature differentiates DEA from the preceding parametric approaches, which require specific functional forms. DEA has been applied to the banking industry of different countries; an extensive review of the relevant literature on this subject can be found in Seiford and Thrall (1990), Lovell (1993) and Berger *et al.* (1997).

The Free Disposal Hull approach (FDH), developed by Deprins, Simar and Tulkens (1984) is a special case of the DEA model, where the hypothesis of convexity of the production possibility set is abandoned and the PPS is composed only of the DEA vertices and the free disposal hull points interior to these vertices. Because FDH frontier is either congruent or interior to the DEA frontier, FDH will typically generate larger estimates of average efficiency than DEA (Tulkens, 1993).

The FDH approach allows for a better approximation or 'envelopment' of the observed data. DEA is a more efficient estimator than FDH, but only if the assumption of convexity is correct.

Either approach permits efficiency to vary over time and makes no prior assumptions regarding the form of the distribution of inefficiencies across observations, except that undominated observations are 100% efficient (Berger and Humphrey, 1997). A key drawback of non-parametric approaches is that they generally assume there is no random error.

4.3.3 Is there a 'best' frontier method?

Frontier analysis is essentially a way to 'benchmark' the relative performance of production units. Most institutions, not only financial institutions, benchmark themselves against a certain standard in order to be able to better evaluate their performance. It is a widespread belief (Bauer *et al.*, 1997) that frontier efficiency outperforms the standard financial ratios from accounting statements - such as the ROE or the Cost/Income ratio - for most regulatory and other purposes. This is because frontier efficiency measures use programming or statistical techniques to try to remove the effects of differences in input prices and other exogenous market factors affecting the standard performance ratios in order to obtain better estimates of the underlying performance of the management. This constitutes the main advantage of frontier efficiency over other indicators of performance, the fact that such approaches generate an objectively determined quantitative measure allows the researcher to focus on the quantitative effects on costs, input use, etc., that changes in regulatory policy (or other factors) are likely to engender (Bauer *et al.*, 1997).

However, despite the intense research effort, there is still no consensus in the literature as to the best method or set of methods for measuring frontier efficiency. Researchers have highlighted the strengths and weaknesses of various approaches, but the lack of agreement regarding a preferred frontier model makes the choice of the model employed very much a matter of opinion.

The parametric approaches impose a particular functional form that presupposes the shape of the frontier. As a consequence, if the functional form is misspecified, measured efficiency may be confounded with the specification error. On the other hand, non-parametric approaches impose less structure on the frontier but do not allow for random error. If random error exists, measured efficiency may be confounded with these random deviations from the true efficient frontier.

Berger and Humphrey (1997) point out that it is not possible to determine which of the two major approaches dominates the other since the true level of efficiency is unknown. The solution they propose consists of adding more flexibility to the parametric approaches and introducing a degree of random error in the non-parametric approaches. By addressing the main limitations of each approach, they state that the efficiency results would presumably yield efficiency estimates that are more consistent across varying approaches.

As far as the parametric approaches are concerned, some studies have tried to introduce more flexible functional forms. To date, this has been done by specifying a Fourier-flexible functional form, which adds Fourier trigonometric terms to a standard translog function[7]. This has greatly increased the flexibility of the frontier by allowing many inflection points and by including essentially orthogonal trigonometric terms that help fit the frontier to the data wherever it is most needed [Berger *et al.* (1997); Berger and Mester (1997)].

[7] Other functional forms have also been specified. For example, Mester (1992) estimated a hybrid translog function and Berger, Hancock and Humphrey (1993) estimated a Fuss normalised quadratic variable profit function.

Spong *et al.* (1995) and Mitchell and Onvural (1996) suggested that the Fourier-flexible functional form should be preferred over the translog because the former better approximates the underlying cost function across a broad range of outputs. Altunbas *et al.* (1999) added that when using the Fourier-flexible functional form, one avoids holding any maintained hypothesis by allowing the data to reveal the true cost function through a large value of fitted parameters. Berger and DeYoung (1997) noted that the use of the Fourier-flexible form instead of the traditional translog cost function, in one case, reduced the amount of measured inefficiency by as much as 50%, since the more flexible frontier was able to be produce a better data fit.

In the field of non-parametric approaches, researchers are following two main directions. The first is analytical and tries to provide a statistical basis for DEA. The second approach is empirical and seeks to develop and implement a stochastic version of DEA.

In the first case, analytical research is seeking to provide a theoretical foundation for statistical hypothesis testing in a DEA environment. However, the main problem relates to the specification of the distribution of efficiency across observations (Simar, 1996). Hypothesis testing can be conducted only after the data generating process has been specified, and in a multidimensional non-parametric setting in which the inefficiencies are one-sided, this is a statistically complex matter. Moreover, the sampling distribution of DEA efficiency estimators remains unknown. One way of obtaining an empirical approximation to the underlying sampling distribution of DEA efficiency estimates is a resampling technique, such as bootstrapping. Once the underlying distribution is approximated, statistical inference can be conducted. Careful attention, however, needs to be paid to the specification of the data generating process (Simar and Wilson, 1995).

On the other hand, an empirical approach is seeking to develop a stochastic version of DEA. In this approach, inequality constraints describing the structure of the non-parametric DEA technology are converted into 'chance constraints' which, due to noise in the data, are allowed to be violated by a certain proportion of the observations. If probability distributions are specified for these violations, the constraints can be converted into certainty equivalents, and chance-constrained DEA models emerge as non-linear programming problems. Although the chance-constrained DEA model remains deterministic, it incorporates 'noise' in the data (see Grosskopf, 1996).

There have been also a number of attempts to improve the standard DEA non-parametric approach that involve the application of FDH [Fried, Lovell and Vanden Eeckaut (1993); Tulkens (1993); Fried and Lovell (1994)], the polyhedral cone-ratio DEA model [Charnes *et al.* (1990); Brockett *et al.* (1997); Resti (1996)] and the assurance region DEA model [Thompson *et al.* (1997); Taylor *et al.* (1997)]. In addition, the non parametric Malmquist Index approach to productivity measurement has been generalised (Griffell-Tatjé and Lovell, 1994) and the sensitivity of DEA and FDH efficiency models to different radial and non-radial measurement techniques have been tested [Ferrier *et al.* (1994); Pastor (1995); DeBorger *et al.* (1995)].

Bergendahl (1995) suggested the concept of a 'composite frontier', that is the DEA frontier should be composed of the most efficient parts of banks within the sample, forming therefore a composite or representative firm, rather then being composed of separate and individual firms. According to Bergendahl, this composite frontier would indicate the efficiency that had been achieved within the sample, although not necessarily all at a single institution. In this way, the frontier would accurately represent the best possible practice, without confounding the efficient results achieved in one specific area with inefficient results in other areas.

While research is evolving along a variety of directions, in a recent paper Bauer *et al.* (1997) argued that it is not necessary to have consensus on which is the single best frontier approach for measuring efficiency. Instead, they proposed a set of consistency conditions that efficiency measures derived from various approaches should meet so as to be useful for regulators or other decision-makers. Specifically, the consistency conditions they put forward are the following (Bauer *et al.*, 1997, p. 3):

(i) the efficiency scores generated by the different approaches should have comparable means, standard deviations and other distributional properties;

(ii) the different approaches should rank the institutions in approximately the same order;

(iii) the different approaches should identify mostly the same institutions as 'best practice' and as 'worst practice';

(iv) all of the useful approaches should demonstrate reasonable stability over time;

(v) the efficiency scores generated by the different approaches should be reasonably consistent with competitive conditions in the market;

(vi) the measured efficiency from all of the useful approaches should be reasonably consistent with the standard non-frontier performance measures, such as return on assets or cost/income ratios.

Consistency conditions *(i)*, *(ii)* and *(iii)* may be thought of as measuring the degree to which the different approaches are mutually consistent, while conditions *(iv)*, *(v)* and *(vi)* may be thought of as measuring the degree to which the efficiency generated by the different approaches are consistent with reality or are believable. As pointed out by Bauer *et al.* (1997), in fact all of the efficiency approaches could be mutually consistent, but may still not be very useful if they are not realistic.

4.3.4 Productive Efficiency in Banking Markets: Empirical Evidence

In recent years, studies on the efficiency of financial institutions have been produced at a conspicuous pace, addressing several issues in the areas of government policy, research and managerial performance. Berger and Humphrey (1997) recently surveyed 130 financial institution efficiency studies, which employed at least five major techniques, in at least 21 countries and for four types of financial institutions - banks, S&Ls, credit unions and insurance firms. They reported roughly an equal split between applications of non-parametric techniques (69 applications) and parametric methods (60 applications) to depository institution data. Most studies relate to the US banking system[8], but European research is developing rapidly. Given the recognised, key importance of European financial sectors in achieving the overall economic gains sought by deregulation and 'free market solutions' in resource allocation within European economic systems, the need for good European research has become pressing (Molyneux *et al.*, 1996).

Applications of efficiency analysis are quite varied and seek to provide valuable information not only for government policy - such as the effects of deregulation, financial institution failure, market structure and mergers - but also on issues such as comparisons of efficiency across international borders, corporate control, risk and stability over time, and improving managerial performance. Possibly, any classification of the studies according to the specific issues they raise could be quite arbitrary, since the conclusions which can be drawn from the results are often of interest to more than a single party. Moreover, the distinction between those studies which employ a parametric approach from the ones which use non-parametric techniques has recently begun to blur, as more and more studies increasingly seek to investigate the consistency of the results of different estimation techniques or when different assumptions are applied within a given efficiency approach [Ferrier and Lovell (1990); Giokas (1991); Ferrier *et al.* (1994); DeBorger *et al.* (1995); Resti (1997); Eisenbeis, Ferrier and Kwan (1996); Casu and Girardone (1998)]. In addition, researchers have started to make comparisons of efficiency estimates cross-countries [Berg *et al.* (1993); Fecher and Pestieau (1993); Berg *et al.* (1995); Bergendhal (1995); Allen and Rai (1996); Pastor, Pérez and Quesada (1995); Pastor, Lozano and Pastor (1997); European Commission (1997a); Dietsch and Weill (1998)].

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[8] Berger and Humphrey (1997) reported that studies focusing on US financial institution were the most numerous, accounting for 66 of the 116 single country studies they reviewed.

Despite the warning of Berger and Humphrey (1997) about the difficulties in performing and interpreting cross-country analysis, for example because of different regulatory and economic environments across countries, this sort of comparison is likely to constitute a literature of growing importance in the newly harmonised European marketplace.

Overall, the empirical evidence from this recent efficiency literature suggests that the efficiency estimates from parametric and non-parametric approaches are quite similar, but the non-parametric methods generally yield slightly lower mean efficiency estimates and seem to have greater dispersion. More specifically, Berger and Humphrey (1997) found that for the US studies that used DEA and other non-parametric methods, the average efficiency score was 0.72 overall. The standard deviation of efficiencies in these studies was 0.17 and the efficiencies ranged between 0.31 and 0.97. The average efficiency scores for the non-US studies that used non-parametric methods was 0.71. On the other hand, studies that employed a parametric methodology yielded an overall mean efficiency of 0.84 for the US banking literature, with a standard deviation of 0.06 and efficiency estimates ranging between 0.61 and 0.95. However, as Berger and Humphrey (1997) pointed out, the similarity in average efficiency values for firms across different models does not strongly carry over to efficiency rankings of individual firms. This suggests that the confidence intervals surrounding individual firm or branch efficiency estimates may be substantial. Tables 4.1 and 4.2 summarise the main empirical findings in the 1990s, distinguishing between US and European based studies.

4.3.5 Comparative Efficiency in European Banking: Empirical Evidence

The earliest cross-country European study was by Berg *et al.* (1993), who examined bank efficiency in the Nordic countries. The study considered the relative efficiency of the banking industries in Finland, Norway and Sweden in 1990, both on the national and on the pooled data sets, within the framework of Data Envelopment Analysis (DEA). Individual country results found that efficiency spreads between banks were most important in Finland and Norway and least important in Sweden. Moreover, they found that the largest Swedish banks were among the most efficient units in the pooled sample, whereas only one large Finnish bank and no large Norwegian bank had efficiency scores above 0.9. A more recent study by Berg, Førsund and Bukh (1995) used DEA to investigate inefficiencies in the banking industries of Denmark, Finland, Norway and Sweden. The study found that the largest Danish and Swedish banks were among the most efficient units in their pooled sample. They concluded that the Danish and Swedish banks were in the best position to expand in a common Nordic banking market.

Pastor *et al.* (1995) analysed productivity, efficiency and differences in technology, using a non-parametric approach and carrying out a comparison between the Spanish banking system and those of Austria, Germany, United Kingdom, Italy, Belgium, France and the US. The data refer to non-consolidated income and balance sheet account for 1992. According to Pastor *et al.* (1995), France, Spain and Belgium appeared to be the countries with the most efficient banking systems (presenting average efficiency scores of 0.950, 0.822 and 0.806 respectively), whereas the UK (0.537), Austria (0.608) and Germany (0.650) showed the lowest bank efficiency levels. Furthermore, they found some evidence of scale inefficiencies in the Austrian, German and American banking systems and almost no trace of scale inefficiency in France and in the UK.

Allen and Rai (1996) applied both a stochastic frontier approach and a Distribution Free model to a sample of 194 banks across 14 OECD countries (including 9 EU countries) for the period 1988-1992. Their results suggested that input inefficiencies outweigh output inefficiencies; furthermore large banks, in countries that prohibit the functional integration of commercial and investment banking, had the largest measure of input inefficiency, amounting to 27.5 per cent of total costs.

The European Commission (1997a) study, using banks' balance sheet and income statement data from 1987 to 1994, estimated a pooled time-series cost frontier for all the main EU banking sectors. Overall, the study found X-inefficiencies for most EU banking markets of around 20%. Results for individual countries, calculated from the pooled EU estimates, showed that Luxembourg banks appeared to be relatively more efficient (0.88) than their counterparts in other banking systems. Average inefficiency levels appeared to be around 25% in the major banking markets. Furthermore, results for the EU banking system estimates showed that bank inefficiency levels, on average, fell between 1990 and 1994. Overall, the individual country estimates suggested that there had been no systematic impact on X-efficiency levels across European banking sectors since the implementation of the SMP. However, pooled EU estimates of bank inefficiency levels showed, on average, a decrease between 1990 and 1994, suggesting a move towards the EU cost efficiency frontier.

Pastor *et al.* (1997) extended the cross-country efficiency comparison by defining a common frontier that incorporated various country-specific environmental conditions. This common frontier is built under the assumption that the environment is likely to differ more across countries than the banking technology. They tried to verify this assumption by evaluating DEA efficiency scores for each European country from a common frontier with and without environmental variables. Pastor *et al.*'s (1997) results showed that when the common frontier is defined without environmental variables, the average efficiency scores were lower than when these variables were considered. Overall, they distinguished three groups: (*i*) Denmark, Spain, Germany, Luxembourg and France showed average bank efficiency scores between 1.00 and 0.88; (*ii*) the Netherlands, Belgium, the UK and Portugal presented average bank efficiency scores between 0.69 and 0.56 while (*iii*) Italy showed the lowest average banks efficiency level (0.35).

Dietsch and Weill (1998) used unconsolidated accounting data of 661 commercial, mutual and savings banks from 11 EU countries between 1992 and 1996, to estimate cost efficiency and productivity change, as well as profit efficiency. The results of the study showed an increase in both cost and profit efficiency over the period; however, this trend was not observed in each country of the sample, with France, Italy, Luxembourg and the UK showing a decreasing cost efficiency level. Productivity results showed an increase in total productivity, mainly due to positive technical progress. Overall, they concluded that European integration had a low positive effect on banking efficiency until 1996.

Altunbas *et al.* (1999) applied a Fourier Flexible functional form and stochastic cost frontier methodologies to estimate scale economies, X-inefficiencies and technical change for a large sample of European banks between 1988 and 1995. The country estimates revealed that the relative inefficiency of various banking markets (Austria, Denmark, Finland, Italy and the UK) have increased over time. On average, X-inefficiencies appeared to be around 25 per cent and more variable across different markets, banks sizes and over time than the scale economy estimates.

Maudos *et al.* (1999) analysed cost and profit efficiency for a sample of banks of 11 EU countries, for the period 1993–1996, taking into account the importance of firms' specialisation in the measurement of efficiency. Using cluster analysis techniques to group banks according to specialisation, they found that both cost efficiency and, to a lesser extent, profit efficiency increase when separate frontiers are estimated for each cluster, instead of using a common frontier for the whole EU banking system. According to their results, the average cost efficiency value obtained for the whole sample is 0.44 compared with 0.74 when estimated using separate frontiers. Maudos *et al.* (1999) concluded that product mix differences are important in explaining EU bank efficiency.

Overall, these cross-country comparisons use a range of competing methodologies and report mixed results. For these reasons (as well as others), Berger and Humphrey (1997, p. 17) noted that there is a clear need for more work in this area, since cross-country studies can provide valuable information regarding the competitiveness of banks in different countries. This is a concern of particular importance in the increasingly harmonised European market for banking services. While much of the recent US literature [for example, Mester (1996), Berger and Mester (1997), Berger and De Young (1997)] use parametric techniques, most of the aforementioned European studies use non-parametric techniques, such as DEA, to estimate efficiency in banking markets. This study, therefore, chooses to use the non-parametric methodologies (DEA and FDH) to estimate the productive efficiency of the main European banking markets.

Table 4.1: Review of US Studies on X-Efficiency

Author	Year	Data	Model	Findings
◊ Sherman and Gold	1985	Data on a savings bank branch with 14 branch offices for 1982	DEA	DEA identified 6 of the 14 banks to be relatively inefficient, with an average efficiency of the sample equal to 0.96.
◊ Parkan	1987	Data on 35 branches of a major Canadian bank	DEA	DEA identified 11 of the 35 branches to be relatively inefficient
◊ Rangan, Grabowski, Aly and Pasurka	1988	Data on 215 independent banks	DEA	The average value of efficiency for the sample was 0.70.
◊ Elyasiani and Mehdian	1990(a)	Data on a random sample of 144 US banks for the period 1980-85	DEA	The average value of efficiency of the sample was 0.90.
◊ Elyasiani and Mehdian	1990(b)	Data on a sample of 191 large US banks for the period 1980-85	DEA	The average value of efficiency of the sample was 0.88, revealing an inward shift of the frontier due to technological advancement.
◊ Aly, Grabowski, Pasurka and Rangan	1990	Data on a sample of 322 independent banks from the call Reports for 1996	DEA	The results indicated a low level of overall inefficiency, which was more technical (0.75) rather than allocative (0.81)
◊ Ferrier and Lovell	1990	Data on 575 banks for 1984	DEA&SFA	Overall inefficiency was 21% according to DEA and 26% according to SFA
◊ Berger and Humphrey	1991	Data on US banks for 1984	TFA	The authors suggested that their efficiency results (0.81) showed operational inefficiencies.
◊ Yue	1992	Data on 60 Missouri banks for the period 1984-90.	DEA	Overall efficiency of 0.8; it appeared that scale inefficiency was not a major source of inefficiency.

Table 4.1: Review of US Studies on X-Efficiency (continued)

Author	Year	Data	Model	Findings
◊ Bauer, Berger and Humphrey	1993	Panel data on 683 large US branching state banks for the period 1977-88.	SFA&TFA	The average efficiency of the sample was 0.87; the levels of efficiency were found to be reasonably consistent between the two approaches and over time.
◊ Berger, Hancock and Humphrey	1993	Data on US commercial banks from the Call Reports for the period 1984-89.	DFA	Inefficiencies in US banks appear to be quite large (0.52 small banks; 0.65 medium banks; 0.66 large banks); larger banks appear to be substantially more efficient than smaller banks.
◊ Kaparakis, Miller and Noulas	1994	Data on 5,548 banks with assets over $50 million, for 1986.	SFA	Overall estimated inefficiency amounted to 10%
◊ Berger, Leusner and Mingo	1994	Data on 760 branches of an anonymous US bank over the period 1989-91.	DFA	Total efficiency averages 0.90 and 0.66 for the intermediation and the production approaches.
◊ Wheelock and Wilson	1994	Data on 269 banks participating to the FCA program for 1993	DEA	Results show considerable inefficiencies among banks in the sample (around 50%).
◊ Hunter and Timme	1995	Data on 317 banks with assets over $1 billion, over the period 1985-1990.	DFA	Overall inefficiencies in the range of 23%-36%.
◊ Kwan and Eisenbeis	1995	Data on 254 bank holding companies, based on semi-annual data from 1986 to 1991	SFA	The average small size firm is found to be relatively less efficient (0.81) than their larger counterpart (0.92). The average X-inefficiency appears to be declining over time.

Table 4.1: Review of US Studies on X-Efficiency (continued)

Author	Year	Data	Model	Findings
◊ Spong, Sullivan and DeYoung	1996	Data on 143 state banks for 1994.	SFA	The average bank in the least efficient group has an efficiency index of 0.71 while the average efficiency index for a bank in the most efficient group is 0.94.
◊ Berger and DeYoung	1997	Data on US commercial banks over the period 1985-94.	SFA	Overall average efficiency of 0.92, over the entire sample period.
◊ Berger and Mester	1997	Data on 6,000 US commercial banks over the period 1990-1995.	DFA	Failure to account for the equity position of a bank makes large banks appear to be more efficient than small banks.
◊ Thompson, Brinkmann, Dharmapala, Gonzalez-Lima and Thrall	1997	Data on a panel of the US's 100 largest banks in asset size over the period 1986-91.	DEA/AR	High levels of inefficiency were found: 0.81; 0.71; 0.61; 0.62; 0.57 and 0.65 for the years of analysis.
◊ Bhattacharyya, Lovell and Sahay	1997	Data on 70 Indian commercial banks over the period 1986-91.	DEA	Overall efficiency of 0,80; publicly owned banks seem to be more efficient (0.87) than their privately owned (0.75) and foreign-owned (0.75) counterparts.
◊ Taylor, Thompson, Thrall and Dharmapala	1997	Data on 13 Mexican commercial banks over the period 1989-91	DEA/AR	The average efficiency is 0.75, 0.72 and 0.69 for the 3 years of analysis.
◊ Humphrey and Pulley	1997	Data on a panel of 683 US banks, all having assets over $100 million in 1988 dollars. Three time periods: 1977-80; 1981-84; 1985-88.	TFA	Overall average efficiency of 0.81; 0.82; 0.85 respectively in the three time periods. Apparently, deregulation brought about an improved business environment.

Table 4.1: Review of US Studies on X-Efficiency (continued)

Author	Year	Data	Model	Findings
◊ Brockett, Charnes, Cooper, Huang and Sun	1997	Data on the 16 largest banks in Texas over the period 1984-85.	DEA/AR	Overall average efficiency scores of 0.97 both in 1984 and 1985 for the CCR DEA and 0.91 for 1984 and 0.89 for 1985 for the cone ratio DEA model.
◊ Schaffinit, Rosen and Paradi	1997	Data on 291 Ontario based branches of a large Canadian bank, subdivided in 4 groups according to size for 1993.	DEA/AR	Overall average efficiency for the basic DEA model of 0.72 and of 0.54 for refined DEA model

Table 4.2: Review of European Studies on X-Efficiency

Author	Year	Data	Model	Findings
◊ Vassiloglou and Giolias (Greece)	1990	Data on 20 Greek bank branches located in the vicinity of Athens	DEA	Average annual efficiency estimate of 0.91.
◊ Drake and Howcroft (UK)	1993	Data on a sample of 190 branches drawn from one of the six largest UK clearing banks.	DEA	Overall average efficiency of 0.92, although there is considerable diversity across branches (St. deviation equal to 0.505).
◊ Berg, Claussen and Forsund (Norway)	1993	Data on 763 banks for the year 1990, of which 502 Finnish, 141 Norwegian and 120 Swedish.	DEA+ Malmquist Index	Overall average efficiency of 0.58 for Finland, 0.78 for Norway and 0.89 for Sweden.
◊ Berg, Forsund, Hjalmarsson and Suominen (Norway)	1993	Data on 503 Finnish, 126 Swedish and 150 Norwegian banks for the year 1990.	DEA	Overall average efficiency of 0.53 for Finland, 0.57 for Norway and 0.78 for Sweden.
◊ Tulkens (Belgium)	1993	Data on 773 branches of a large publicly owned Belgian bank for the month of January 1987.	FDH	Out of the total of 773 branches, 136 are found to be inefficient; inefficiency seems be more frequent in small branches than in large ones. Average efficiency appears to be quite high (0.97) due to the large percentage of observation that are 100% efficient.
◊ Altunbas, Molyneux and DiSalvo (Italy)	1994	Data on 516, 452, 483 Italian credit co-operative banks for the years 1990, 1991 and 1992 respectively.	SFA	The mean inefficiency score was 13.1% in 1990; 15.9% in 1991 and 17% in 1992.
◊ Grifell-Tatjé and Lovell (Spain)	1995(b)	Data on nearly all Spanish savings banks over the period 1986-91.	DEA+ Malmquist Index	Overall average efficiency of 0.78, 0.78, 0.79, 0.83, 0.83 and 0.83 for the five years of investigation. Average Malmquist Index 0.97.

Table 4.2: Review of European Studies on X-Efficiency (continued)

Author	Year	Data	Model	Findings
◊ Grifell-Tatjé and Lovell (Spain)	1995(c)	Data on nearly all Spanish savings banks over the period 1986-91.	DEA+ Malmquist Index	Overall average efficiency of 0.75, 0.74, 0.75, 0.80, 0.77, 0.80 for the five years of investigation. Average Malmquist Index 0.945.
◊ Berg, Førsund and Bukh (Norway)	1995	Data on 714 banks of 4 Nordic countries for 1993.	DEA	Largest Danish and Swedish banks are the most efficient.
◊ Maudos, Pastor and Quesada (Spain)	1995	Data on a panel of Spanish savings banks over the period 1985-94.	SFA	The estimated average impact of technical change of average costs corresponds to an annual rate of 68%.
◊ Pastor, Perez and Quesada (Spain)	1995	Data on 168 US, 45 Austrian, 59 Spanish, 22 Germans, 18 UK, 31 Italian, 17 Belgian and 67 French banks for 1992.	DEA+ Malmquist Index	Overall weighted average efficiency estimates of 0.81 for the US, 0.89 for Spain, 0.93 for Germany, 0.92 for Italy, 0.92 for Austria, 0.54 for the UK, 0.95 for France and 0.92 for Belgium.
◊ Favero e Papi (Italy)	1995	Data on a sample of 174 Italian banks for 1991	DEA	Overall average efficiency equal to 0.96 for the production approach and 0.95 for the intermediation approach.
◊ Allen and Rai (Italy)	1996	Data on 194 banks from 11 OECD countries (9 EU countries) for the periods 1988 – 1992.	DFA&SFA	Prevalence of cost inefficiencies on diseconomies of scale and scope. Input inefficiency amounting to 27.5% of total costs.
◊ Resti (Italy)	1997	Data on a panel of 270 Italian banks over the period 1988-92.	SFA&DEA	Overall average efficiency of 0.69 for the SFA and 0.74 for the DEA model.

Table 4.2: Review of European Studies on X-Efficiency (continued)

Author	Year	Data	Model	Findings
◊ European Commission	1997	Balance sheet and income statement data from 1987(295 banks) to 1994 (1451 banks), obtained from the IBCA Bankscope database for 10 EU countries	SFA&DEA	Average efficiency levels in the EU of 0.72, 0.71, 0.73, 0.75, 0.77 respectively for the 5 years under investigation, according to the SFA. According to the DEA, average efficiency levels are decreasing from 0.96 in 1990 to 0.93 in 1994.
◊ Pastor, Lozano and Pastor (Spain)	1997	Data for 1993 for 24 Belgian, 29 Danish, 150 French, 203 German, 26 Italian, 68 Luxemburgian, 22 Dutch, 17 Portuguese, 28 Spanish and 45 British banks.	DEA	Average efficiency scores: 0.78 for Belgium, 0.71 for Denmark, 0.37 for France, 0.51 for Germany, 0.85 for Italy, 0.59 for Luxembourg, 0.71 for the Netherlands, 0.85 for Portugal, 0.82 for Spain and 0.56 for the UK.
◊ Lovell and Pastor (Spain)	1997	Data on 545 branch offices of a large anonymous Spanish bank for the first semester of 1995.	DEA	Overall average efficiency of 0.92, 60 bank branches out of 545 were found efficient.
◊ Athanassopoulos (Greece)	1997	Data on a sample of 68 commercial branches of a large bank in Greece.	DEA	The efficiency of the bank branches was estimated equal to 0.90.
◊ Casu and Girardone (Italy)	1998	Data on 32 banking groups and 78 bank parent companies and subsidiaries for the year 1995	DEA&SFA	SFA efficiency estimates equal to 0.927 for banking groups and 0.947 for bank parent companies and subsidiaries; DEA efficiency estimates equal to 0.887 for banking groups and 0.903 for bank parent companies and subsidiaries.

Table 4.2: Review of European Studies on X-Efficiency (continued)

Author	Year	Data	Model	Findings
◊ Maudos, Pastor, Pérez and Quesada (Spain)	1998	Data on 879 European banking firms over the period 1993-96.	DFA	The results at 5% level truncation show a level of cost efficiency of 0.91 for the average of the 11 EU countries considered.
◊ Dietsch and Weill	1998	Data on 661 commercial, mutual and savings banks form 11 EU countries for the period 1992 – 1996.	DEA + Malmquist + Profit Efficiency	The results showed an increase in both cost and profit efficiency over the period. Increase in total productivity mainly due to positive technical progress.
◊ Altunbas, Gardener, Molyneux and Moore	1999	Data for a sample of European banks for the period 1988 – 1995.	Fourier Flexible	The country estimates show that the relative inefficiency of various banking markets has increased over time, averaging around 25% of total costs.
◊ Maudos, Pastor, Pérez and Quesada	1999	Data for a sample of banks (879 banks) form 11 EU countries for the period 1993 – 1996.	Cost and Profit translog functions	Average cost efficiency value obtained for the whole sample equal to 0.44: this value is increasing to 0.74 when bank specialisation is taken into account.

Table 4.2: Review of European Studies on X-Efficiency (continued)

Author	Year	Data	Model	Findings
◊ Maudos, Pastor, Pérez and Quesada (Spain)	1998	Data on 879 European banking firms over the period 1993-96.	DFA	The results at 5% level truncation show a level of cost efficiency of 0.91 for the average of the 11 EU countries considered.
◊ Dietsch and Weill	1998	Data on 661 commercial, mutual and savings banks form 11 EU countries for the period 1992 – 1996.	DEA + Malmquist + Profit Efficiency	The results showed an increase in both cost and profit efficiency over the period. Increase in total productivity mainly due to positive technical progress.
◊ Altunbas, Gardener, Molyneux and Moore	1999	Data for a sample of European banks for the period 1988 – 1995.	Fourier Flexible	The country estimates show that the relative inefficiency of various banking markets has increased over time, averaging around 25% of total costs.
◊ Maudos, Pastor, Pérez and Quesada	1999	Data for a sample of banks (879 banks) form 11 EU countries for the period 1993 – 1996.	Cost and Profit translog functions	Average cost efficiency value obtained for the whole sample equal to 0.44: this value is increasing to 0.74 when bank specialisation is taken into account.

4.4 Conclusions

This chapter reviewed the main results of the literature on cost efficiency in banking. This review covers a 30 year period, illustrating the evolution of the research, from the initial, relatively simplistic attempts to the increasingly sophisticated econometric techniques developed in recent years. While the previous literature concentrated mainly on the estimation of scale and scope efficiency, more recent literature has focused on frontier efficiency estimation, that is the empirical evaluation of how close financial institutions are to a 'best practice' frontier. The efficiency literature employs five major different efficiency techniques, three parametric, SFA; DFA, TFA, and two non-parametric, DEA and FDH.

To date, there is a virtual consensus in the literature that differences in frontier efficiency among financial institutions exceed differences attributable to incorrect scale or scope; nevertheless there is still no consensus as to the best method for estimating the best-practice frontier. The variety of parametric and non-parametric approaches which have recently been developed do not achieve consistent results, suggesting, therefore, that despite the conspicuous number of studies recently published on cost efficiency in banking, there is still a need for further research. Two main directions are being currently followed. For the parametric techniques the new developments include the specification of more globally flexible functional forms, the use of less restrictive assumptions on the distribution of inefficiencies, and the measurement of confidence intervals. For the non-parametric approaches, these improvements include finding a statistical basis for the non-stochastic approaches, resampling techniques to take into account some of the random error in the data and, as well, the measurement of confidence intervals.

This thesis aims to address some of the issues that are the focus of the current literature. In particular, the remainder of this thesis estimates the relative efficiency of five main European countries, by implementing two non-parametric approaches, DEA and FDH. In addition, the productivity change across banking markets is calculated using the Malmquist Productivity Index (MPI). The determinants of European bank efficiency are also evaluated by using the Tobit regression model approach to investigate the influence of various country-specific and environmental factors on bank efficiency. In addition, this thesis aims to investigate the stability of efficiency scores over time with standard non-frontier approaches, such as financial ratios.

The following Chapter 5 illustrates the methodological approaches used to estimate European bank efficiency and its possible determinants.

5 Data and Methodology

Although there have been a number of international comparisons of banks' efficiency, [see Berg *et al.* (1993); Fecher and Pestieau (1993); Berg *et al.* (1995); Bergendhal (1995); Allen and Rai (1996); Pastor, Pérez and Quesada (1997); Pastor, Lozano and Pastor (1997); European Commission (1997); Dietsch and Weill (1998); Maudos *et al* (1999)][1] the need for further research in this area has been highlighted by a recent survey undertaken by Berger and Humphrey (1997). This need is particularly pressing in the light of relevant changes in the regulation of financial systems, especially in Europe, where structural deregulation (structure and conduct rules) has been a major feature of the EU Single Market Programme and of the evolution of the European Economic and Monetary Union (EMU).

This thesis aims to investigate whether the productive efficiency of the European banking systems has improved since the creation of the Single Market Programme. This chapter examines the main European banking markets between 1993 and 1997 to investigate whether there has been an increase and a convergence of efficiency levels following the process of legislative harmonisation. Non-parametric estimation techniques, in the form of Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) approaches are applied in order to evaluate the relative efficiency of European banking. This choice has been motivated by the fact that non-parametric approaches permit efficiency to vary over time and make no prior assumptions regarding the form of distribution of inefficiencies across observations.

[1] See Section 4.3.5 for a detailed literature review on this issue.

These characteristics have attracted most researchers dealing with the issue of cross-country efficiency comparisons [see, among others, Berg *et al.* (1993); Pastor, Pérez and Quesada (1995); Pastor; Lozano and Pastor (1997); Dietsch and Weill (1998); Maudos *et al.* (1999)]. In addition, productivity change across banking markets using the Malmquist Productivity Index (MPI) was calculated. In addition, this study also evaluates the determinants of European bank efficiency by using the Tobit regression model approach to investigate the influence of various country-specific and environmental factors on bank efficiency. To overcome the problem of the inherent dependency of DEA efficiency scores when used in regression analysis a bootstrapping technique is applied.

This chapter identifies the sample used in the research and examines in some detail the methodological approaches followed in the empirical analysis.

5.1 Definition of the Sample and Data Sources

This study examines bank efficiency in the following countries: France, Germany, Italy, Spain and the United Kingdom. The choice of the above markets is based as much on their relative economic weight inside the EU as on the size of their respective banking sectors[2]. The time span considered is from 1993 to 1997; that is following the implementation of the Single Market Programme (SMP).

A sample of 750 banks from the above countries, (the largest 150 banks by asset size in each respective country) was drawn from the London-based International Bank Credit Analysis (IBCA) 'Bankscope' database. The subsidiaries of foreign banks, the specialised financial institutions and the central institutions were then excluded from the sample.

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[2] In 1998, the total assets of the banking sectors of France, Germany, Italy, Spain and the UK amounted to $16,530 billion, representing nearly 80% of the total assets of the banking sector of the European Union as a whole ($20,717)(Banca d'Italia, Annual Report, 1998).

Furthermore, given the need for comparable data from different countries, 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 removed from the sample. The result is a pooled sample of 530 banks. The data were extracted from non-consolidated income statement and balance sheet data corresponding to the years 1993-97. All data are reported in ECU as the reference currency; they are in real 1997 terms and have been converted using individual country GDP deflators[3].

Table 5.1 gives details about the composition of the sample in each year of investigation and Table 5.2 illustrates the composition of the sample according to bank specialisation. The different number of banks in each year was thought of as reflecting the changes that occurred in the banking systems over time[4].

Table 5.1: Composition of the Sample (by year)

	1993	1994	1995	1996	1997	Total n. of observations
France	94	102	103	101	93	493
Germany	107	107	111	111	99	535
Italy	111	115	112	109	77	524
Spain	90	91	91	111	94	477
United Kingdom	68	69	66	67	61	331
Euro5	470	484	484	499	424	2360

Table 5.2: Composition of the Sample (by bank specialisation)

	Commercial banks	Savings banks	Co-operative banks	Real estate mortgage banks	Total n. of observations
France	41	16	55	-	112
Germany	24	65	11	12	112
Italy	38	40	38	-	116
Spain	40	50	26	-	116
United Kingdom	12	-	-	62	74

[3] To convert values in local currencies into a common currency it is possible to use either the official exchange rate or the purchasing power parity (PPP) rate as computed by the OECD; the two approaches seem to yield very similar results [Berg *et al.* (1993)].

[4] The sample will be later reorganised in the form of a balanced panel in order to estimate the Malmquist Productivity Index.

Table 5.3 shows some descriptive statistics relating to the sample, for 1997. Differences in the average size of banks are substantial (the average total assets size of UK banks is more than double that of Italian banks and nearly four times that of Spanish banks). Moreover, the average size of commercial banks is nearly five times bigger than that of their savings bank, co-operative bank and real estate bank counterparts. These large discrepancies across countries can be thought of reflecting the legacy of different banking regulations [Dietsch and Weill (1998)].

Table 5.3: Descriptive Statistics

				Size (total assets) in mil ECU, 1997				
COUNTRY	**N. OF BANKS**	**MEAN**	**MED.**	**ST.DEV.**	**MIN**	**MAX**	**Q1**	**Q3**
France	112	14,657	3,890	43,014	1,585	310,669	2,906	6,448
Germany	112	16,562	4,660	45,104	2,560	376,349	3,230	9,390
Italy	116	9,926	2,567	19,416	872	109,076	1,537	7,071
Spain	116	5,962	1,784	13,190	283	81,986	782	4,245
U.K.	74	21,919	2,158	53,227	46	335,632	321	16,795
Euro5	530	13,136	3,264	36,785	46	376,349	1,719	7,062
BANK TYPE	**N. OF BANKS**	**MEAN**	**MED.**	**ST.DEV.**	**MIN**	**MAX**	**Q1**	**Q3**
Commercial	155	30,367	5,983	61,748	312	376,349	2,172	24,798
Savings & Others	375	6,014	3,037	13,041	46	170,432	1,512	5,359

5.2 Input and Output Definition

In the present international setting, the need for comparable data from different countries imposes strong restrictions on variables one is able to use, not least because of the various accounting criteria used in the five countries under investigation. To minimise possible bias arising from different accounting practices the broad definition of variables as presented by IBCA Bankscope [5] was chosen.

[5] Pastor, Pérez and Quesada (1995) followed the same approach.

As reviewed in Chapter 4, one of the main problems faced by researchers investigating banks' cost efficiency relates to difficulties in the definition and measurement of the concept of bank output, mainly as a result of the nature and functions of financial intermediaries. The most debated issue regards the role of deposits: on the one hand, it is argued that they are an input to the production process (*intermediation and asset approach*); on the other hand, it is suggested that deposits are an output (*production approach*), involving the creation of value added, and for which customers bear an opportunity cost (*value added approach, user cost approach*).

Even today, there is no all-encompassing theory of the banking firm: in particular, there is no agreement on the explicit definition and measurement of banks' inputs and outputs. Berger and Humphrey (1997) pointed out that, although there is no 'perfect approach', the intermediation approach may be more appropriate for evaluating entire financial institutions because this approach is inclusive of interest expenses, which often account for one-half to two-thirds of total costs. Moreover, the intermediation approach may be superior for evaluating the importance of frontier efficiency to the profitability of financial institutions, since the minimisation of total costs, not just production costs, is needed to maximise profits.

Following the modern empirical literature [see, among others, Molyneux *et al.*, (1996); Mester (1996)], we use the intermediation approach, which views financial institutions as mediators between the supply and the demand of funds. The main consequence of the intermediation approach is that deposits are considered as inputs, and interest on deposits is a component of total costs, together with labour and capital. Accordingly, this study employs two outputs: y_1= total loans, y_2 = other earning assets; and two inputs: x_1 = total costs (interest expenses, non-interest expenses, personnel expenses), x_2 = total customers and short term funding (total deposits).
Table 5.4 shows descriptive statistics of our input and output variables[6].

[6] Descriptive statistics relative to input and output variables for all the years of observation can be found in Appendix 3.

Table 5.4: Descriptive Statistics of Input and Output Variables (mil ECU, 1997)

	MEAN	MED.	ST.DEV.	MIN	MAX	Q1	Q3
FRANCE							
Total A	6,552	2,507	17,801	175	107,989	1,551	3,634
Total B	8,602	1,534	25,066	225	172,325	716	3,873
Total G	13,314	3,879	36,482	1,496	240,126	2,687	6,280
Total C	1,094	311	3,019	79	17,548	208	472
GERMANY							
Total A	10,073	2,968	25,403	620	190,298	2,065	6,115
Total B	7,938	1,973	22,546	583	179,693	1,281	3,775
Total G	14,393	4,516	40,819	1,243	347,244	2,974	8,181
Total C	993	304	2,478	129	18,925	209	742
ITALY							
Total A	5,940	1,475	10,375	332	51,244	842	5,448
Total B	5,225	1,555	8,759	295	44,535	780	4,871
Total G	8,985	2,249	15,462	481	75,305	1,342	8,021
Total C	931	255	1,597	85	8,206	154	836
SPAIN							
Total A	3,406	1,394	5,938	26	30,959	557	3,039
Total B	3,344	921	7,656	38	45,746	375	2,801
Total G	6,339	2,382	12,449	279	75,036	915	5,713
Total C	467	163	936	20	4,854	68	381
U.K.							
Total A	15,755	760	34,442	34	149,811	258	7,634
Total B	8,198	163	24,305	9	149,442	60	2,067
Total G	21,531	973	49,171	48	255,796	338	12,193
Total C	1,798	46	4,121	3	18,717	17	739

NOTE: Total A = Total Assets; Total B = Total Other Earning Assets, Total G = Total Customers and Short Term Funding (Deposits); Total C = Total Costs (Interest Expenses + Non-Interest Expenses + Personnel Expenses).

The average values of inputs and outputs for banks of the five EU countries essentially depict the differences in average size of banks, as shown in the analysis of the average value of assets (table 5.3), but they also reflect differences in banking practice in the various countries.

5.3 Estimation Techniques

The techniques employed in this study to estimate the productive efficiency of the main European banking systems are non-parametric: they include Data Envelopment Analysis (DEA) and its relative, the Free Disposal Hull (FDH) approach.

The choice of implementing non-parametric methodologies for the estimation of European bank efficiencies is related to the fact that DEA (and FDH) approaches do not require the specification of a predetermined functional form, as the parametric approaches do, but calculate efficiencies relative to the observations in the sample. As noted in Chapter 4, most European studies investigating the issue of cross-country efficiency comparisons use non-parametric techniques to estimate and compare efficiency levels in banking markets.

The efficiency estimates obtained from the aforementioned non-parametric approaches express the relative efficiency at a given point in time. In order to estimate changes over time, productivity change using the Malmquist Productivity Index (MPI) is calculated. Sections 5.3.1, 5.3.2 and 5.3.3 introduce the DEA, FDH and MPI techniques respectively, providing some relevant technical detail.

Although the basic DEA models have been improved in a number of ways in recent years [see Lovell (1993) and Seiford (1996)], one of the main criticisms faced by researchers using non-parametric methods is the difficulty of drawing statistical inference. The more recent literature, however, has sought ways to overcome this problem [see Grosskopf (1996)]. One of the first tools employed to this end was regression analysis. The basic idea of what has become known as the "Two-Step" procedure is to treat the efficiency scores as data or indices and use linear regression to explain the variation of these efficiency scores. The first improvement to this model has come with the attempt to account for the fact that efficiency scores are censored [Lovell, Walters and Wood (1995)]; as a result, a model that accounted for the fact that the dependent variable was limited became preferred to OLS.

Section 5.4.1 describes the two-steps procedure implemented in this study. A new conceptual issue has recently been raised by Xue and Harker (1999): they point out that efficiency scores generated by DEA models are clearly dependent on each other in the statistical sense. The reason for dependency is the well-known fact that the DEA efficiency score is a relative efficiency index, not an absolute efficiency index. Because of the presence of the inherent dependency among efficiency scores, one basic model assumption required by regression analysis, independence within the sample, is violated. As a result, the conventional procedure, followed in the literature, is invalid. Xue and Harker (1999) propose a bootstrap method to overcome this problem. An introduction to the bootstrap methodology is offered in Section 5.4.2 and a review of its applications in a DEA/FDH framework are discussed in Section 5.4.3. Section 5.5 concludes this review of the methodological issues relevant to the study.

5.3.1 Data Envelopment Analysis (DEA)

The approach to frontier estimation proposed by Farrell (1957) was not given much detailed empirical attention for about two decades, until a study by Charnes, Cooper and Rhodes (CCR) (1978), in which the term Data Envelopment Analysis (DEA) was first used. Since then there has been a large number of papers which have extended and applied the methodology[7].

[7] See Lovell (1993) and Seiford (1996) for extensive bibliographies of this literature.

Data Envelopment Analysis (DEA) is a mathematical programming approach[8] for the construction of 'best practice' production frontiers and the measurement of efficiency relative to the constructed frontiers. DEA is based on a concept of efficiency very similar to the microeconomic one; the main difference is that the DEA production frontier is not determined by some specific functional form, but it is generated from the actual data for the evaluated firms. In other words, the DEA frontier is formed as the piecewise linear combination that connect the set of 'best-practice observations', yielding a convex production possibility set (PPS). As a consequence, the DEA efficiency score for a specific firm (or Decision-Making Unit, DMU) is not defined by an absolute standard, but it is defined relative to the other firms into consideration. This feature differentiates DEA from the parametric approaches, which require a specific pre-specified functional form of the modelled production or cost function. DEA has been applied to the banking industry of different countries; a review of the relevant literature on this subject was presented in Chapter 4.

5.3.1.1 Constant Returns to Scale

In their original paper, Charnes, Cooper and Rhodes (1978) proposed a model that had an input orientation and assumed constant return to scale (CRS). Later studies have considered alternative sets of assumptions. The assumption of variable returns to scale (VRS) was first introduced by Banker, Charnes and Cooper (1984).

[8] In this study, the linear programming problems are solved by using the DEAP Version 2.1 Computer Programme, by Tim Coelli. The terminology adopted is the standard terminology, as can be found in Charnes *et al.* (1978). All references to 'A Guide to DEAP 2.1: A Data Envelopment Analysis (Computer) Programme' are here acknowledged.

Let us introduce some notations. Assume there are K inputs and M outputs for each of N firms. For the i-th firm, these are represented by the column of vectors x_i and y_i respectively. The KxN input matrix, X, and MxN output matrix, Y, represent the data for all N firms.

The purpose of DEA is to construct a non-parametric envelopment frontier over the data points such that all observed points lie on or below the production frontier. Efficiency is defined and measured as the distance from the computed best practice frontier; the shape of the DEA production frontier is not pre-specified as a particular functional form, but is generated from the actual data for the evaluated firms. As a consequence, the DEA efficiency score for a specific firm (or Decision Making Unit, DMU) is not defined by an absolute standard, but it is defined relative to the other firms in that particular data set.

A simple graphical example will be useful to better illustrate this important concept. Consider a sample composed of six firms, which are using a single input to produce a single output. Let us denote:

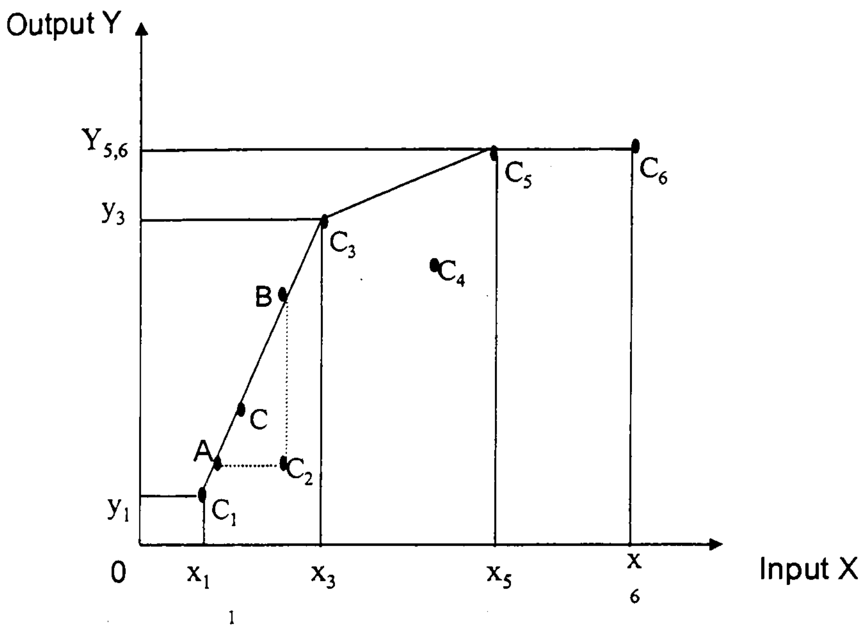
x_i (i=1,2, ...,6) the inputs and
y_i (i=1,2, ...,6) the outputs.

Let us call the input-output combinations:

C_s (s=1,2,...,6)

The production frontier is generated by the input-output combinations for the firms 1, 3, 5 and 6, and the efficient portion of the production frontier is shown by the connected segments. C2 and C4 are DEA inefficient since they lie inside the frontier and C6 is inefficient because the same output can be produced with less input. The piecewise linear form of the non-parametric frontier can cause measurement problems in those sections of the frontier that run parallel to the axes. This problem is known as *input* *slack* in the literature[9].

Figure 5.1: DEA Production Frontier



Source: Yue (1992, Figure 1, p.34)

As shown in the example in figure 5.1, C2 can become efficient by rising to some point on the C1-C3 facet. In this example, it could move either to A by using fewer inputs or to B by producing more output, or to any point C (A<C<B) by both reducing inputs and increasing outputs. Within this context, it is important to point out that the fundamental assumption underlying this model is that linear combinations of efficient firms are in fact feasible.

[9] The problems of *slacks* is not a trivial one and the literature has suggested several solutions [see Coelli *et al.* (1998), p. 175]. This study employs the Multi-stage DEA approach, as proposed by Coelli (1996).

Consider now a generic situation, with N DMUs, each of which consumes K different inputs to produce M different outputs. For each DMU we would like to obtain a measure of the ratio of all outputs over all inputs, such as $u'y_i/v'x_i$, where u is an Mx1 vector of outputs weights and v is a Kx1 vector of input weights. To select the optimal weights, we specify the following mathematical problem:

$$\max_{u,v}\left(u'y_i/v'x_i\right) \tag{5.1}$$

$$\text{st} \quad u'y_j/v'x_j \leq 1, \qquad j=1,2,\ldots,N$$

$$u,v \geq 0$$

The solution of the problem involves finding values for u and v such that the efficiency measure of the i-th DMU is maximised, subject to the constraint that all efficiency measures must be less than or equal to one. One problem with this particular ratio formulation is that it has an infinite number of solutions. To overcome this problem, it is necessary to impose an additional set of constraints:

$$\max_{\mu,\nu}\left(\mu'y_i\right), \tag{5.2}$$

$$\text{st} \quad \nu'x_i = 1$$

$$\mu'y_j - \nu x_j' \leq 0, \qquad j=1,2,\ldots,N$$

$$\mu,\nu \geq 0$$

where the notation change from u and v to μ and ν reflects the transformation. The form in equation (5.2) is known as the *multiplier* form of the DEA linear programming problem. The μ and ν weights can be interpreted as normalised shadow prices.

Using the duality in linear programming, one can derive an equivalent envelopment form of this problem:

$$\min_{\theta,\lambda} \theta, \tag{5.3}$$

$$\begin{aligned} \text{st} \quad & -y_i + Y\lambda \geq 0 \\ & \theta x_i - X\lambda \geq 0 \\ & \lambda \geq 0 \end{aligned}$$

where θ is a scalar and λ is a Nx1 vector of constants. This envelopment form involves fewer constraints than the multiplier form and it is generally the preferred form to solve.

The value of θ obtained will be the efficiency score for the i-th firm: it will satisfy the condition θ ≤ 1, with a value of 1 indicating a point on the frontier and therefore a technically efficient firm[10].

In other words, DEA establishes a 'benchmark' efficiency score of unity that no individual observation can exceed. This benchmark is a linear combination of efficient DMUs in a sample. Efficient DMUs will receive efficiency scores of unity, while DMUs scoring less than unity are considered inefficient. The basic DEA model (CCR model) implied the assumption of constant returns to scale; this assumption was later relaxed to allow for the evaluation of variable returns to scale and scale economies.

[10] Note that the linear programming problem must be solved N times, once for each DMU: a value of θ is then obtained for each DMU.

5.3.1.2 Variable Returns to Scale

The CRS model is only appropriate when all DMUs are operating at an optimal scale. Imperfect competition, constraints on finance, etc., may cause a DMU to be not operating at optimal scale. The use of the CRS specification when all DMUs are not operating at optimal scale will result in measures of technical efficiency (TE) which are confounded by scale efficiencies (SE).

The CRS linear programming problem can be easily modified to account for VRS by adding the convexity constraint: N1'λ = 1 to equation (5.3) to provide:

$$\min_{\theta,\lambda} \theta, \tag{5.4}$$

$$\begin{aligned} \text{st} \; -y_i + Y\lambda &\geq 0 \\ \theta x_i - X\lambda &\geq 0 \\ N1'\lambda &= 1 \\ \lambda &\geq 0 \end{aligned}$$

where N1 is an Nx1 vector of ones.

This approach forms a convex hull of intersecting planes which envelope the data points more tightly than the CRS conical hull and thus provide technical efficiency scores which are greater than or equal to those obtained using the CRS model.

The VRS specification has been the most commonly used specification in the 1990s [Coelli *et al.* (1998)].

5.3.1.3 Scale Efficiencies

In addition to evaluating the productive or technical efficiency (TE) of Decision-Making Units, it is also possible to determine the amount of scale efficiency (SE)[11].

Many studies have decomposed the TE scores obtained from DEA into two components, one due to scale inefficiency and the other due to 'pure' technical inefficiency. One way of doing this is by conducting both CRS and VRS DEA upon the same data. If there is a difference in the two TE scores for a particular DMU, then this indicates that the DMU has scale inefficiency and that the scale inefficiency can be calculated from the difference between the VRS TE and the CRS TE score. This is because technical efficiency is usually measured relative to VRS production technology, while scale efficiency is evaluated relative to the CRS technology, since this latter provides a long run competitive equilibrium benchmark. Efficiency measurements relative to the CRS technology thus conflate scale and technical efficiency. Therefore, it is straightforward to define SE as the ratio of the two efficiency measures: one calculated on a CRS technology and one computed on a VRS technology (Kerstens and Vanden Eeckaut, 1999).

Figure 5.2 depicts the CRS and VRS frontiers in the case of one-input and one-output technology. Under CRS, the input-orientated technical inefficiency of the point P is the distance PP_C, while under VRS the technical inefficiency would be only PP_V. The difference between these two is put down to scale inefficiency.

$$TE_{I,\,CRS} = AP_C/AP \tag{5.5}$$

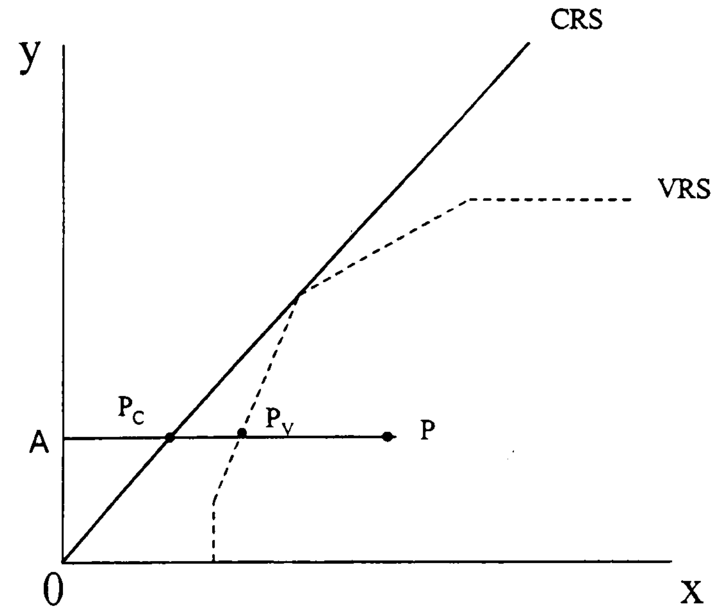
$$TE_{I,\,VRS} = AP_V/AP \tag{5.6}$$

$$SE_I = AP_C/AP_V \tag{5.7}$$

[11] Assuming that technology is represented by its Production Possibility Set T, global scale behaviour can be defined in terms of the Production Possibility Set (Färe *et al.*, 1994, p. 33):

- technology exhibits Constant Return to Scale (CRS) if $\delta T = T$, $\delta > 0$;
- technology displays Non-Increasing Return to Scale (NIRS) if $\delta T \subseteq T$, $0 < \delta \leq 1$;
- technology exhibits Non-Decreasing Returns to Scale (NDRS) if $T \subseteq \delta T$, $0 < \delta \leq 1$.

Figure 5.2: Scale Efficiencies in DEA



Source: Adapted from Coelli et al. (1998), p. 152.

The nature of the scale inefficiencies (i.e. due to increasing or decreasing return to scale) for a particular DMU can also be determined[12].

The ratio SE_I indicates the lowest possible input combination able to produce the same output in the long run as the technically efficient combination situated on the CRS technology. Since $TE_{I,\,CRS} \leq TE_{I,\,VRS}$, evidently, $0 < SE_I \leq 1$.

If $SE_I = 1$, then the technology exhibits constant return to scale at the observation under evaluation (or at its input-oriented projection point). If $SE_I < 1$, then the evaluated observation is not located (or projected) on the piecewise linear segment where constant returns to scale prevail, and it is possible to determine, for each observation, the exact nature of the returns to scale.

[12] In order to determine the nature of the scale inefficiencies it is necessary to compute the TE scores under the assumption of non-increasing return to scale (NIRS). This can be done by altering the DEA model in equation (5.4) by substituting the $N1'\lambda = 1$ restriction with $N1'\lambda \leq 1$. It is then necessary to compare the NIRS TE with the VRS TE. If they are unequal, then increasing return to scale exist for that DMU; if they are equal then decreasing return to scale apply.

Kerstens and Vanden Eeckaut (1999) review the three main traditional methods of estimating returns to scale using DEA models and they introduce a new, and more general, method to ascertain the exact source of SE relative to non-parametric deterministic production technologies. This method exploits the relationship between efficiency measures and goodness-of-fit tests, thus allowing for the possibility to apply it to a series of non-convex production models with different returns to scale assumptions, to which it is impossible to apply the traditional methods.

In this study, the amount of scale efficiency (SE) is evaluated by conducting both CRS and VRS DEA upon the same data and calculate the SE as the difference between the two TE scores for each DMU.

5.3.1.4 Input and Output Orientations

In the preceding input-orientated models, the method seeks to identify technical inefficiency as a proportional reduction in input usage. It is also possible to measure technical inefficiency as a proportional increase in output production. These two measures provide the same value under CRS but are unequal when VRS is assumed. The choice of orientation has both practical and theoretical implications. In some applications, the choice of the orientation is clear; for example, in industries where the emphasis is on cost-control, the 'natural' choice would be an input-orientation (Ferrier and Valdmanis, 1996).

Many studies have tended to select input-orientated measures because many DMUs have particular orders to fill and the input quantities appears to be the primary decision variables, although this argument may not be valid in all industries. Basically, one should select an orientation according to which quantities (inputs or outputs) the managers have most control over.

Nevertheless, some recent research has pointed out that restricting the attention to a particular orientation may neglect major sources of technical inefficiency in the other direction (Berger *et al.* 1993). To date, the theoretical literature is inconclusive as to the best choice among the alternative orientations of measurement. This study, in order to obtain a more complete picture of the relative efficiency of the main European banking systems, estimates both the input and output-oriented measures of productive efficiency. However, it is necessary to point out that output- and input-orientated models will estimate exactly the same frontier and therefore, by definition, identify the same set of efficient DMUs. It is only the efficiency measures associated with the inefficient DMUs that may differ between the two methods.

5.3.1.5 Limitations of Basic DEA models

To conclude, it is necessary to point out the limitations of the DEA methodology and some problems that may arise in conducting efficiency analysis using DEA. The principal limitations can be summarised[13] as follows:

- measurement error and other noise can influence the shape of the frontier;
- the results can be influenced by outliers;
- the exclusion of an important input or output can result in biased results;
- the efficiency scores obtained are only relative to the best firms in the sample;
- it is difficult to compare mean efficiency scores from two studies; they only reflect the dispersion of efficiencies within each sample but do not give any indication about the efficiency of a sample relative to the other;
- few observations and many inputs and/or outputs may results in an increase of the TE scores (i.e. too many DMU may result on the frontier);
- treating inputs and/or outputs as homogeneous when they are heterogeneous may bias results;
- not accounting for environmental differences may give misleading indications of relative managerial competence;

[13] See Coelli *et al.* (1998) p. 180.

- standard DEA does not account for multi-period optimisation nor risk in management decision making.

It is important to highlight that the basic DEA models (CRS and VRS) have been improved in a number of ways in recent years. A detailed review of all the different mathematical assumption underlying the extensions to the basic DEA models is outside the boundaries of this study[14]. However, it is worth mentioning some of the most well-known extensions of the basic DEA framework: the stochastic DEA models (Land, Lovell and Thore, 1993), the additive DEA model (ADEA), proposed by Charnes *et al.* (1985), the Free Disposal Hull, developed by Deprins, Simar and Tulkens (1984), the Malmquist approach of Fare *et al.* (1994) and the attempts at developing statistical inference from DEA [Banker (1996); Grosskopf (1996); Simar (1996)]. The FDH and Malmquist approaches will be discussed in some detail in Section 5.3.2 and 5.3.3 respectively.

5.3.2 Free Disposal Hull (FDH)

The introduction of the Free Disposal Hull (FDH) can be attributed to the seminal paper of Deprins, Simar and Tulkens (1984). In the paper the authors, in addition to noting the differences in efficiency estimates resulting from the two reference technologies which were standard at the time (the Cobb-Douglas production function and the convex polyhedral production set of the type used in DEA), stressed how both estimates of the technologies were characterised by an extremely bad data fit. This led the authors to use a third form of reference technology, labelled the FDH production set.

[14] See Post (1999) for a review of methodological advances in DEA.

Several other studies have been carried out with the FDH method, many of which are reported in Tulkens (1986, 1990 and 1993).

In order to introduce the FDH methodology, Tulkens (1993) recalled the fact that the production possibility set that economic theory associates with any productive activity is usually unknown. Therefore, an efficiency analyst, when constructing the reference, bases the chosen method on the relationship between the statistical observations and the elements of the constructed set. This relationship may be required to have various properties and the differences in the properties this relationship is postulated to have are at the root of the differences between the alternative reference set used, and therefore between the results obtained in the efficiency measurement literature.

Defining a production plan as any vector of input (x) and output (y) quantities and expressing the postulates in terms of the elements which are allowed to belong to a reference set, we consider the following list (Tulkens, 1993, p. 180):

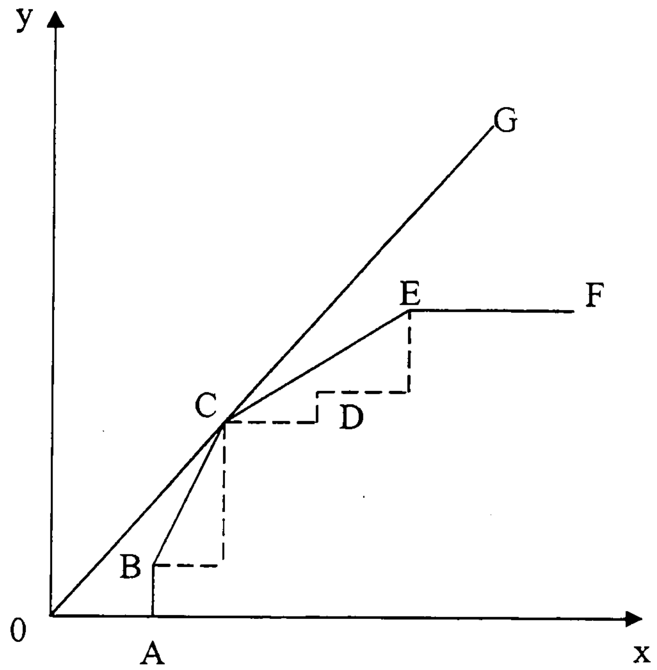
1. deterministic postulate: all the observed production plans.
2. free disposal postulate: any not observed production plan with output levels equal to or lower than those of some observed production plan and more of at least one input; or with input levels equal or higher than those of some observed production plan and less of at least one output; or still with both these properties.
3. convexity postulate: any not observed production plan that is a convex combination of some production plans induced by 1 and 2.
4. convexity and partial proportionality postulate: any not observed production plan that is a convex combination of some production plans induced by 1 and 2, or some of such plans and the origin of the input-output space.
5. full proportionality postulate: any not observed production plan that is proportional to some observed production plan induced by 1 and 2.

Postulates 1 and 2 together are sufficient to induce a reference set that has all the properties economic theory requires of a production set. As these postulates make this set to be the 'free disposal hull' of the observed plans, it will be denoted as Y_{FDH}. It should be noted that postulate 1 rules out stochastic elements, as does most of the non-parametric literature.

By adding the third postulate, one obtains the convex polyhedral reference set used in the VRS DEA model proposed by Banker, Charnes and Cooper (1984). Adding postulate 4 yields a convex polyhedron with non-increasing returns to scale (NIRS DEA). Finally, by adding postulates 1 to 5 together, the obtained reference set is the one used in the original form of DEA proposed by Charnes, Cooper and Rhodes (1978). It has the form of a cone issued from the origin of the space of input and output quantities, implying constant returns to scale (CRS).

From Figure 5.3, it is possible to note that, in the one-input one-output case, these sets appear nested in one another: Y_{FDH} (whose frontier is the staircase ABCDEF) is contained in $Y_{VRS\text{-}DEA}$ (whose piecewise linear frontier is ABCEF), which, in turn, is contained in $Y_{NIRS\text{-}DEA}$ (whose frontier is OCEF) and this latter is further contained in $Y_{CRS\text{-}DEA}$ (whose frontier is OCG).

Figure 5.3: Reference Production Sets



Source: Adapted from Tulkens (1993) p. 185.

Note that, in comparison with other methodologies, FDH makes the weakest postulates as to how the reference set is constructed. According to its authors, it is, among the four frontiers considered, the closest to the data set, due to the absence of convexity assumptions in the definition of the FDH set. Though not as popular as DEA in applied work, FDH provides an attractive basis for the evaluation of efficiency measures. The actual computation of the efficiency scores requires the solution of problems of mixed integer programming. Solutions are obtained by means of a vector comparison procedure that amounts to a complete enumeration algorithm[15].

Crucial in FDH methodology is the notion of *dominance* between observations: an observation is defined as efficient if it has the property of being *undominated* in inputs and/or in outputs, respectively, by any of the other observations (other than

[15] The algorithm of implicit enumeration to solve efficiency on FDH has been described in Tulkens (1993); Fried, Lovell and Vanden Eeckaut (1995); Lovell (1995). In this study, FDH efficiency measures are evaluated by using a programme written in GAMS by K. Kerstens of LABORES, Université Catholique de Lille, France.

checking that the resulting efficiency measures are equal to 1)[16]. In this context, efficiency appears to be a property of an observation essentially in relation to another observation rather than in relation to a predefined frontier.

Tulkens (1993) points out that, from a managerial point of view, the identification of a set of dominating observations, by showing actually implemented production plans that are clearly more efficient, gives to the inefficiency scores a credibility that that they usually lack when reference is only made to an abstract frontier.

With non-parametric methods, sensitivity to outliers increases with the strength of the postulates made in constructing the reference production set. It is therefore lowest with FDH, since the method imposes minimal assumptions.

5.3.3 Malmquist Productivity Index (MPI)

5.3.3.1 An Introduction to Index Numbers

Index numbers are the most commonly used instruments to measure changes in levels of various economic variables. The aim of this section is to provide a simple introduction to index numbers that are relevant in the context of measuring productivity changes over time and space.

It is possible to define an index number as a real number that measures changes in a set of related variables (Coelli *et al.*, 1998). Index numbers have a long and distinguished history in economics, with some of the most important contributions due to Laspeyres and Paasche, dating back more than a century. It was the work of Irving Fisher (1922) '*The Making of Index Numbers*' that recognised the possibility of using statistical formulae to derive appropriate index numbers. The Tornquvist Index, which

[16] Within a usually rather large subset of observation whose efficiency score is equal to 1, it is important to further distinguish between:
- observations which dominate some inefficient one(s); for these superiority of behaviour is hardly questionable;
- observations so-called 'efficient by default', defined by the fact that there is no other observation in the data set they dominate and their 'efficiency' label actually amounts to one of noncomparability.

dates back to 1936, still plays a major role in productivity measurements.

In terms of measuring productivity changes, index numbers are used in measuring changes in the levels of output produced and the level of input used in the production process over two times period or across two firms. This can be achieved by using a suitable formula to compute input and output quantity index numbers.

A total factor productivity (TFP) index measures changes in total output relative to the change in the usage of all inputs.

The input and output quantity index numbers, and productivity indices are all based on the ideas of Malmquist and the distance function approach outlined in Malmquist (1953)[17].

The seminal paper by Cave, Christensen and Diewert (1982b) provided the theoretical framework for the measurement of productivity and forms the basis for what has become known as the Malmquist Productivity Index (MPI) number approach.

Within a consumer context, Malmquist (1953) introduced the notion of *proportional scaling* needed of quantities observed in year t_2 to allow a consumer the same utility level as in year t_1. The proportional scaling factor was interpreted as a quantity index. Cave, Christensen and Diewert (CCD) developed the Malmquist idea into a proper productivity index. They made use of Shephard's concept of the distance function when defining proportional scaling, without noting the direct connection with Farrell's (1957) efficiency measures (Berg *et al.*, 1992). This connection has been pointed out by Färe *et al.* (1985) and follows directly from the definition of distance functions and Farrell efficiency measures.

[17] 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 Fare, Grosskopf and Lovell (1985, 1994).

Under the CCD approach, one way to measure change in productivity is to see how much more output has been produced, using a given level of inputs and the present state of technology, relative to what could be produced under a given reference technology using the same level of inputs. An alternative is to measure change in productivity by examining the reduction in input use that is feasible given the need to produce a given level of output under a reference technology. These two approaches are referred to as the *output-orientated* and *input-orientated measures* of change in productivity. This corresponds to input savings and output increasing Farrell's measures.

Malmquist index numbers can be defined using either the output-orientated or input-orientated approach.

5.3.3.2 The Malmquist TFP Index

The Malmquist index[18] is defined using distance functions. Distance functions allow us to describe a multi-input, multi-output production technology without the need to specify a behavioural objective (i.e. cost minimisation or profit maximisation). An input distance function can be defined as the function that characterises the production technology by looking at a maximal proportional contraction of the input vector, given an output vector. An output distance function considers a maximal proportional expansion of the output vector, given the input vector.

[18] All notations adopted in this section are those used by Coelli *et al.* (1998), since their computer routine for computing the Malmquist index is used in this empirical analysis. The seminal paper in this area is Färe, Grosskopf, Norris and Zhang (1994). For a literature survey on the subject, see Grosskopf (1993) and Färe, Grosskopf and Roos (1997).

The Malmquist TFP index measures the TFP change between two data points by calculating the ratio of the distances of each data point relative to a common technology. Following Färe *et al.* (1994) the Malmquist (output oriented) TFP change index between period s (the base period) and period t is given by:

$$m_0(y_s, x_s, y_t, x_t) = \left[\frac{d_0^s(y_t, x_t)}{d_0^s(y_s, x_s)} \times \frac{d_0^t(y_t, x_t)}{d_0^t(y_s, x_s)} \right]^{1/2} \tag{5.8}$$

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 (5.8) 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:

$$m_0(y_s, x_s, y_t, x_t) = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)} \times \frac{d_0^s(y_s, x_s)}{d_0^t(y_s, x_s)} \right]^{1/2} \tag{5.9}$$

where the ratio outside the square brackets measures the change in the output orientated 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 (5.9) 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, the two terms in equation (5.9) are:

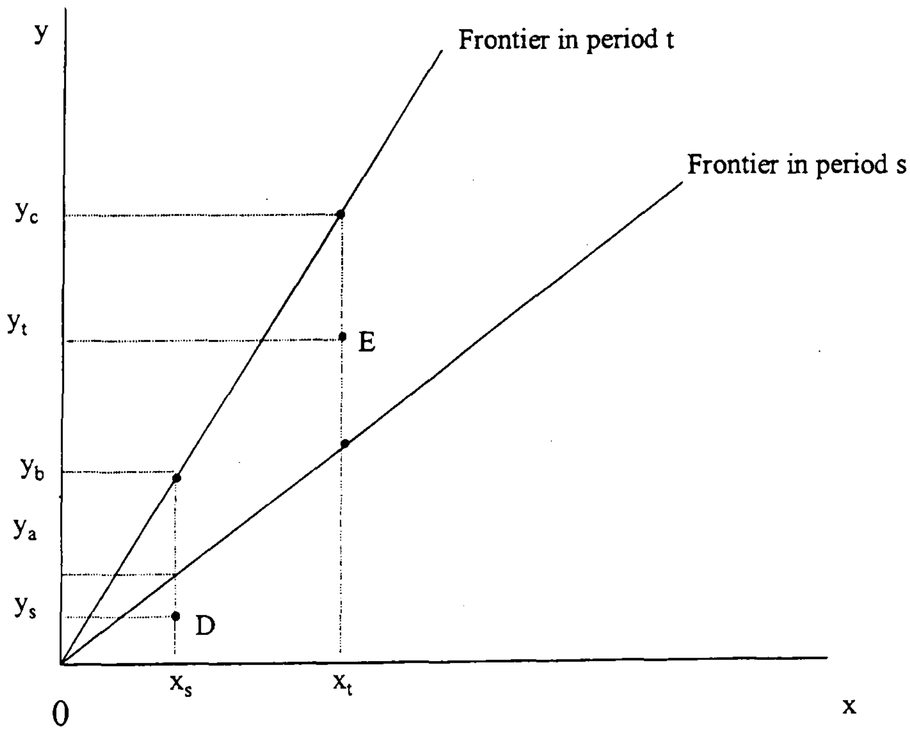
$$\text{Efficiency change} = \frac{d_0^t(y_t, x_t)}{d_0^s(y_s, x_s)} \qquad (5.10)$$

and

$$\text{Technical change} = \left[\frac{d_0^s(y_t, x_t)}{d_0^t(y_t, x_t)} \times \frac{d_0^s(y_s, x_s)}{d_0^t(y_s, x_s)}\right]^{1/2} \qquad (5.11)$$

Figure 5.4 below illustrate this decomposition.

Figure 5.4: Malmquist Productivity Indices



Source: Adapted from Coelli *et al.*, p. 225.

We consider the case of constant returns to scale technology involving one input and one output. The firm produces at the points D and E in period s and t respectively. In each period the firm is operating below the technology for that period. Therefore, there is technical inefficiency in both periods. Using equation (5.10) and (5.11) it is possible to obtain:

$$\text{Efficiency change} = \frac{y_t/y_c}{y_s/y_a} \tag{5.12}$$

$$\text{Technical change} = \left[\frac{y_t/y_b}{y_t/y_c} \times \frac{y_s/y_a}{y_s/y_b}\right]^{1/2} \tag{5.13}$$

Grifell-Tatjé and Lovell (1995a) stress the importance of the constant return to scale property of technological change in the TFP measurement. They point out how a Malmquist TFP index may not correctly measure TFP changes when VRS is assumed for the technology, since the resulting measure may not properly reflect the TFP gains or losses resulting from scale effects.

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[19].

[19] See Appendix 4 for more details.

5.4 Non-Parametric Efficiency and Statistical Inference

Although the basic DEA models (CRS and VRS) have been improved in a number of ways in recent years, one of the main criticisms faced by researchers using non-parametric methods is the difficulty of drawing statistical inference. The more recent literature, however, has sought ways to overcome this problem. Grosskopf (1996) surveys statistical inference in the non-parametric, deterministic, linear programming-based models, starting with non-parametric regularity tests, sensitivity analysis, Two-Stage (or Two-Steps) analysis with regression and non-parametric statistical tests. It also includes a discussion on DEA (and FDH) as maximum likelihood estimators and on the asymptotic properties of these estimators. Furthermore, it introduces recent attempts to employ resampling methods to derive empirical distributions for hypothesis testing.

The next section will focus on the Two-Stage (or Two-Steps) analysis with regression and on the resampling methods like the bootstrap.

5.4.1 The Two-Step Approach

One of the first tools employed to pursue statistical inference and hypothesis testing in the context of non-parametric efficiency measures was regression analysis. The basic idea of what has become known as the "Two-Step" procedure is to treat the efficiency scores as data or indices and use linear regression to explain the variation of these efficiency scores. The basic procedure for this kind of method can be summarised as follows:

- run the DEA model to calculate the DEA efficiency scores;
- fit a regression model in which the DEA efficiency score is the dependent variable;

- perform hypothesis testing on the results from fitting the regression model to determine whether or not a certain explanatory variable influences the DMUs efficiency scores.

The first improvement to this model has come with the attempt to account for the fact that efficiency scores are censored [Lovell, Walters and Wood (1995)]; as a result, a model that accounted for the fact that the dependent variable was limited became preferred to OLS.

An important conceptual issue relates to the data-generating process and the associated issue of distribution of the error terms. Put simply, if the variables used in specifying the original efficiency are correlated with the explanatory variables used in the second stage, then the second stage estimates will be inconsistent and biased [Deprins and Simar (1989); Simar, Lovell and Vanden Eeckaut (1994)].

Another criticism that is sometimes levelled against this approach is that it only considers radial inefficiency and ignores the slacks. A possible solution to this has been proposed by Fried, Schmidt and Yaisawarng (1995) and involves estimating a SUR (Seemingly Unrelated Regression) system of equations for the slacks. Bhattacharyya *et al.* (1997) pointed out that when employing regression analysis in the second step to explain the variation of the efficiency scores, it is likely that the included explanatory variables fail to explain the entire variation in the calculated efficiencies and the unexplained variation mixes with the regression residuals, adversely affecting statistical inference. They propose the use of a stochastic frontier regression model, which allows for the decomposition of the variation of the calculated efficiencies into a systematic component and a random component.

In this study, following Coelli *et al.* (1998, p. 167), we employ the Two-Step approach to take into account environmental variables. In this context, the term *environment* is used to describe factors that could influence the efficiency of a firm, where such factors are not traditional inputs and are not under the control of management [Fried, Lovell and Vanden Eeckaut (1995)]. Such factors can include, for example, ownership differences (public/private), location characteristics and government regulations. There are a number of ways in which such factors can be accommodated in DEA analysis [see Rouse (1996) for a survey of alternative approaches to the treatment of environmental factors in DEA].

The Two-Step approach involves solving a DEA problem in a first stage analysis, involving only the traditional inputs and outputs. In the second stage, the efficiency scores from the first stage are regressed upon environmental variables. The sign of the coefficients of the environmental variables indicate the direction of the influence, and standard hypothesis testing can be used to assess the strength of the relationship. This method, which can accommodate both continuous and categorical variables, is conducted by using Tobit regression model because it can account for truncated data[20].

As suggested by Coelli et al. (1998), we use the efficiency measures derived from the DEA estimations as the dependent variable, and then estimate the following Tobit regression model[21]:

$$\theta_i = \beta_1 FRA + \beta_2 GER + \beta_3 ITA + \beta_4 SPA + \beta_5 UK + \beta_6 ETA + \beta_7 ROAE + \beta_8 COMM + \beta_9 QUOT + \varepsilon_i \quad (5.14)$$

where:

1. FRA, GER, ITA, SPA and UK are dummy variables indicating the country of origin of the bank (= 1 if based in the country; = 0 otherwise);
2. ETA: Equity/Total Assets;

[20] It should be noted that frequently, a significant proportion of the efficiency scores is equal to one and that the OLS regression could predict scores greater than one. Therefore it is recommended that the Tobit regression model be used, because it can account for truncated data [McCarty and Yaisawarng (1993)].
[21] The Tobit regression analysis is computed in Limdep 7.0.

3. ROAE: Return on Average Equity;
4. COMM = 1 if a commercial bank; = 0 otherwise;
5. QUOT = 1 if the bank is listed on the Stock Exchange; = 0 otherwise.

Country dummies (FRA, GER, ITA, SPA and UK) are used to distinguish between the country of origin of the banks in the sample. We then use the average capital and profitability ratios. The average capital ratio is measured by equity over total assets (E/TA) while the profitability ratio is defined as the Return on Average Equity (ROAE). In the empirical literature, other studies [see Mester (1996); Pastor et al. (1997); Carbo *et al.* (1999)] have found positive relationships both between ROE and efficiency (i.e., the larger the profits, the higher the efficiency) and between E/TA and efficiency (i.e. lower E/TA leads to lower efficiency levels, because lower equity ratios imply a higher risk-taking propensity and greater leverage, which could result in greater borrowing costs). We introduce the dummy variable COMM in order to detect whether there are efficiency differences between commercial banks and other types of banks (such as savings and co-operative banks). Finally, the dummy variable QUOT is included to distinguish between quoted and non-quoted banks.

To test for differences between the country dummy coefficients, we test the null hypothesis $H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5$ against the alternative hypothesis (H_1) that one pair at least is unequal in each year. Finally, in order to investigate possible determinants of bank efficiency, we test the following hypothesis at $\alpha = 0.05$ significance level: $H_0 : \beta_{6,7,8,9} = 0$ vs. $H_1 : \beta_{6,7,8,9} \neq 0$.

A new conceptual issue has recently been raised by Xue and Harker (1999): they point out that efficiency scores generated by DEA models are clearly dependent on each other in the statistical sense. The reason for dependency is the well-known fact that the DEA efficiency score is a relative efficiency index, not an absolute efficiency index. Because of the presence of the inherent dependency among efficiency scores, one basic model assumption required by regression analysis, independence within the sample, is violated. As a result, the conventional procedure, followed in the literature, is invalid. They propose a bootstrap method to overcome this problem.

5.4.2 The Bootstrap Method

The bootstrap was introduced by Efron (1979) as a data-based simulation method for statistical inference[22]. It is basically a resampling technique, based on the idea of estimating the sampling distribution ($\hat{F}$) of some pre-specified random variable based on the observed data set (F). If $\hat{F}$ is a reasonable estimator of F, then the known bootstrap distribution mimics the original unknown sampling distribution of the estimator of interest[23].

[22] 'The use of the term bootstrap derives from the phrase *to pull oneself up by one's bootstrap*, widely thought to be based on one of the eighteen century Adventures of Baron Munchausen, by R. E. Raspe. (The Baron had fallen to the bottom of a deep lake. Just when it looked like all was lost, he thought to pick himself up by his own bootstraps).' [Efron and Tibshirani (1993), p. 5].

[23] As described in Efron (1979) the principle of the bootstrap method can be summarised as follows:

1) Construct the sample probability distribution F, assigning probability 1/n at each point in the observed sample: $x_1, x_2, \ldots, x_n$.
2) Draw a random sample of size n with replacement from F while F is fixed at its observed value. That is

$$X_i = x_i, X_i \approx_{ind} F, \quad i = 1,2,\ldots,n \tag{1}$$

The sample $X = (X_1, X_2, \ldots, X_n)$ is defined as the bootstrap sample.

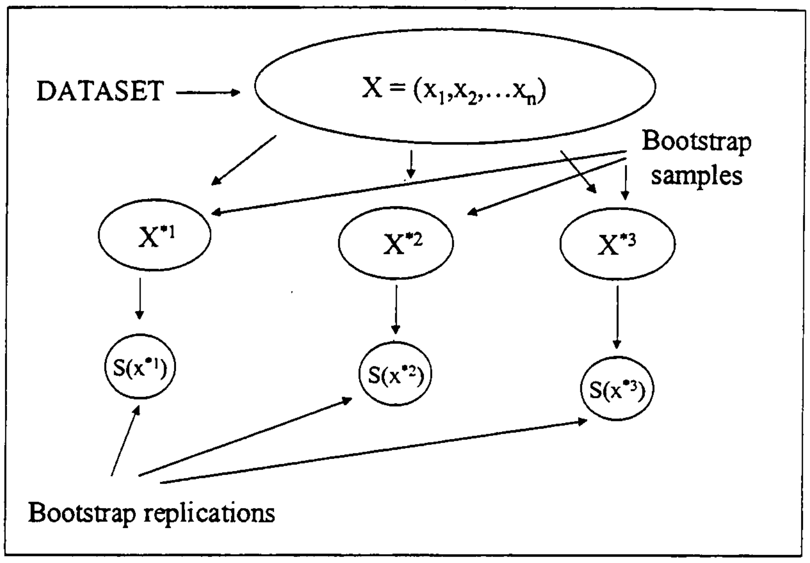
3) The distribution of the random variable R(X,F) is approximated by the bootstrap distribution of

$$R^* = R(X^*, F) \tag{2}$$

For more details on the bootstrap method see Efron (1979) and Efron and Tibshirani (1993).

Figure 5.5a below illustrates the basic idea of the bootstrap process for estimating the standard error of a statistic s(x).

Figure 5.5a: The Bootstrap Process



Source: Adapted from Efron and Tibshirani (1993), p. 13.

[Figure 5.5a: Schematic of the bootstrap process for estimating the standard error of a statistic s(x). B bootstrapped samples are generated from the original data set. Each bootstrap sample has n elements, generated by sampling with replacement n times from the original data set. Bootstrap replicates $s(x^{*1})$, $s(x^{*2}),\ldots s(x^{*B})$ are obtained by calculating the value of the statistic s(x) on each bootstrap sample. Finally, the standard deviation of the values $s(x^{*1})$, $s(x^{*2}),\ldots s(x^{*B})$ is our estimate of the standard error of s(x). Efron and Tibshirani (1993), p. 13].

Bootstrap methods depend on the notion of *bootstrap sample.* A bootstrap sample is defined to be a random sample of size n drawn form $\hat{F}$. The star notion indicates that x* is not the actual data set x, but a randomised, or *resampled*, version of x. The bootstrap data set $(x_1^*, x_2^*, \ldots, x_n^*)$ consist of members of the original data set $(x_1, x_2, \ldots, x_n)$, some appearing zero times, some appearing once, some appearing twice, etc. Corresponding to a bootstrap data set x* is a bootstrap replication of $\hat{\theta}$:

$$\hat{\theta}^* = s(\mathrm{x}^*) \tag{5.15}$$

The quantity $s(x^*)$ is the result of applying the same function $s(.)$ to x^* as was applied to x. For example, if $s(x)$ is the sample mean $\bar{x}$, then $s(x^*)$ is the mean of the bootstrap data set, $\bar{x}^* = \sum_{i=1}^{n} x_i^* / n$.

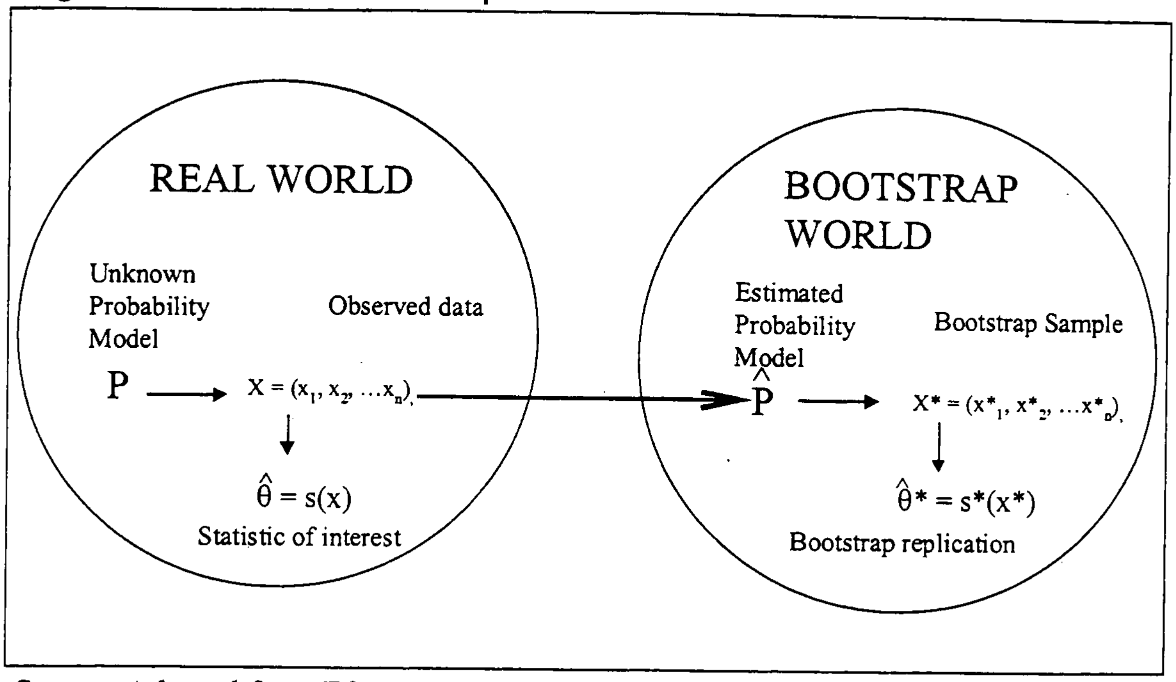
The bootstrap estimate of $se_F\left(\hat{\theta}\right)$, the standard error of a statistic $\hat{\theta}$ is a plug-in estimate that uses the empirical distribution function $\hat{F}$ in place of the unknown distribution F. Specifically, the bootstrap estimate $se_F\left(\hat{\theta}\right)$ is defined by:

$$se_{\hat{F}}\left(\hat{\theta}^*\right) \tag{5.16}$$

In other words, the bootstrap estimate of $se_F\left(\hat{\theta}\right)$ is the standard error of $\hat{\theta}$ for the data sets of size n randomly sample from $\hat{F}$.

This approach can be applied to more general data structures, with not much difference but the level of generality involved. Figure 5.5b illustrates this concept.

Figure 5.5b: The Bootstrap Process



Source: Adapted from Efron and Tibshirani (1993), p. 33.

5.4.3 Application of the Bootstrap Method in DEA-FDH Framework

Simar (1992) was possibly the first to introduce the bootstrap method to efficiency scores derived the from non-parametric frontier estimation. Efficiency scores are generally measured relative to an estimated production frontier. The DEA approach is based on linear programming techniques and the frontier is a boundary of the convex hull of the set of observed points; it relies on the convexity assumptions of the attainable set of productions. The FDH approach extended the idea, allowing non-convex production sets. Since statistical estimators of the frontier are obtained from finite samples, the corresponding measures of efficiency are sensitive to the sampling variations of the obtained frontier.

Banker (1993) and Korostelev, Simar and Tsybakov (1992, 1995) established that DEA and FDH were maximum likelihood estimators of a boundary set. Korostelev, Simar and Tsybakov (1992, 1995) derived the rate of convergence of the FDH and DEA estimators[24]. These results finally established a statistical foundation for non-parametric measures, at least in terms of asymptotic properties. Unfortunately, the obtained rates of convergence are very slow. This is one of the reasons why Simar (1992) proposed to use the bootstrap method for computing confidence intervals for efficiency scores derived from non-parametric frontier methods. Since then, the bootstrap has been used to provide an empirical distribution of efficiency scores for each observation in the sample (Atkinson and Wilson, 1995), to derive the confidence intervals and a measure of bias for the DEA efficiency scores (Ferrier and Hirschberg, 1995) and to analyse the sensitivity of efficiency scores to the sampling variations of the estimated frontier (Simar and Wilson, 1995).

In their work Simar and Wilson (1995) propose an alternative bootstrap method (the smoothed bootstrap) which takes into account boundary problems (i.e., the truncation at one) associated with using the original empirical distribution of efficiency as the basis for resampling. The method they suggest improves the one suggested by Ferrier and Hirschberg (1995) and yields a bootstrap which is consistent and unbiased (Grosskopf, 1996).

To summarise, all the literature to date has concentrated mainly on the estimation of the distribution of the efficiency scores. Xue and Harker (1999) have been the first, as far as we are aware, to address the problem of the inherent dependency[25] of efficiency scores when used in regression analysis. They present the following procedure for the regression analysis of the DEA efficiency scores by using the bootstrap approach[26] to solve the dependency problem:

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[24] Specifically, the rate of convergence is $n^{-1/(s+1)}$ for FDH and $n^{-2/(s+2)}$ for DEA, where s is the number of inputs and outputs and n is the number of observation.

[25] In regression analysis, if the response variables Y_1, Y_2,...,Y_n are dependent on each other, or correlated, if we fit the regression model as if they were not, the estimate of the standard error of the regression coefficient estimate, $\hat{s}e(\hat{\beta}_j)$, which is obtained by fitting the regression model, is no longer correct. As a consequence, the t-ratios and P-values for the Hypothesis Tests are no longer correct. Therefore, the conclusion reached through this kind of direct regression analysis may be misleading (Xue and Harker, 1999).

[26] Bootstrapping of regression models is discussed, among others, in Efron and Tibshirani (1993).

- **Step 1**: Construct the sample probability distribution $\hat{F}$ by assigning probability of 1/n at each DMU in the observed sample ($x_1, x_2, ..., x_n$).
- **Step 2**: Draw c (c is a constant) random samples of size n with replacement from the original sample ($x_1, x_2, ..., x_n$):

$$S_k = (x_{k1}, x_{k2}, ... x_{kn}), \qquad k = 1,2,\ldots c \tag{5.17}$$

where $x_{ki} = (u_{ki}, v_{ki})$, i = 1,2,…n. S_k is the so-called *bootstrap sample.*

- **Step 3**: for each bootstrap sample S_k, k = 1,2,…c, run the DEA model and recalculate the efficiency scores for all n DMUs:

$$\theta_{ki} = \phi_i(u_k), \qquad i = 1,2,\ldots n, \tag{5.18}$$

- **Step 4**: for each bootstrap sample S_k, k = 1,2,…c, evaluate the *bootstrap replication* $\hat{\beta}_{kj}$, k = 1,2,…c, j= 0,1,..,m, by fitting the regression model:

$$\theta_{ki} = G(\beta_k, v_{ki}) + \varepsilon_{ki}, \quad i=1,2,\ldots n, \quad \beta_k = (\beta_{k0}, \beta_{k1}, \ldots, \beta_{kj}, \ldots, \beta_{km}) \tag{5.19}$$

- **Step 5**: Estimate the standard error $se\left(\hat{\beta}_j\right)$ by the sample standard deviation of the c bootstrap replications of $\hat{\beta}_j$:

$$\hat{se}_c\left(\hat{\beta}\right)=\left\{\sum_{k=1}^{c}\left(\hat{\beta}_{kj}-\overline{\beta_j}\right)^2\Big/(c-1)\right\}^{1/2},\quad j=1,2,\ldots,m \tag{5.20}$$

where

$$\overline{\beta_j}=\frac{\sum_{k=1}^{c}\hat{\beta}_{kj}}{c},\qquad j=1,2,\ldots,m \tag{5.21}$$

We call $\hat{se}_c\left(\hat{\beta}_j\right)$ the *bootstrap estimator* for the standard error of $\hat{\beta}_j$.

Now it is possible to use a *t*-test to test the following hypothesis:

$$H_0:\beta_j=0,\quad \text{vs.}\quad H_1:\beta_j\neq 0.$$

Calculate the test statistic[27] according to:

$$t=\frac{\hat{\beta}_j}{\hat{se}_c\left(\hat{\beta}_j\right)}, \tag{5.22}$$

and compare t to the critical value $t_{\alpha/2}$ from the Student t distribution with degrees of freedom equal to (n-m-1). If $|t|>t_{0.025}$, reject the null hypothesis $H_0:\beta_j=0$, in favour

[27] Through the use of the bootstrap one can obtain accurate intervals without having to make normal theory assumptions. One way of getting such intervals is the so-called 'bootstrap-t approach'. This procedure estimates the distribution of Z directly from the data. The bootstrap-*t* procedure is a useful and interesting generalisation of the usual Student's *t* method. For details on the bootstrap-t approach and its improvements refer to Efron and Tibshirani (1993).

of $H_1 : \beta_j \neq 0$, at $\alpha = 0.05$ significant level. Otherwise, the null hypothesis $H_0 : \beta_j = 0$, is tenable at $\alpha = 0.05$ significant level.

According to its authors, the above procedure, unlike ordinary regression, correctly implements Efron's bootstrap to give appropriate standard errors when the n original DMUs X_i *i*=1,2,...*n*, are independently sampled from F, even though the efficiency scores computed from the X's are dependent.

This study implements a 'Three-Step' approach, which can be summarised as follows:

1. run the DEA model to calculate the DEA efficiency scores;
2. fit a Tobit regression model in which the DEA efficiency score is the dependent variable to investigate the determinants of bank efficiency;
3. substitute the conventional estimators of the Tobit regression coefficient estimates, with the bootstrap estimators for the standard errors of these estimates, to account for the problem of inherent dependency arising when DEA scores are used in regression analysis.

Following Xue and Harker (1999), the bootstrap method is implemented as follows[28]:

- Construct the sample probability distribution $\hat{F}$, assigning probability of 1/379 at each DMU in the observed sample[29].
- Take c = 1000 random samples of size 379 with replacement from the observed sample of 379 European banks. These samples are the bootstrap samples.
- Compute the DEA efficiency scores for each bootstrap sample.

[28] The computer routine to perform the described procedure has been written by C. Verdes, University of AL I CUZA, Iasi, Romania – SEES, University of Wales, Bangor.
[29] To complete this exercise, a balanced sample on a pooled European basis was considered.

- Within each bootstrap sample, fit the following regression model:

$$\hat{\theta}_{ki} = \hat{\beta}_{k1} FRA + \hat{\beta}_{k2} GER + \hat{\beta}_{k3} ITA + \hat{\beta}_{k4} SPA + \hat{\beta}_{k5} UK +$$

$$+ \hat{\beta}_{k6} ETA_{ki} + \hat{\beta}_{k7} ROAE_{ki} + \hat{\beta}_{k8} COMM_{ki} + \hat{\beta}_{k9} QUOT_{ki} + \varepsilon_{ki} \qquad (5.23)$$

for i = 1,2, …, 379; k = 1,2,…,1000.

Here θ_{ki} is the DEA efficiency score for DMU i in bootstrap sample k and $\hat{\beta}_{kj}$ (j=1,…9) are the bootstrap replications for $\hat{\beta}_j$ in bootstrap sample k.

- Estimate the standard error $se(\hat{\beta}_j)$ by the sample standard deviation of the c bootstrap replications of $\hat{\beta}_j$ [see equation (5.20)].

  where

$$\overline{\beta_j} = \frac{\sum_{k=1}^{c} \hat{\beta}_{kj}}{c}, \qquad j = 1,2,\ldots,9 \qquad c = 1000 \qquad (5.24)$$

- Calculate the t-statistic according to equation (5.22) and then test the individual hypothesis $H_0 : \beta_j = 0$ against the two-sided alternative $H_0 : \beta_j \neq 0$ at $\alpha = 0.05$ significant level.

4. Perform hypothesis testing on the results from fitting the bootstrap regression model to determine whether or not a certain explanatory variable influences the DMUs efficiency scores.

5.5 Conclusions

This chapter reviewed the methodological issues this thesis aims to investigate. In particular, the chapter focused on the use of non-parametric deterministic approaches to the evaluation of productive efficiency (DEA and FDH) and technological change (MPI). The last part of the chapter discussed the most recent literature on the issue of statistical inference in non-parametric studies, focusing on the so-called 'Two-Step' approach and the bootstrap method. Finally, it identifies the 'Three-Step' approach which will be implemented in the empirical analysis. Chapter 6 will summarise the main results of our empirical investigation on the efficiency characteristics of European banking.

6 Productive Efficiency in European Banking: Empirical Findings

This empirical analysis investigates whether the productive efficiency of European banking systems has improved since the creation of the Single Internal Market. Selected European banking markets between 1993 and 1997 are examined using both non-parametric DEA and FDH approaches; the aim is to investigate whether there has been an increase and convergence of bank efficiency levels following the process of legislative harmonisation. In addition, productivity change across banking markets is calculated using the Malmquist Productivity Index (MPI). This study also evaluates the determinants of European bank efficiency by using the Tobit regression model approach in order to analyse the influence of various country-specific and environmental factors on bank efficiency. In order to overcome the problem of the inherent dependency of DEA efficiency scores when used in regression analysis, a bootstrapping technique is used. Overall, the results suggest that since the onset of the EU's Single Market Programme there has been a small improvement in bank efficiency levels, although there is little evidence to suggest that these have converged. Efficiency differences across European banking markets appear to be mainly determined by country-specific factors.

The results of the empirical investigation are organised as follows: Section 1 presents the FDH and DEA efficiency estimates. Scale efficiency scores are also reported. Moreover, Malmquist Productivity Indices, which identify productivity growth or decline in the European banking markets between 1993 and 1997, are presented. Consistency tests of the efficiency scores over time and with standard non-frontier measures of performance are also presented in Section 6.2. The determinants of European bank efficiency are investigated in Section 6.3; Section 6.4 concludes.

6.1 Efficiency Estimates

The first part of this chapter reports the results of our empirical investigation on the productive efficiency and productivity change of the main European banking systems. Efficiency estimates and TFP changes are illustrated both relative to each country's national frontier and on a pooled European basis. It is necessary to recall that the sample comprises only large European banks.

6.1.1 Individual Country DEA Efficiency Estimates

This section reports the DEA efficiency scores[1] of the five main European banking systems, namely France, Germany, Italy, Spain and the UK, when considering their own national frontier, calculated according to the different assumptions of constant and variable returns to scale and under the alternative input and output orientations[2].

Table 6.1 presents the DEA efficiency scores[3] relative to the sub-sample of French banks (493 observations):

[1] In this study, the linear programming problems are solved by using the DEAP Version 2.1 Computer Program, by Tim Coelli.

[2] It is worth remembering that Input and Output orientations yield the same value under the CRS assumptions.

[3] In order to check that the results are not too sensitive to the presence of outliers, we followed a procedure used, among others, by Resti (1997). After solving the DEA problems using all the observations composing the sample, all banks presenting an efficiency score equal to unity were deleted and DEA problems were solved once more on the new sample. The correlation between the efficiency scores obtained on the original samples and on the reduced samples is an indicator of the robustness of the results. The procedure has been followed for all the countries in the sample. The Pearson correlation coefficient and the Spearman rank correlation coefficient were then estimated to detect the sensitivity to outliers and the results were satisfactory.

Table 6.1: DEA Efficiency Estimates (France)

	CONSTANT RETURNS TO SCALE					VARIABLE RETURNS TO SCALE									
						INPUT BASED					OUTPUT BASED				
	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3
1993 *(94)*	0.798	0.820	0.136	0.680	0.906	0.833	0.846	0.128	0.733	0.946	0.837	0.846	0.123	0.738	0.944
1994 *(102)*	0.700	0.686	0.109	0.635	0.737	0.791	0.766	0.124	0.702	0.888	0.803	0.789	0.121	0.705	0.895
1995 *(103)*	0.794	0.776	0.098	0.719	0.874	0.835	0.828	0.109	0.735	0.933	0.838	0.836	0.108	0.733	0.929
1996 *(101)*	0.815	0.813	0.098	0.723	0.888	0.855	0.865	0.105	0.760	0.944	0.853	0.859	0.108	0.741	0.944
1997 *(93)*	0.838	0.835	0.072	0.780	0.881	0.885	0.882	0.077	0.827	0.949	0.886	0.885	0.076	0.825	0.945

Note: The numbers in brackets refer to the number of observations.

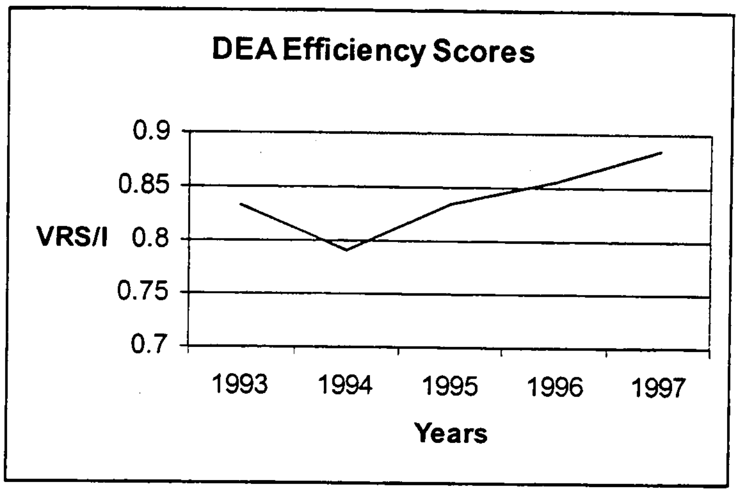
Table 6.2 below reports the number of efficient observations, i.e. the number of DMUs composing the efficient frontier. From tables 6.1 and 6.2 and from figure 6.1 it is possible to detect an improvement of the relative efficiency scores of French banks. Indeed, the efficiency levels appear to have increased (+5.2%) over the period. Input and Output orientations yield very similar results. However, as can be see from the frequency distribution of the average efficiency scores, the majority of French banks present relatively high levels of inefficiency[4], equal to around 20%. These results suggest that there are substantial cost savings opportunities obtainable in the French banking industry.

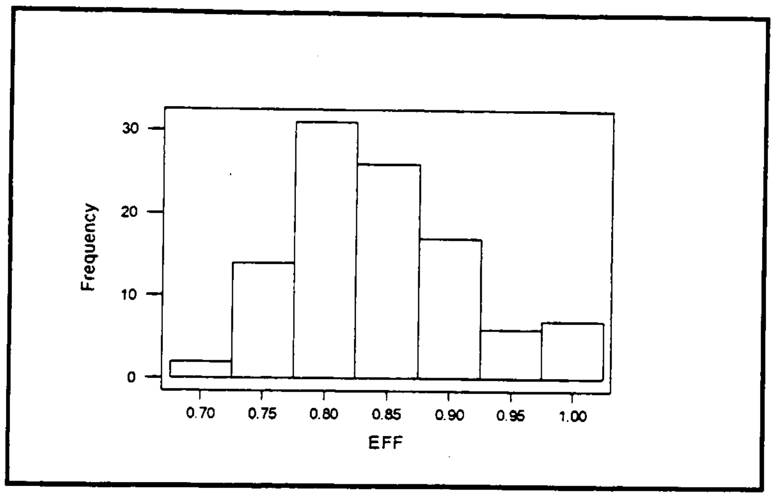
Table 6.2: Number of Efficient Banks (France)

	CR	VR
1993	6	13
1994	5	14
1995	5	15
1996	7	17
1997	5	16

[4] Please note that, in this context, Inefficiency = 1 – Efficiency.

Figure 6.1: Efficiency Scores (VRS/I): Trend and Frequency Distribution (France)





NOTE: VRS/I = Variable Returns to Scale, Input-based approach.

Table 6.3 reports the DEA efficiency scores for the sample of German banks (535 observations). German banks seem to have achieved a consistent improvement of their efficiency levels, having reduced the average input inefficiency by 17.1% over the five years of investigation. Output efficiency registered a less marked, but still substantial improvement (+8.5%). According to these results, German banks seem to have been comparatively successful in cutting costs, but less able to increase the output production. This steady improvement in cost efficiency levels can be easily detected from Figure 6.2. However, the frequency distribution histogram displays how the majority of banks in the sample cluster around average inefficiency levels around 20%.

Table 6.3: DEA Efficiency Estimates (Germany)

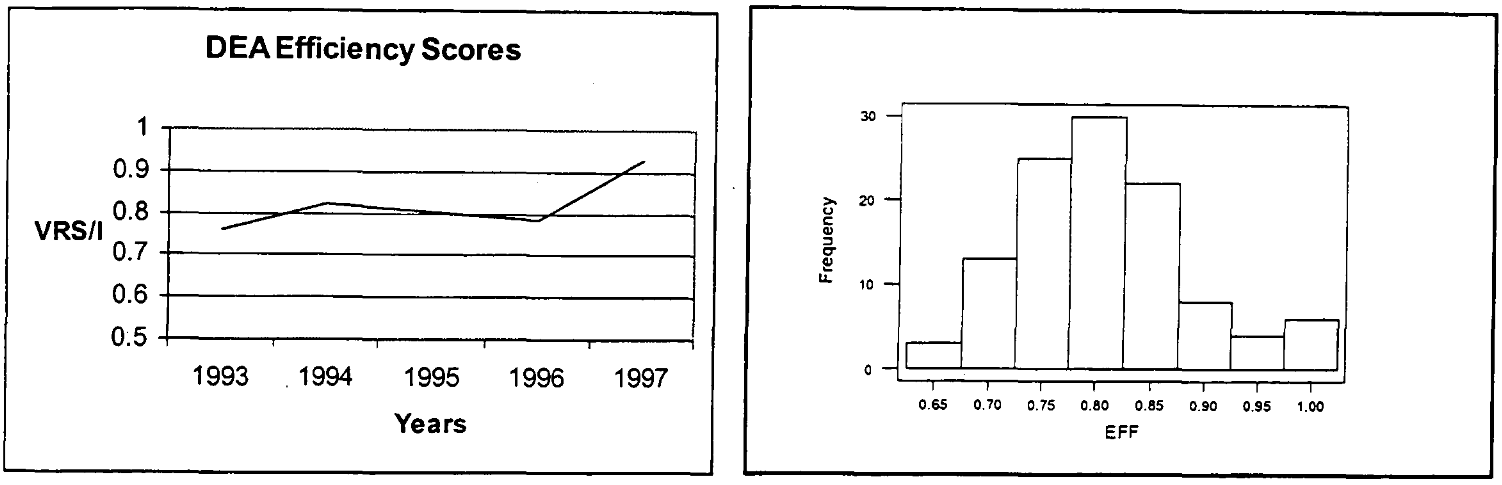
	CONSTANT RETURNS TO SCALE					VARIABLE RETURNS TO SCALE									
						INPUT BASED					OUTPUT BASED				
	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3
1993 *(107)*	0.681	0.632	0.118	0.641	0.732	0.759	0.708	0.132	0.661	0.883	0.738	0.696	0.139	0.631	0.836
1994 *(107)*	0.773	0.753	0.086	0.711	0.804	0.824	0.798	0.099	0.749	0.914	0.812	0.774	0.103	0.733	0.902
1995 *(111)*	0.743	0.720	0.091	0.686	0.775	0.803	0.782	0.108	0.718	0.871	0.784	0.753	0.111	0.704	0.863
1996 *(111)*	0.755	0.713	0.107	0.679	0.824	0.785	0.734	0.115	0.696	0.883	0.783	0.736	0.116	0.696	0.884
1997 *(99)*	0.845	0.820	0.101	0.760	0.914	0.930	0.962	0.075	0.898	0.983	0.823	0.782	0.111	0.740	0.937

Note: The numbers in brackets refer to the number of observations.

Table 6.4: Number of Efficient Banks (Germany)

	CR	VR
1993	4	12
1994	5	14
1995	4	13
1996	5	12
1997	5	15

Figure 6.2: Efficiency Scores (VRS/I): Trend and Frequency Distribution (Germany)



NOTE: VRS/I = Variable Returns to Scale, Input-based approach.

Results for the Italian banking system (524 observations) are reported in table 6.5, while table 6.6 summarises the number of efficient banks composing the Italian efficient frontier.

Table 6.5: DEA Efficiency Estimates (Italy)

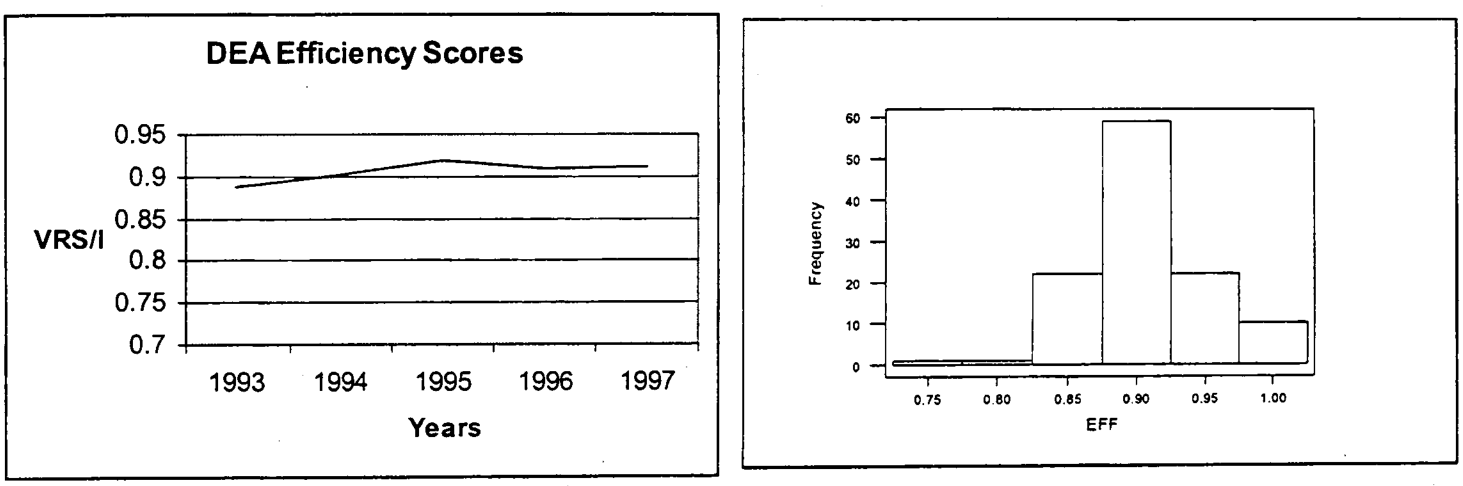
	CONSTANT RETURNS TO SCALE					VARIABLE RETURNS TO SCALE									
						INPUT BASED					OUTPUT BASED				
	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3
1993 *(111)*	0.853	0.843	0.083	0.804	0.900	0.887	0.886	0.081	0.841	0.955	0.880	0.881	0.086	0.828	0.955
1994 *(115)*	0.866	0.872	0.082	0.819	0.933	0.902	0.907	0.080	0.843	0.970	0.899	0.905	0.834	0.840	0.967
1995 *(112)*	0.889	0.893	0.077	0.845	0.925	0.918	0.917	0.068	0.867	0.994	0.915	0.914	0.071	0.864	0.989
1996 *(109)*	0.884	0.893	0.079	0.829	0.942	0.909	0.921	0.076	0.862	0.983	0.905	0.912	0.079	0.858	0.982
1997 *(77)*	0.878	0.883	0.071	0.831	0.942	0.912	0.919	0.069	0.868	0.969	0.909	0.913	0.070	0.867	0.970

Note: The numbers in brackets refer to the number of observations.

Table 6.6: Number of Efficient Banks (Italy)

	CR	VR
1993	7	17
1994	7	18
1995	9	27
1996	9	25
1997	6	15

Figure 6.3: Efficiency Scores (VRS/I): Trend and Frequency Distribution (Italy)



NOTE: VRS/I = Variable Returns to Scale, Input-based approach.

The Italian banking system shows a relatively low average level of inefficiency (around 9.5%, confirmed by the frequency distribution of the average efficiency scores) with constant improvement (from 11.3% inefficiency 1993 to 8.8% in 1997). These results tend to confirm the findings of previous studies [Favero and Papi (1995) found average efficiency levels in the Italian banking industry equal to 0.95; Casu (1998) found average efficiency levels of 0.94].

Very similar results are achieved by the Spanish banking system (477 observations), as illustrated in table 6.7 and in Figure 6.4, with overall inefficiency levels constantly under 10%. Previous studies on the Spanish banking system found similar results [Pastor, Pérez and Quesada (1995) found average DEA efficiency levels of 0.89 and Pastor, Lozano and Pastor (1997) reported average DEA efficiency scores of 0.82].

Table 6.7: DEA Efficiency Estimates (Spain)

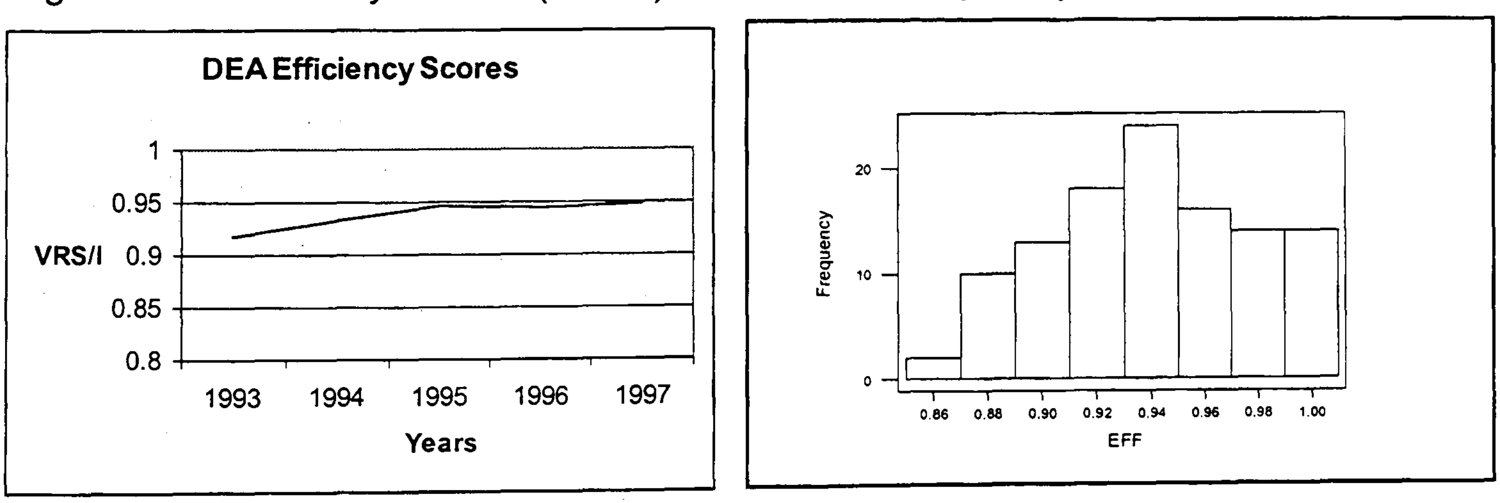
	CONSTANT RETURNS TO SCALE					VARIABLE RETURNS TO SCALE									
						INPUT BASED					OUTPUT BASED				
	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3
1993 *(90)*	0.832	0.828	0.091	0.772	0.901	0.918	0.927	0.072	0.878	0.978	0.919	0.927	0.074	0.883	0.978
1994 *(91)*	0.819	0.810	0.064	0.783	0.847	0.933	0.939	0.063	0.901	0.990	0.936	0.941	0.060	0.905	0.991
1995 *(91)*	0.882	0.882	0.053	0.847	0.908	0.947	0.955	0.046	0.917	1.000	0.948	0.956	0.046	0.915	1.000
1996 *(111)*	0.913	0.908	0.039	0.883	0.934	0.945	0.949	0.039	0.914	0.975	0.944	0.948	0.040	0.913	0.976
1997 *(94)*	0.917	0.911	0.035	0.893	0.938	0.949	0.948	0.038	0.918	0.984	0.949	0.948	0.039	0.919	0.985

Note: The numbers in brackets refer to the number of observations.

Table 6.8: Number of Efficient Banks (Spain)

	CR	VR
1993	6	18
1994	4	20
1995	6	23
1996	6	19
1997	6	16

Figure 6.4: Efficiency Scores (VRS/I): Trend and Frequency Distribution (Spain)



NOTE: VRS/I = Variable Returns to Scale, Input-based approach.

Finally, table 6.9 illustrates the efficiency of the UK banking system (331 observations) and figure 6.5 highlights the trend over the period. The overall efficiency level seems to be relatively high and stable over time (only a slight decrease by 1,6% from 1993 to 1997), with the majority of banks in the industry displaying average inefficiency levels of around 8%, as highlighted in the frequency distribution histogram in Figure 6.5.

Table 6.9: DEA Efficiency Estimates (UK)

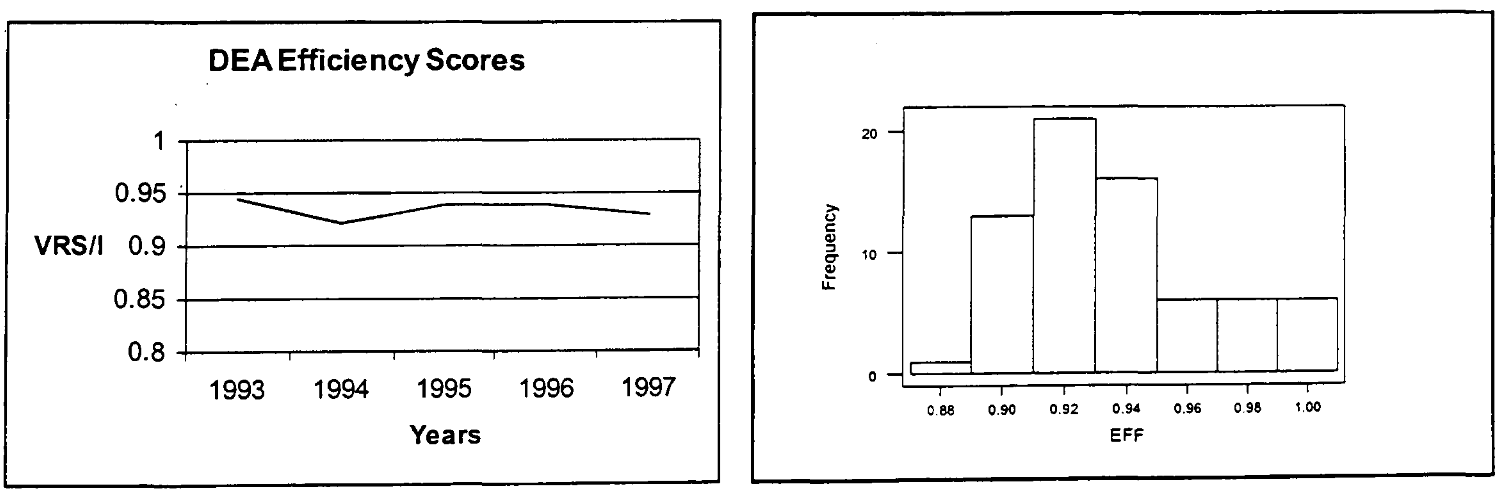
	CONSTANT RETURNS TO SCALE					VARIABLE RETURNS TO SCALE									
						INPUT BASED					OUTPUT BASED				
	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3
1993 *(68)*	0.933	0.937	0.043	0.906	0.968	0.944	0.944	0.041	0.915	0.980	0.943	0.943	0.042	0.914	0.982
1994 *(69)*	0.904	0.896	0.044	0.871	0.924	0.922	0.911	0.046	0.883	0.962	0.923	0.912	0.047	0.883	0.962
1995 *(66)*	0.928	0.931	0.049	0.893	0.972	0.939	0.945	0.050	0.901	0.989	0.939	0.943	0.051	0.901	0.989
1996 *(67)*	0.925	0.922	0.051	0.881	0.973	0.938	0.939	0.049	0.900	0.986	0.938	0.939	0.050	0.899	0.985
1997 *(61)*	0.919	0.909	0.047	0.887	0.956	0.928	0.915	0.048	0.894	0.973	0.928	0.915	0.049	0.892	0.974

Note: The numbers in brackets refer to the number of observations.

Table 6.10: Number of Efficient Banks (UK)

	CR	VR
1993	8	13
1994	5	9
1995	6	12
1996	11	15
1997	9	12

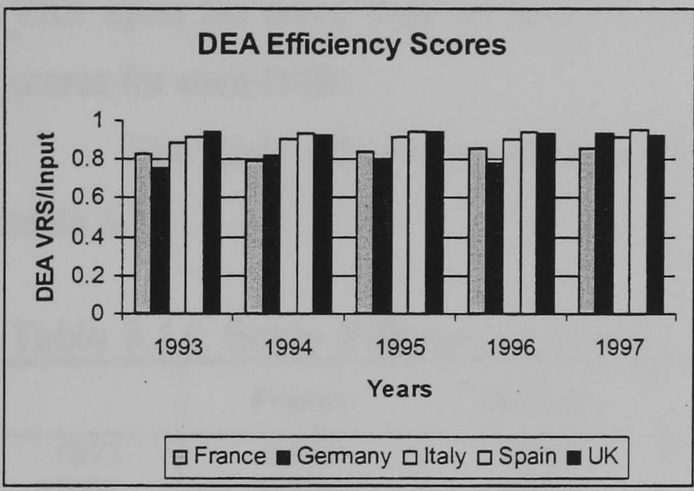
Figure 6.5: Efficiency Scores (VRS/I): Trend and Frequency Distribution (UK)

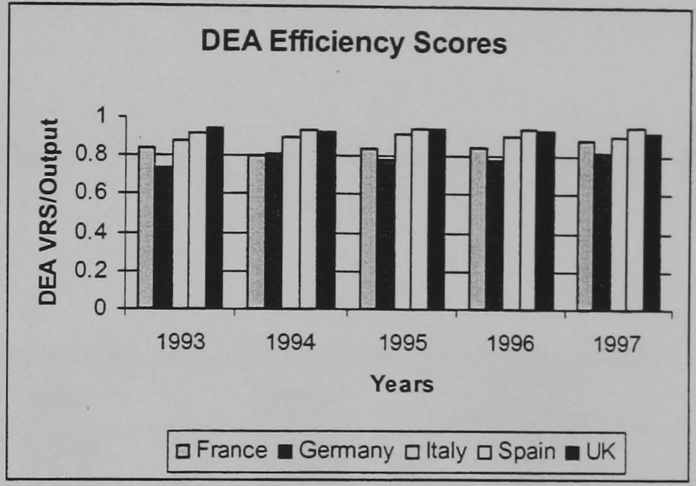


NOTE: VRS/I = Variable Returns to Scale, Input-based approach.

Figures 6.6 and 6.7 summarise the trend of the efficiency scores (VRS) in each country over time, both according to the input-based and to the output-based model.

Figure 6.6: I/based DEA Efficiency Scores Figure 6.7: O/based DEA Efficiency Scores





The relative efficiencies for the vast majority of banks seem consistent with a reasonably competitive industry in local markets. Overall, these five European countries seem to have increased the average level of productive efficiency of their banking systems during the period under investigation. The most efficient banking sectors appear to be those of Spain, the UK and Italy, while in the French and German banking systems there seems to exist still substantial cost savings opportunities.

6.1.2 Individual Country Scale Efficiency Estimates

As illustrated in Chapter 5, in addition to evaluating the technical or productive efficiency of DMUs, the DEA methodology allows for the estimation of scale economies[5].

[5] In this context, scale economies estimates are calculated as follows:

$$SE_I = TE_{I,\,CRS} / TE_{I,\,VRS} \tag{1}$$

The ratio SE_I indicates the lowest possible input combination able to produce the same output in the long run as technically efficient combination situated on the CRS technology.

Since $TE_{I,\,CRS} \leq TE_{I,\,VRS}$, evidently, $0 < SE_I \leq 1$.

If $SE_I = 1$, then the technology exhibits constant return to scale at the observation under evaluation (or at its input-oriented projection point). If $SE_I < 1$, then the evaluated observation is not located (or projected) on piecewise linear segment where constant return to scale prevail (see Section 5.3.1.3 for greater details).

In this study we evaluate the amount of scale efficiency by conducting both CRS and VRS upon the same data set and calculate SE as the difference between the two TE scores for each DMU.

The scale efficiency estimates for each country in the sample are reported in table 6.11.

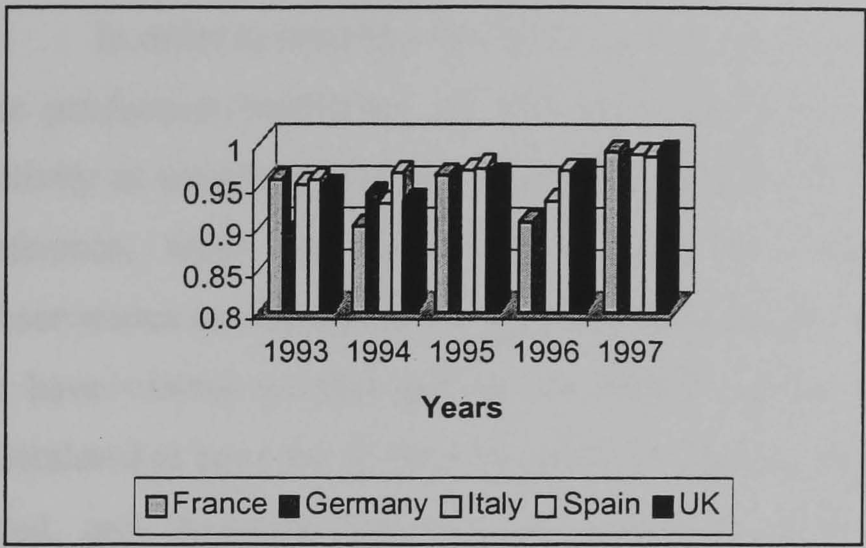
Table 6.11: Scale Efficiency Scores

	France	Germany	Italy	Spain	United Kingdom
1993	0.957	0.902	0.962	0.908	0.989
1994	0.892	0.941	0.959	0.879	0.980
1995	0.952	0.929	0.969	0.932	0.988
1996	0.956	0.965	0.972	0.967	0.986
1997	0.947	0.931	0.962	0.967	0.990
Average	0.941	0.934	0.965	0.931	0.986
% Change	-0.01	+0.03	-	+0.06	-

Overall, scale inefficiency seems to amount to around 5% and be relatively stable over the period of analysis. These results seem to confirm those usually found in the banking literature in recent years, where scale and product mix inefficiency are found to account for less than 5% of total costs (Berger *et al.*, 1993).

Among the countries in our sample, the UK banking system displays the higher level of scale efficiency. On the other hand, Spanish and German banks, although showing the lower levels of scale efficiency, are also showing a positive percentage of change over the period under observation, thus highlighting a decrease in scale inefficiency levels.

Figure 6.8: Scale Efficiency Scores



The next section reports the results of the computation of the Malmquist Productivity Indices (MPI) measures of Total Factor Productivity (TFP) change over the period under analysis.

6.1.3 Individual Country Malmquist Productivity Indices

Following Färe *et al.* (1994) the Malmquist (output-orientated) TFP change index (M_0) has been calculated[6]. A value of M_0 greater than one indicates positive TFP growth while a value less than one indicates TFP decline over the period. It is possible to decompose productivity change into two components:

- Technological Change, which reflects improvement or deterioration in the performance of best practice DMUs.
- Technical Efficiency Change, which reflects the convergence towards or divergence from the best practice on part of the remaining DMUs.

[6] To calculate the Malmquist TFP Index, the data have been rearranged in the form of a balanced panel. In this study, the linear programming problems are solved by using the DEAP Version 2.1 Computer Program, by Tim Coelli.

The value of the decomposition is that it provides information on the source of the overall productivity change in the banking sector of the main EU countries. The approach has been further extended by decomposing the technical efficiency change into scale efficiency and 'pure' technical efficiency. The following decomposition of the Malmquist Index is presented[7]:

- Technological Change;
- Technical Efficiency Change;
- Pure Technical Efficiency Change;
- Scale Efficiency Change;
- Total Factor Productivity (TFP) Change.

The productivity change results are summarised in table 6.12. The annual entries in each column are geometric means of results for individual banks and the period results reported in the last row are geometric means of the annual geometric means.

[7] All indices are calculated relative to the previous year.

Table 6.12: Malmquist Index (Summary of Annual Means)

	Years	Pure Technical Efficiency Change	Scale Efficiency Change	Efficiency Change	Technological Change	Scale Efficiency Change	Total Factor Productivity Change
FRANCE	1993/94	0.993	0.982	0.975	1.006	0.982	0.980
	1994/95	0.987	0.981	0.968	0.989	0.981	0.957
	1995/96	1.000	1.003	1.003	1.018	1.003	1.021
	1996/97	0.975	0.947	0.924	1.085	0.947	1.003
	mean	**0.989**	**0.978**	**0.967**	**1.024**	**0.978**	**0.990**
GERMANY	1993/94	1.154	1.768	2.039	0.454	1.768	0.926
	1994/95	0.865	0.573	0.496	2.051	0.573	1.016
	1995/96	1.029	1.208	1.243	0.781	1.208	0.971
	1996/97	1.013	1.218	1.234	0.780	1.218	0.963
	mean	**1.010**	**1.105**	**1.116**	**0.868**	**1.105**	**0.968**
ITALY	1993/94	0.997	0.825	0.822	1.249	0.825	1.027
	1994/95	1.000	1.137	1.137	0.926	1.137	1.052
	1995/96	1.044	1.003	1.048	0.932	1.003	0.976
	1996/97	1.050	1.124	1.180	0.917	1.124	1.082
	mean	**1.022**	**1.014**	**1.037**	**0.997**	**1.014**	**1.034**
SPAIN	1993/94	0.961	1.044	1.003	0.982	1.044	0.985
	1994/95	0.986	0.944	0.931	1.036	0.944	0.964
	1995/96	1.012	0.885	0.896	1.187	0.885	1.063
	1996/97	0.992	1.138	1.129	0.935	1.138	1.056
	mean	**0.987**	**0.998**	**0.986**	**1.031**	**0.998**	**1.016**
UK	1993/94	0.999	1.014	1.013	0.976	1.014	0.989
	1994/95	1.002	0.985	0.987	0.995	0.985	0.982
	1995/96	1.028	1.028	1.056	1.007	1.028	1.064
	1996/97	0.999	0.994	0.993	0.990	0.994	0.983
	mean	**1.007**	**1.005**	**1.012**	**0.992**	**1.005**	**1.004**

From table 6.12 it is possible to note that the TFP change for the French banking sector shows a decline over the 1993-1997 period; however, the TFP indices over the last two years seem to indicate a productivity growth. Only in 1996 did French banks register an improvement in their productive efficiency, while in all four years and for the overall period there occurred improvements in technological change. These results suggest an improvement in the performance of best practice banks (an almost constant increase in productivity, totalling a 2.4% improvement over the period), with the other institutions declining by 3.3% in productivity over the period. 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 French banking sector.

On the other hand, the overall TFP index for the German banking sector indicates a productivity decline over the period, but this decline seems to be mainly attributable to the deterioration of the performance of best practice banks (- 13.2% over the period). In four of the five years under investigation, and for the overall period, there occurred an improvement in productive efficiency. This 'catching up' with best practice increased productivity by 11.6% over the period, and most of this improvement can be related to scale efficiency change (+10.5% over the period) rather than pure technical efficiency change (only + 1% over the period, even though the trend in the rate of growth is positive). From these results it seems that in the German banking system the overall productivity has not improved during the period under investigation, and the most interesting features are the catching up with best practice institutions and the positive scale efficiency change, possibly signalling a reshaping of the sector as a whole.

The results relative to the Italian banking sector show a constant improvement in the TFP index with an overall increase in productivity of about 3.4%. This productivity growth seems to have been brought about by a deterioration of the performance of best practice institutions (the trend shows a constant decrease in the last 3 years of analysis) and the convergence towards best practice on the part of the remaining banks. The improvement in productive efficiency results from both increases in pure technical efficiency (+2.2% over the period) and in scale efficiency (+1.4% over the period).

Productivity change results for the Spanish banking sector can be summarised as follows: the geometric mean of the Malmquist TFP index exceeds unity for the last two years of analysis and, for the entire 1993-1997 period the geometric mean of annual Malmquist TFP index suggests a 1.6% productivity increase. The decomposition of the index offers an explanation for the measured productivity growth by the improvement in the best practice institutions. These results are consistent with other recent studies on the sources of productivity change in Spanish banking. Grifell-Tatjé and Lovell (1997) found evidence of productivity growth rates in excess of 2% per year within the sector. These results, which are consistent with Pastor (1995), but opposite to the finding of

Grifell-Tatjé and Lovell (1995c), seem to indicate that deregulation in the Spanish banking sector is achieving one of its main objective.

Finally, according to the Malmquist TFP results for the UK banking system, the period geometric mean of annual Malmquist TFP suggest a 0.4% productivity gain, even though the yearly mean exceed unity in only one year. The decomposition of the Malmquist TFP index seems to suggest that there has been a slight decline (-0.8%) in the performance of the best practice institutions, while there occurred an improvement in productive efficiency. This catching up with best practice increased productivity by 1.2% over the period (both pure technical efficiency and scale efficiency show an improvement). The picture that emerges is an almost constant rate of productivity change, resulting from a decline in the performance of the best practice institutions. Since production possibilities are determined by best practice, it appears that other institutions have been able to 'catch up' with best practice, i.e. converging towards the frontier. Overall, the progress indicated by the Malmquist TFP Index seems to be mainly due to a reduced spread of productivity levels within the UK banking industry.

Overall, these five European countries seem to have experienced different trends in productivity change, possibly attributable to varying competitive conditions in their respective banking sectors. The impact of banking deregulation and the relaxation of barriers to competition may also have impacted banks operating in individual banking markets in a diverse manner.

6.1.4 DEA Efficiency Estimates (Pooled European Sample)

This section reports the results of the analysis relative to the European common frontier. To allow for international comparison, we first define the common frontier following the traditional approach, that is building the EU frontier by pooling the data set for the banks in all five countries in the sample. This allows us to compare the banks of each country against the same benchmark.

Table 6.13 illustrates the average efficiency scores relative to the whole sample[8].

Table 6.13: DEA Efficiency Estimates (Euro5)

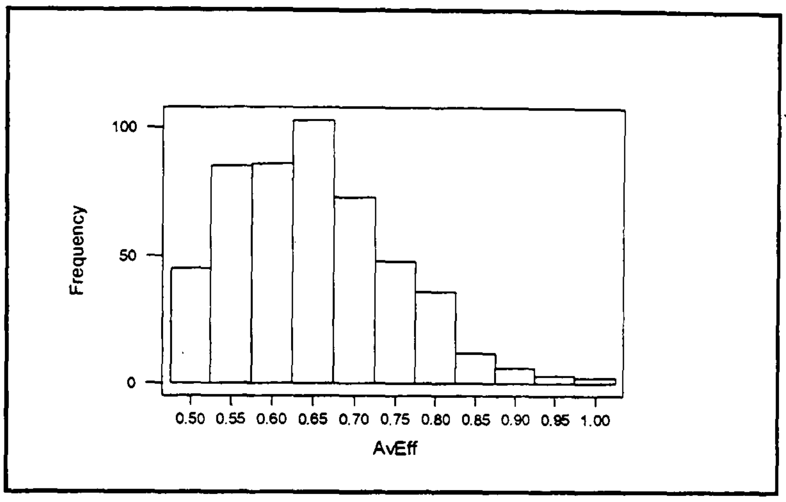
	CONSTANT RETURNS TO SCALE					VARIABLE RETURNS TO SCALE									
						INPUT BASED					OUTPUT BASED				
	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3	Mean	Med.	St. D.	Q1	Q3
1993 *(470)*	0.591	0.571	0.125	0.507	0.648	0.619	0.595	0.143	0.516	0.694	0.624	0.597	0.144	0.522	0.701
1994 *(484)*	0.634	0.616	0.111	0.552	0.700	0.651	0.631	0.125	0.558	0.719	0.654	0.632	0.126	0.562	0.720
1995 *(483)*	0.567	0.547	0.106	0.493	0.634	0.601	0.570	0.133	0.508	0.671	0.609	0.585	0.134	0.508	0.679
1996 *(499)*	0.602	0.569	0.137	0.496	0.670	0.630	0.585	0.151	0.520	0.702	0.635	0.593	0.153	0.522	0.726
1997 *(424)*	0.649	0.626	0.125	0.560	0.716	0.682	0.655	0.134	0.591	0.753	0.690	0.667	0.132	0.596	0.765

Note: The numbers in brackets refer to the number of observations.

Overall, the results show relatively low average efficiency scores; nevertheless, it is possible to detect a slight improvement in the efficiency levels through time (+6.3% according to the input-based approach and +6.6% according to the output-based approach, between 1993 and 1997). Figure 6.9 below illustrates the frequency distribution of average efficiency scores over the period of analysis. The majority of DMUs comprising the sample seem to cluster around levels of efficiency of around 0.65. This is the same range as those found in other recent studies on European bank efficiency using DEA [for example, Berg *et al.* (1993) found overall average efficiency of 0.58 for Finland, 0.78 for Norway and 0.89 for Sweden; European Commission (1997a) found average efficiency levels in the EU of 0.73; Pastor *et al.* (1997) report average efficiency levels equal to 0.79 and Dietsch and Weill (1998) found average efficiency levels in the EU of 0.64].

[8] It is important to remember that the sample comprises the largest banks in each country and that the number of banks comprising the sample changes in different years, in order to allow us to investigate the impact on cost efficiency of the restructuring process that has taken place in the five European countries during the time of analysis.

Figure 6.9: Frequency Distribution of Average DEA Efficiency Scores (Euro5)



It is of interest to analyse the relative position of each country on the European common frontier. These results are summarised in table 6.14 and in figure 6.10: it is possible to detect an improvement in the average bank productive efficiency scores for almost all countries in the sample over the period of analysis, with the exception of Italy, which records a slight decrease (-0.5% over the period). In particular, bank efficiency levels in Spain seem to have improved the most (+11% over the period) followed by the UK (+9.4%) and France (+4.6%). Overall, the results seem to indicate that the efficiency gap among countries grew wider over the period [in 1993, the difference between the banking system showing the higher efficiency levels (UK) and the one showing the lowest (Spain) was 19.1% while in 1997, the difference in efficiency levels between the UK and Italy was equal to 26.6%][9].

[9] The non-parametric Mann-Whitney test was used for testing the null hypothesis that the central locations of the two populations are the same against the one-sided alternative that the central location of the 1993 efficiency scores is lower than that of 1997: according to the results of the test, the null hypothesis is to be rejected at 99% confidence interval.

Table 6.14: DEA Efficiency Estimates (VRS – Input Based) (Pooled European Sample)

	France		Germany		Italy		Spain		UK	
	Mean	St. D.	Mean	St. D.	Mean	St. D.	Mean	St. D.	Mean	St. D.
1993	0.607	0.179	0.697	0.132	0.558	0.080	0.534	0.096	0.725	0.108
1994	0.648	0.144	0.725	0.109	0.567	0.064	0.590	0.081	0.763	0.089
1995	0.589	0.139	0.690	0.121	0.502	0.066	0.540	0.079	0.772	0.096
1996	0.620	0.136	0.724	0.128	0.508	0.059	0.544	0.071	0.829	0.108
1997	0.653	0.121	0.762	0.118	0.553	0.063	0.644	0.074	0.819	0.114

Figure 6.10: DEA Efficiency Scores (Pooled European Sample)

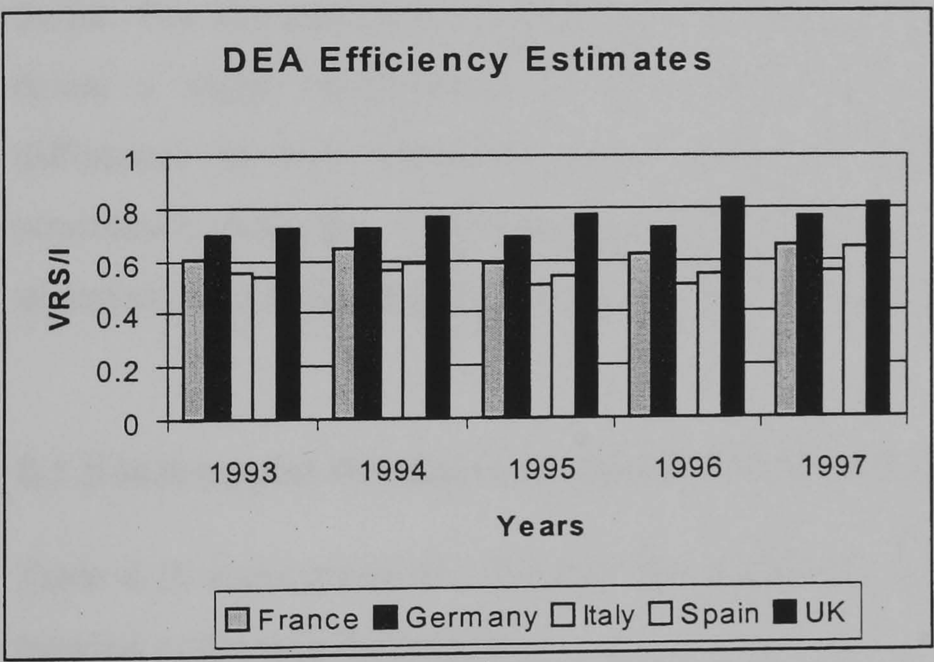


Table 6.15 illustrates the composition of the European efficient frontier. It is worth remembering that in DEA methodology the efficient frontier is generated by the input/output combination of the 'best-practice' units, i.e. by those DMUs which achieved an efficiency score of unity. In other words, DEA establishes a 'benchmark' efficiency score of unity that no individual firm can exceed. This benchmark is a linear combination of efficient banks in a sample, which constitute the reference technology for the sample.

Table 6.15: Composition of the Euro5 Efficient Frontier (VRS)

NUMBER OF EFFICIENT BANKS	1993	1994	1995	1996	1997
FRANCE	8	7	4	6	4
GERMANY	7	8	7	8	7
ITALY	-	-	-	-	-
SPAIN	1	-	-	1	1
UK	4	3	2	6	6
EURO5	20	18	13	21	18

It is possible to note that the influence of the banks of each country changes slightly, with the importance of French banks in building the frontier decreasing in favour of UK banks. The aforementioned results seem to suggest that, even though it is possible to detect a slight improvement in the overall efficiency scores, there are marked differences in bank efficiency levels across EU countries. This seems to be in accordance with the assumption that country-specific characteristics still play an important part in the explanation of bank efficiency levels.

6.1.5 Malmquist Productivity Indices (Pooled European Sample)

Table 6.16 summarises the results of the Malmquist TFP for the five main European banking systems in the sample.

Table 6.16: Malmquist Index (Summary of Annual Means) (Euro5)

Years	Pure Technical Efficiency Change	Scale Efficiency Change	Efficiency Change	Technological Change	Total Factor Productivity Change
1993/94	0.987	1.027	1.014	0.990	1.003
1994/95	1.007	0.976	0.983	0.996	0.978
1995/96	1.023	1.380	1.413	0.735	1.038
1996/97	1.086	1.500	1.629	0.632	1.029
mean	**1.025**	**1.200**	**1.231**	**0.822**	**1.012**

Overall, one can detect TFP growth during the period. This productivity growth seems to have been brought about by a deterioration of the performance of the best practice institutions (the trend shows a steady decrease during the last three years of analysis) and the convergence towards best practice on the part of the remaining banks. This improvement in productive efficiency results mostly from a sharp increase in scale efficiency (+20% over the period) rather than in pure technical efficiency (+2.5% over the period). It may be possible to relate these results to the restructuring of the EU banking systems, as described in Chapter 3. In particular, the wave of M&A activity during the period under observation has resulted in a substantial decrease in the number of banks [see table 3.2, which shows an EU-wide percentage of change over the 1990-1997 period of –22%]. This trend towards consolidation is possibly reflected in the substantial scale efficiency change. On the other hand, the small but positive technical efficiency change may be though of as reflecting the efforts of EU banks towards cutting costs.

6.1.6 FDH Efficiency Estimates (Pooled European Sample)

Aggregate statistics of the FDH[10] efficiency estimates for the input based model relative to the pooled European frontier are reported in table 6.17. (The results relative to the output-based model are shown in table 6.18). From the Euro5 rows in table 6.17 it possible to identify the total number of observations found to be inefficient in every year. The percentage of inefficient banks on the total sample show a decreasing trend, from 17% of inefficient observations in 1993 to 11% in 1997 (with a slight increase in 1996).

[10] Individual countries FDH efficiency estimates were calculated but, possibly due to the relatively small sample size, the results were found to be not informative (i.e. all DMUs showed efficiency scores equal to one). Therefore, only the FDH estimates relative to the pooled EU sample are presented. In this study, FDH efficiency measures are evaluated by using a program written in GAMS by K. Kerstens of LABORES, Université Catholique de Lille, France.

On the other hand, as much as 89% observations in 1997 appear to be undominated. Within this rather large subset, it is possible to further distinguish those observations which are both efficient and dominating. The 'superiority of behaviour' for these 'best practice' European banks is hardly questionable. It appears to be a rather stable group of 'top performers', ranging between 7% and 8% of the whole sample. According to the FDH methodology, we define the remaining observations as 'efficient by default', defined by the fact that there is no other observation in the data set they dominate. According to Tulkens (1993), the 'efficiency' label for these observations actually amounts to one of 'non-comparability'.

To summarise, the FDH methodology enables us to identify three distinct groups of observations: a group comprising 7%-8% of banks in the sample are 'best-practice'; a group of 11%-17% of banks in the sample that are inefficient and 75% to 82% that are non comparable.

Table 6.17: Summary Statistics of FHD Efficiency Results (Input based Approach)

Country		Efficient Observations						Inefficient Observations		Average FDH Efficiency Scores
1993	Number of Obs.	Efficient and Dominating		Efficient by Default		Total efficient		Total inefficient		
		N.	%	N.	%	N.	%	N.	%	
France	94	8	*0.08*	78	*0.83*	86	*0.92*	8	*0.08*	0.9977
Germany	107	19	*0.17*	85	*0.79*	104	*0.97*	3	*0.03*	0.9991
Italy	111	6	*0.05*	72	*0.64*	78	*0.70*	33	*0.30*	0.9475
Spain	90	2	*0.02*	59	*0.66*	61	*0.68*	29	*0.32*	0.9623
UK	68	-	-	62	*0.91*	62	*0.91*	6	*0.88*	0.9939
Euro5	470	35	*0.07*	356	*0.76*	391	*0.83*	79	*0.17*	0.9790
1994	Number of Obs.	Efficient and Dominating		Efficient by Default		Total efficient		Total inefficient		
		N.	%	N.	%	N.	%	N.	%	
France	102	7	*0.07*	80	*0.78*	87	*0.85*	15	*0.15*	0.9946
Germany	107	21	*0.20*	83	*0.77*	104	*0.97*	3	*0.03*	0.9990
Italy	115	9	*0.08*	84	*0.73*	93	*0.81*	22	*0.19*	0.9896
Spain	91	4	*0.04*	69	*0.76*	73	*0.80*	18	*0.20*	0.9852
UK	69	-	-	68	*0.98*	68	*0.98*	1	*0.02*	0.9985
Euro5	484	41	*0.08*	384	*0.79*	425	*0.88*	59	*0.12*	0.9932
1995	Number of Obs.	Efficient and Dominating		Efficient by Default		Total efficient		Total inefficient		
		N.	%	N.	%	N.	%	N.	%	
France	103	7	*0.07*	73	*0.71*	80	*0.78*	23	*0.22*	0.9852
Germany	111	26	*0.23*	81	*0.73*	107	*0.96*	4	*0.04*	0.9982
Italy	112	4	*0.04*	91	*0.81*	95	*0.85*	17	*0.15*	0.9853
Spain	91	2	*0.02*	72	*0.79*	74	*0.81*	17	*0.19*	0.9912
UK	66	1	*0.01*	63	*0.95*	64	*0.97*	2	*0.03*	0.9995
Euro5	483	40	*0.08*	380	*0.77*	420	*0.87*	63	*0.13*	0.9913
1996	Number of Obs.	Efficient and Dominating		Efficient by Default		Total efficient		Total inefficient		
		N.	%	N.	%	N.	%	N.	%	
France	101	3	*0.03*	80	*0.79*	83	*0.82*	18	*0.18*	0.9891
Germany	111	25	*0.22*	75	*0.68*	100	*0.90*	11	*0.10*	0.9936
Italy	112	11	*0.10*	84	*0.75*	95	*0.85*	17	*0.15*	0.9917
Spain	111	1	*0.01*	86	*0.77*	87	*0.78*	24	*0.22*	0.9828
UK	67	-	-	62	*0.92*	62	*0.92*	5	*0.08*	0.9937
Euro5	499	40	*0.08*	384	*0.77*	424	*0.85*	75	*0.15*	0.9899
1997	Number of Obs.	Efficient and Dominating		Efficient by Default		Total efficient		Total inefficient		
		N.	%	N.	%	N.	%	N.	%	
France	93	5	*0.05*	73	*0.79*	78	*0.84*	15	*0.16*	0.9909
Germany	99	19	*0.19*	70	*0.71*	89	*0.90*	10	*0.10*	0.9935
Italy	77	4	*0.05*	67	*0.87*	72	*0.93*	5	*0.07*	0.9969
Spain	94	2	*0.02*	80	*0.85*	82	*0.87*	12	*0.13*	0.9933
UK	61	-	-	55	*0.90*	55	*0.90*	6	*0.10*	0.9937
Euro5	424	30	*0.07*	346	*0.82*	376	*0.89*	48	*0.11*	0.9935

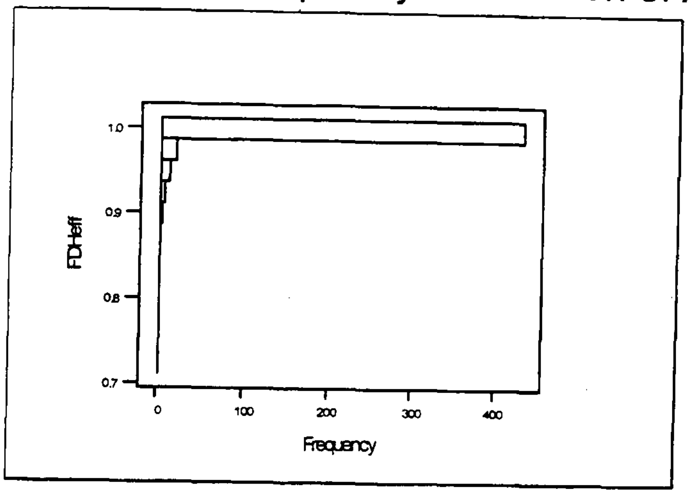
Table 6.18: Summary Statistics of FHD Efficiency Results (Output based Approach)

Country		Efficient Observations						Inefficient Observations		Average FDH Efficiency Scores
1993	Number of Obs.	Efficient and Dominating		Efficient by Default		Total efficient		Total inefficient		
		N.	%	N.	%	N.	%	N.	%	
France	94	6	*0.06*	80	*0.85*	86	*0.91*	8	*0.09*	0.9963
Germany	107	22	*0.21*	84	*0.78*	106	*0.99*	1	*0.01*	0.9997
Italy	111	8	*0.07*	70	*0.63*	78	*0.70*	33	*0.30*	0.9693
Spain	90	2	*0.02*	59	*0.66*	61	*0.68*	29	*0.32*	0.9706
UK	68	-	-	62	*0.92*	62	*0.92*	6	*0.08*	0.9958
Euro5	470	38	*0.08*	355	*0.75*	393	*0.84*	77	*0.16*	0.9857
1994	Number of Obs.	Efficient and Dominating		Efficient by Default		Total efficient		Total inefficient		
		N.	%	N.	%	N.	%	N.	%	
France	102	6	*0.06*	81	*0.79*	87	*0.85*	15	*0.15*	0.9923
Germany	107	25	*0.23*	79	*0.74*	104	*0.97*	3	*0.03*	0.9992
Italy	115	8	*0.07*	84	*0.73*	92	*0.80*	23	*0.20*	0.9905
Spain	91	4	*0.04*	69	*0.76*	73	*0.80*	18	*0.20*	0.9909
UK	69	1	*0.01*	66	*0.96*	67	*0.97*	2	*0.03*	0.9993
Euro5	484	44	*0.09*	379	*0.78*	423	*0.87*	61	*0.13*	0.9941
1995	Number of Obs.	Efficient and Dominating		Efficient by Default		Total efficient		Total inefficient		
		N.	%	N.	%	N.	%	N.	%	
France	103	7	*0.07*	73	*0.71*	80	*0.78*	23	*0.22*	0.9812
Germany	111	25	*0.22*	82	*0.74*	107	*0.96*	4	*0.04*	0.9973
Italy	112	5	*0.04*	88	*0.79*	93	*0.83*	19	*0.17*	0.9887
Spain	91	2	*0.02*	72	*0.79*	74	*0.81*	17	*0.19*	0.9869
UK	66	1	*0.01*	63	*0.96*	64	*0.97*	2	*0.03*	0.9955
Euro5	483	40	*0.08*	378	*0.78*	418	*0.86*	65	*0.14*	0.9897
1996	Number of Obs.	Efficient and Dominating		Efficient by Default		Total efficient		Total inefficient		
		N.	%	N.	%	N.	%	N.	%	
France	101	2	*0.02*	81	*0.80*	83	*0.82*	18	*0.18*	0.9768
Germany	111	24	*0.22*	75	*0.67*	99	*0.89*	12	*0.11*	0.9938
Italy	112	13	*0.12*	81	*0.72*	94	*0.84*	18	*0.16*	0.9893
Spain	111	1	*0.01*	86	*0.77*	87	*0.78*	24	*0.22*	0.9754
UK	67	-	-	62	*0.92*	62	*0.92*	5	*0.08*	0.9964
Euro5	499	40	*0.08*	382	*0.76*	422	*0.84*	77	*0.16*	0.9862
1997	Number of Obs.	Efficient and Dominating		Efficient by Default		Total efficient		Total inefficient		
		N.	%	N.	%	N.	%	N.	%	
France	93	4	*0.04*	74	*0.80*	78	*0.84*	15	*0.16*	0.9900
Germany	99	16	*0.16*	73	*0.74*	89	*0.90*	10	*0.10*	0.9945
Italy	77	4	*0.05*	68	*0.88*	72	*0.93*	5	*0.07*	0.9976
Spain	94	2	*0.02*	80	*0.85*	82	*0.87*	12	*0.13*	0.9895
UK	61	-	-	55	*0.90*	55	*0.90*	6	*0.10*	0.9947
Euro5	424	26	*0.06*	350	*0.82*	376	*0.88*	48	*0.12*	0.9930

Turning to the average efficiency scores, they appear to be quite high (from 0.93 in 1993 to 0.99 in 1997), due to the large percentage of observations which are found 100% efficient, and show an increasing trend[11].

Figure 6.11 illustrates the frequency distribution of FHD average efficiency scores. It exhibits the typical FHD decreasing shape (Tulkens 1993), with the number of inefficiency cases declining when the inefficiency increases.

Figure 6.11 Frequency Distribution of Average FDH Efficiency Scores



6.2 An Analysis of 'Consistency Conditions'

In a recent paper Bauer *et al.* (1997) proposed a set of 'consistency conditions' that efficiency measures derived form the various approaches should meet to be most useful for regulators or other decision makers[12].

[11] Due to the specifications of the FDH model or to the characteristics of the sample, a very large number of observations turned out to be 100% efficient. It is necessary, however, to remember that around 80% of the observations in the sample are labelled 'non-comparable' according to the FDH methodology. In other words, these observations are not necessarily 100% efficient, but there is a lack of any 'peer' to benchmark these efficiency levels.

[12] See Section 4.4.3.

Basically, the efficiency estimates derived from the different approaches should be consistent in their efficiency levels, rankings and identification of best and worse firms, consistent over time and with competitive conditions in the market; finally, they should be consistent with standard non-frontier measures of performance.

This study investigates the consistent-with-reality or believability conditions, particularly the stability of efficiency scores over time and their consistency with standard non-frontier approaches. Evidence on these aspects is rather limited at present and the results are quite mixed across studies. The standard non-frontier measures of performance to which efficiency scores should be positively correlated are in general identified as the Return on Assets (ROA), Return on Equity (ROE) and the Cost/Income Ratio (C/I). These ratios have been chosen even in this empirical analysis 'because they proxy for key and fundamental aspects of bank strategic management; that is, taken together they proxy for productive efficiency' (Carbo *et al.*, 1999).

6.2.1 Consistency Tests: The Stability of Efficiency Scores Over Time

As pointed out by Bauer *et al.* (1997) it is important that the efficiency measures demonstrate reasonable stability over time. To test for consistency over time, the Spearman rank order correlation for DEA efficiency measures between each pair of years was calculated. Table 6.19 presents the average Spearman rank correlation coefficients.

Table 6.19: Stability over Time (Spearman Rank Correlation)

	1993	1994	1995	1996	1997
FRANCE					
1993	1	**0.737**	0.751	0.737	0.521
1994		1	**0.637**	0.817	0.729
1995			1	**0.766**	0.523
1996				1	**0.848**
1997					1
GERMANY					
1993	1	**0.376**	0.461	0.402	0.330
1994		1	**0.854**	0.857	0.821
1995			1	**0.915**	0.845
1996				1	**0.870**
1997					1
ITALY					
1993	1	**0.675**	0.665	0.663	0.576
1994		1	**0.787**	0.784	0.667
1995			1	**0.786**	0.674
1996				1	**0.763**
1997					1
SPAIN					
1993	1	**0.658**	0.469	0.372	0.380
1994		1	**0.744**	0.635	0.613
1995			1	**0.782**	0.770
1996				1	**0.848**
1997					1
U.K.					
1993	1	**0.642**	0.240	0.627	0.285
1994		1	**0.482**	0.579	0.227
1995			1	**0.395**	0.461
1996				1	**0.519**
1997					1

The correlation coefficients are all positive and high over all the available lags, even though they predictably decline over time. This suggest that many of the 'best practice' and 'worst practice' banks tend to remain so over time and satisfy the condition requiring stability over time.

6.2.2 Correlation with Standard Non-Frontier Measures of Performance

Efficiency measures should be positively correlated with standard non-frontier measures of performance. As pointed out by Bauer *et al.* (1997), positive correlation with these measures would give evidence that the frontier measures are not simply artificial products. The correlation between the efficiency measures and the accounting ratios of performance is not, however, expected to be close to 1.00, since the accounting ratios embody not only the efficiencies but also the effects of differences in input prices and other exogenous variables. Table 6.20 shows the correlation between the efficiencies generated by the DEA methodology (both CRS and VRS) and the Return on Average Assets (ROAA), the Return on Average Equity (ROAE) and the negative of the Cost/Income Ratio (-C/I)[13]. To reduce the effect of noise, the rank-order correlation of the average efficiencies and average accounting ratios over time are presented.

Table 6.20: DEA Efficiency Correlation with Standard Non-Frontier Performance Measures

	France	Germany	Italy	Spain	UK	Average
ROAA	0.161	-0.081	0.067	0.098	0.028	0.055
ROAE	0.062	0.023	-0.031	-0.097	0.105	0.012
-C/I	0.195	0.034	0.117	0.164	0.025	0.107

Looking at the results reported in table 6.20, twelve of the fifteen correlation between DEA efficiency scores and accounting ratios are positive (although some are barely so). The cost/income ratio seems to be the accounting measure most closely correlated to DEA efficiency scores. Overall, the simple average of the fifteen correlations, equal to 0.058, seem to suggest that DEA efficiency is at best weakly related to the chosen indicators of firm performance. These results, which are consistent with previous findings[14], seem to suggest the need to complete the analysis of the efficiency results generated by non-parametric methodologies by employing appropriate statistical tools to enable the researcher to draw inference from the findings.

[13] The negative sign is used to simplify the discussion, all three measures should be positively correlated with frontier efficiency.

[14] Bauer at al. (1997) found an overall correlation between DEA efficiency scores and accounting ratios of 0.053.

6.3 Determinants of European Bank Efficiency

To examine the determinants of European bank efficiency we follow the so-called Two-Step approach, as suggested by Coelli *et al.* (1998). Using the efficiency measures derived from the DEA estimations as the dependent variable, we then estimate the following Tobit regression model[15]:

$$\theta_i = \beta_1 FRA + \beta_2 GER + \beta_3 ITA + \beta_4 SPA + \beta_5 UK + \beta_6 ETA + \beta_7 ROAE + \beta_8 COMM + \beta_9 QUOT + \varepsilon_i \quad (6.1)$$

where:

1. FRA, GER, ITA, SPA and UK are dummy variables indicating the country of origin of the bank (= 1 if based in the country; = 0 otherwise);
2. ETA: Equity/Total Assets;
3. ROAE: Return on Average Equity;
4. COMM = 1 if a commercial bank; = 0 otherwise;
5. QUOT = 1 if the bank is listed on the Stock Exchange; = 0 otherwise.

Country dummies (FRA, GER, ITA, SPA and UK) are used to distinguish between the country of origin of the banks in the sample. We then use the average capital and profitability ratios. The average capital ratio is measured by equity over total assets (E/TA) while the profitability ratio is defined as the Return on Average Equity (ROAE). In the empirical literature, other studies [see Mester (1996); Pastor et al. (1997); Carbo *et al.* (1999)] have found positive relationships both between ROE and efficiency (i.e., the larger the profits, the higher the efficiency) and between E/TA and efficiency (i.e. lower E/TA leads to lower efficiency levels, because lower equity ratios imply a higher risk-taking propensity and greater leverage, which could result in greater borrowing costs). We introduce the dummy variable COMM in order to detect whether there are efficiency differences between commercial banks and other types of banks (such as

[15] The Tobit regression analysis is computed in Limdep 7.0.

savings and co-operative banks). Finally, the dummy variable QUOT is included to distinguish between quoted and non-quoted banks.

To test for differences between the country dummy coefficients, we test the null hypothesis $H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5$ against the alternative hypothesis (H_1) that one pair at least is unequal in each year. Finally, in order to investigate possible determinants of bank efficiency, we test the following hypothesis at $\alpha = 0.05$ significance level: $H_0 : \beta_{6,7,8,9} = 0$ vs. $H_1 : \beta_{6,7,8,9} \neq 0$.

The results of the Tobit regression analysis (with degrees of freedom equal to 369) are summarised in the following tables:

Table 6.21: Tobit Regression Analysis (1993)

	$\hat{\beta}_j$	**Std. Error**	**t value**	**Pr** $(>\lvert t \rvert)$	**Hypothesis Testing**
β_1	.628416	.018059	34.798	.0000	
β_2	.740559	.015776	46.942	.0000	
β_3	.565592	.024866	22.745	.0000	
β_4	.529152	.021563	24.539	.0000	
β_5	.757705	.021366	35.464	.0000	
β_6	.0000333	.0025217	.013	.9895	Accept H_0
β_7	.0005445	.0003128	1.740	0.0818	Accept H_0
β_8	.0020804	.0149369	.139	.8892	Accept H_0
β_9	.0647023	.0185407	3.490	.0005	Reject H_0

Table 6.22: Tobit Regression Analysis (1994)

	$\hat{\beta}_j$	Std. Error	t value	Pr (>|t|)	Hypothesis Testing
β_1	.722489	.0113681	52.8085	.0000	
β_2	.785564	.011820	67.3038	.0000	
β_3	.644545	.018974	33.9692	.0000	
β_4	.654217	.016146	40.5185	.0000	
β_5	.785788	.016326	48.1301	.0000	
β_6	.132317E-02	.184337E-02	.717801	.4729	Accept H_0
β_7	.295890E-03	.326345E-03	.906678	.3646	Accept H_0
β_8	.531899E-02	.011247	.472934	.6363	Accept H_0
β_9	.30135	.013720	2.19645	.0281	Reject H_0

Table 6.23: Tobit Regression Analysis (1995)

	$\hat{\beta}_j$	Std. Error	t value	Pr (>|t|)	Hypothesis Testing
β_1	.643098	.017291	37.1920	.0000	
β_2	.754802	.014508	52.0265	.0000	
β_3	.555382	.022040	25.1992	.0000	
β_4	.585460	.020944	27.9531	.0000	
β_5	.731742	.019778	36.9972	.0000	
β_6	-203572E-02	.220280E-02	-.924154	.3554	Accept H_0
β_7	.131381E-02	.636268E-03	2.06587	.0389	Reject H_0
β_8	-.33813E-02	.012845	-.263234	.7924	Accept H_0
β_9	.058225	.015857	3.67186	.0002	Reject H_0

Table 6.24: Tobit Regression Analysis (1996)

	$\hat{\beta}_j$	Std. Error	t value	Pr $(>\|t\|)$	Hypothesis Testing
β_1	.610190	0.14786	41.2684	.0000	
β_2	.719010	.012675	56.7248	.0000	
β_3	.481954	.017506	27.5314	.0000	
β_4	.518734	.017213	30.1356	.0000	
β_5	.783748	.016999	46.1043	.0000	
β_6	.562716E-02	.145072E-02	3.87887	.0001	Reject H_0
β_7	-.11383E-03	.399853E-03	-.284687	.7759	Accept H_0
β_8	.469199E-02	.013359	.351225	.7254	Accept H_0
β_9	.053910	.016660	3.23599	.0012	Reject H_0

Table 6.25: Tobit Regression Analysis (1997)

	$\hat{\beta}_j$	Std. Error	t value	Pr $(>\|t\|)$	Hypothesis Testing
β_1	.622509	.017445	35.6843	.0000	
β_2	.732809	.014637	50.0659	.0000	
β_3	.500420	.022235	22.5055	.0000	
β_4	.580022	.021130	27.4496	.0000	
β_5	.791588	.019954	396707	.0000	
β_6	.357723E-02	.222236E-02	1.60965	.1075	Accept H_0
β_7	.231090E-02	.641920E-03	3.59998	.0003	Reject H_0
β_8	.018185	.012959	1.40322	.1606	Accept H_0
β_9	.037875	.015998	2.36745	.0179	Reject H_0

The coefficients $\beta_1, \beta_2, \beta_3, \beta_4, \beta_5$ of the dummy variables (FRA, GER, ITA, SPA and UK) represent the intercepts for the five banking systems under study. In order to test the influence of the geographical location, we tested the null hypothesis $H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5$ against the alternative hypothesis (H_1) that one pair at least is unequal in each year. The results of the F-test allowed us to reject the null hypothesis in every year[16].

[16] F-test (df_1= 4;df_2= 374): 1993 = 4730.862; 1994= 1588.623; 1995= 1682.859; 1996= 4730.246; 1997= 2640.862.

The results note that although there is a positive sign on the (E/TA) variable, generally it is not statistically significant at the 5% level. (In fact, we only find the equity ratio to have a positive statistically significant relation to efficiency in our 1996 estimates). As such, there does not appear to be a strong relationship between variation in bank equity and efficiency levels. In contrast, ROAE is positively related to bank efficiency; in our 1995 and 1997 estimates profitable banks appear more efficient. However, this relationship is only found to hold in two of the years of analysis. The results also suggest that commercial banks are no more efficient than their savings and co-operative bank counterparts. The positive and statistically significant sign on the QUOT variable (a relationship found in all our yearly estimates) indicates that listed banks are more efficient than their non-listed counterparts.

However confident we may feel about these results, we need to take into account the problem of the inherent dependency of efficiency scores when used in regression analysis. To recall, the reason for dependency is the well-known fact that the DEA efficiency score is a relative efficiency index. Because of the presence of the inherent dependency among the efficiency scores, one basic model assumption required by regression analysis, independence within the sample, is violated. As noted by Xue and Harker (1999), the conventional procedure, as outlined so far in this chapter, may be inappropriate and the results could be misleading. In an attempt to overcome this problem, a bootstrapping technique is applied.

6.3.1 The Bootstrapping Procedure[17]

Following Xue and Harker (1999), the bootstrap method is implemented as follows:

- Construct the sample probability distribution $\hat{F}$, assigning probability of 1/379 at each DMU in the observed sample[18].

[17] The computer routine to perform the described procedure has been written by C. Verdes, University of AL I CUZA, Iasi, Romania – SEES, University of Wales, Bangor.
[18] To complete this exercise, we considered a balanced sample on a pooled European basis.

- Take c = 1000 random samples of size 379 with replacement from the observed sample of 379 European banks. These samples are the bootstrap samples.
- Compute the DEA efficiency scores for each bootstrap sample.
- Within each bootstrap sample, fit the following regression model:

$$\hat{\theta}_{ki} = \hat{\beta}_{k1} FRA + \hat{\beta}_{k2} GER + \hat{\beta}_{k3} ITA + \hat{\beta}_{k4} SPA + \hat{\beta}_{k5} UK +$$

$$+ \hat{\beta}_{k6} ETA_{ki} + \hat{\beta}_{k7} ROAE_{ki} + \hat{\beta}_{k8} COMM_{ki} + \hat{\beta}_{k9} QUOT_{ki} + \varepsilon_{ki} \qquad (6.2)$$

for i = 1,2, …, 379; k = 1,2,…,1000.

Here θ_{ki} is the DEA efficiency score for DMU *i* in bootstrap sample *k* and $\hat{\beta}_{kj}$ (j=1,…9) are the bootstrap replications for $\hat{\beta}_j$ in bootstrap sample k.

- Estimate the standard error $se(\hat{\beta}_j)$ by the sample standard deviation of the *c* bootstrap replications of $\hat{\beta}_j$

$$\hat{s}e_c\left(\hat{\beta}\right) = \left\{ \sum_{k=1}^{c} \left(\beta_{kj} \hat{-} \overline{\beta_j}\right)^2 \Big/ (c-1) \right\}^{1/2}, \quad j=1,2,\dots,m \qquad (6.3)$$

where

$$\overline{\beta_j} = \frac{\sum_{k=1}^{c} \hat{\beta}_{kj}}{c}, \qquad j=1,2,\dots,9 \qquad c = 1000 \qquad (6.4)$$

- Calculate the *t*-statistic according to equation

$$t = \frac{\hat{\beta}_j}{\hat{se}_c\left(\hat{\beta}_j\right)}, \qquad (6.5)$$

and then test the individual hypothesis $H_0 : \beta_j = 0$ against the two-sided alternative $H_0 : \beta_j \neq 0$ at $\alpha = 0.05$ significant level.

The results of the bootstrapping procedure shown in tables 6.25 to 6.30.

Table 6.26: Bootstrap Tobit Regression with C = 1000 Samples (1993)

	$\hat{\beta}_j$	$\bar{\beta}_j$	$\hat{se}_{100}\left(\hat{\beta}_j\right)$	t value	Hypothesis Testing
β_1	.628416	.676553	.052819	11.89753	
β_2	.740559	.776139	.033371	22.19168	
β_3	.565592	.609849	.050313	11.24147	
β_4	.529152	.571722	.047938	11.03825	
β_5	.757705	.788606	.029285	25.87347	
β_6	.0000332485	.000501	.003321	0.010012	Accept H_0
β_7	.000544515	.000460	.000382	1.425434	Accept H_0
β_8	.00208044	.005369	.016981	0.122516	Accept H_0
β_9	.0647023	.062147	.027051	2.391862	Reject H_0

Table 6.27: Bootstrap Tobit Regression with C = 1000 Samples (1994)

	$\hat{\beta}_j$	$\bar{\beta}_j$	$\hat{se}_{100}\left(\hat{\beta}_j\right)$	t value	Hypothesis Testing
β_1	.722489	.741347	.031735	22.76631	
β_2	.795564	.815620	.029239	27.209	
β_3	.644545	.665026	.040140	16.05742	
β_4	.654217	.672066	.032637	20.04526	
β_5	.785788	.816669	.029793	26.37492	
β_6	.00132317	.001818	.002383	0.555254	Accept H_0
β_7	.000295890	.000326	.000575	0.514591	Accept H_0
β_8	.00531899	.011047	.013562	0.392198	Accept H_0
β_9	.030135	.032408	.017517	1.720329	Accept H_0

Table 6.28: Bootstrap Tobit Regression with C = 1000 Samples (1995)

	$\hat{\beta}_j$	$\bar{\beta}_j$	$\hat{se}_{100}\left(\hat{\beta}_j\right)$	t value	Hypothesis Testing
β_1	.643098	.681423	.040642	15.82348	
β_2	.754802	.790288	.030779	24.52328	
β_3	.555382	.598257	.051829	10.71566	
β_4	.585460	.620156	.040030	14.62553	
β_5	.731742	.770682	.038527	18.99297	
β_6	-.00203572	-.001273	.002980	-0.68313	Accept H_0
β_7	.00131381	.001092	.000790	1.663051	Accept H_0
β_8	-.0033813	-.001622	.016602	-0.20367	Accept H_0
β_9	.058225	.057351	.025906	2.247549	Reject H_0

Table 6.29: Bootstrap Tobit Regression with C = 1000 Samples (1996)

	$\hat{\beta}_j$	$\bar{\beta}_j$	$\hat{se}_{100}\left(\hat{\beta}_j\right)$	t value	Hypothesis Testing
β_1	.610190	.662319	.042511	14.3537	
β_2	.719010	.771952	.037906	18.96824	
β_3	.481954	.551079	.062123	7.758061	
β_4	.518734	.572392	.044392	11.6853	
β_5	.783748	.825845	.029934	26.18253	
β_6	.00562716	.004095	.003039	1.851649	Accept H_0
β_7	-.00011383	-.000241	.001016	-0.11204	Accept H_0
β_8	.00469199	.004730	.017498	0.268144	Accept H_0
β_9	.053910	.053397	.025292	2.131504	Reject H_0

Table 6.30: Bootstrap Tobit Regression with C = 1000 Samples (1997)

	$\hat{\beta}_j$	$\bar{\beta}_j$	$\hat{se}_{100}\left(\hat{\beta}_j\right)$	t value	Hypothesis Testing
β_1	.622509	.666153	.041083	15.15247	
β_2	.732809	.769757	.031524	23.24607	
β_3	.500420	.565224	.071447	7.004073	
β_4	.580022	.622903	.039952	14.51797	
β_5	.791588	.811953	.025614	30.90451	
β_6	.003577	.004325	.002895	1.235579	Accept H_0
β_7	.002310	.001906	.01010	0.228713	Accept H_0
β_8	.018185	.020081	.015789	1.151751	Accept H_0
β_9	.037875	.034222	.026283	1.441046	Accept H_0

Comparing the results of the bootstrap regression to the results of the direct Tobit regression, the first conclusion we can draw is that the bootstrap method helps us to reduce the ambiguity of the responses of the hypothesis testing. In fact, the coefficients $\beta_1, \beta_2, \beta_3 \beta_4, \beta_5$ lead us to the same conclusions reached earlier[19] (i.e. geographic location influences average efficiency levels), we also find little evidence to support the hypothesis that the average capital ratio (E/TA) and the Return on Average Equity (ROAE) influence bank efficiency levels. These latter results, contrast with the positive relationship between both ROAE and E/TA and efficiency levels found in previous studies [see Mester (1996); Pastor et al. (1997); Carbo et al. (1999)] and the positive statistically significant relationship between ROAE and efficiency presented in some of our earlier non bootstrapped results. Overall, these findings seem to suggest that inference on the determinants of bank efficiency drawn from non-bootstrapped regression analysis may be biased and misleading. Note also that in the bootstrap estimates the QUOT dummy is found to be statistically significant at the 5% level in 1993, 1995 and 1996, compared with the conventional Tobit estimates, where QUOT was statistically significant in all years under study. (The COMM dummy was

[19] Results of the F-test allow us to reject the null hypothesis $H_0 : \beta_1 = \beta_2 = \beta_3 = \beta_4 = \beta_5$ against the alternative hypothesis (H_1) that one pair at least is unequal in each year.

statistically insignificant for all years using both the conventional and the bootstrap estimations).

Overall, both the bootstrap and the conventional Tobit results presented above suggest that most of the efficiency differences found across European banking systems are due to country-specific aspects of the banking technology. This can be thought of as reflecting both the legacy of different banking regulations and the different managerial strategies implemented to face up to the new challenges brought about by information technology, financial innovation and greater competition within the European banking market. These results, to a certain extent, confirm previous findings[20] and lead us to conclude that country-specific factors are still important determinants in explaining differences in bank efficiency levels across Europe. In addition, these findings suggest that the EU's SMP has not had a major influence in promoting a convergence of bank efficiency levels.

6.4 Conclusions

This chapter investigated whether there has been an improvement and convergence of productive efficiency across European banking markets since the creation of the Single Internal Market. Non-parametric approaches, in the form of Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH) were applied. In addition, productivity changes across banking markets were calculated using the Malmquist Productivity Index (MPI).

Using efficiency measures derived from DEA estimation this chapter also evaluated the determinants of European bank efficiency using the Tobit regression model approach. To overcome the inherent dependency problem of DEA efficiency scores when used in regression analysis, we followed the approach suggested by Xue and Harker (1999) and applied a bootstrapping technique.

The first part of the empirical analysis estimated DEA efficiency scores for five selected European banking systems, namely France, Germany, Italy, Spain and the UK,

[20] For example, Pastor *et al.* (1997) conclude that the country-specific environmental factors exercise a strong influence over the average efficiency score of each country.

relative to their own national frontier. According to country estimates, these European countries seem to have increased the average level of productive efficiency of their banking systems during the period under investigation. The most efficient banking sectors appear to be those of Spain, the UK and Italy, while in the French and German banking systems there seems to exist still substantial cost savings opportunities. The scale efficiency estimates for each country in the sample seem to amount to around 5% and be relatively stable over the period of analysis.

The MPI results evidence that these five European countries have experienced different trends, possibly attributable to varying competitive conditions in their respective banking systems. In particular, the French and German banking sectors show productivity decline over the 1993-97 period, while the Italian, Spanish and UK banking sectors show an improvement in the MPI.

Turning to the pooled European estimates, overall, the DEA results show relatively low average efficiency levels; nevertheless, it is possible to detect a slight improvement in the average efficiency scores over the period of analysis for almost all banking systems in the sample, with the exception of Italy. However, the results show that the efficiency gap among countries grew even wider over the period 1993 -1997. These results partially contrast with those found investigating each banking market separately, suggesting perhaps that most European banks benchmark their efficiency performance against 'best-practice' domestic banks and not against 'best-practice' European counterparts.

The pooled results of the Malmquist Index analysis find evidence of TFP growth during the period under investigation. This productivity growth seems to have been brought about by a deterioration of the performance of the best practice institutions and convergence towards best practice on the part of the remaining banks. This improvement in productive efficiency results mostly from a sharp increase in scale efficiency rather than in pure technical efficiency.

The results of the analysis of the determinants of European bank efficiency note that there does not appear to be a strong relationship between variation in bank equity and efficiency levels. In contrast, ROAE is found to be positively related to bank efficiency; however, this relationship is only found to hold in two of the years of analysis. The results also suggest that commercial banks are no more efficient than their savings and co-operative bank counterparts. The positive and statistically significant sign on the QUOT variable indicates that listed banks are more efficient than their non-listed counterparts.

The bootstrapped results provided little evidence to suggest that the average capital ratio (E/TA) and the Return on Average Equity (ROAE) explain variation in bank efficiency levels. These results contrast with the positive relationship between both ROAE and E/TA and efficiency levels found in some of our non-bootstrapped estimates and in previous studies. This may suggest that inference on the determinants of bank efficiency drawn from non-bootstrapped regression analysis may be biased and misleading.

Finally, both the bootstrap and the conventional Tobit results presented in this chapter suggest that most of the efficiency differences found across European banking systems are due to country-specific aspects of the banking technology. This can be thought of as reflecting both the legacy of different banking regulations and the different managerial strategies implemented to face up to the new challenges brought about by information technology, financial innovation and greater competition within the European banking market. These results imply that country-specific factors appear still to be important determinants in explaining differences in bank efficiency levels across Europe. This suggests that the EU SMP environment has not had a major effect to date in promoting a convergence of bank efficiency levels.

7 Conclusions and Limitations of the Research

This thesis aimed to investigate whether the productive efficiency of the main European banking systems has improved since the creation of the Single Market Programme (SMP). One of the major objectives of the EU's 1992 SMP was to facilitate the free movement of goods and services across Member States and to improve economic efficiency. An integral part of the SMP was directed at harmonising regulations and fostering competition in the banking sector. In order to investigate whether there has been an increase and a convergence of efficiency levels following the process of legislative harmonisation, the main European banking markets between 1993 and 1997 were examined. To evaluate the relative efficiency of European banking, non-parametric estimation techniques, in the form of Data Envelopment Analysis (DEA) and Free Disposal Hull (FDH), were applied to a sample of large European banks. In addition, productivity change across banking markets was also calculated using the Malmquist Productivity Index (MPI). This thesis also evaluated the determinants of European bank efficiency by using the Tobit regression model approach in order to investigate the influence of various country-specific and environmental factors on bank efficiency. It also extended the established literature on the determinants of bank efficiency by taking into account the problem of the inherent dependency of DEA efficiency scores when used in regression analysis. To overcome the dependency problem a bootstrapping technique was applied.

This thesis was organised as follows. Chapter 2 offered an overview of the major changes in European banking, with a particular focus on the EU banking regulation. The first part of the chapter examined the moves towards a single market for financial products in the EU and offered a detailed review of the relevant legislation that led to the SMP and to EMU. The second part of the chapter outlined the other forces of change, with a particular focus on the role of technology. Chapter 3 analysed the structure and performance characteristics of EU banking markets over the last decade. It emerged that the strategic response of EU banks has been to focus on reorganising in three main areas. First, many banks have sought to improve their services and procedures. This involved both the development of better quality services, staff and IT combined with attempts to reduce costs and improve overall efficiency. The ultimate objective is to enhance profitability and therefore increase shareholder value. Secondly, the EU Second Banking Directive legislated for a universal banking model and this has enabled many banks to expand their product range into insurance (*bancassurance*), asset management and investment banking. The SMP has also fostered further geographical expansion. Finally, increased competitive pressure and the wider opportunities afforded under EMU have facilitated the growth of mergers and acquisitions (M&As) activities, strategic alliances and co-operation agreements. The aims of such developments are to improve cost efficiency, enhance diversification opportunities and build new distributions channels.

In recent years, studies on the efficiency of financial institutions have developed, addressing several issues in the areas of government policy, research and managerial performance. This literature has focused mainly on frontier efficiency, that is the empirical estimation of how close financial institutions are to a 'best practice' frontier. The main aim of Chapter 4 was to review the financial institution efficiency literature, with a particular focus on international comparisons. Chapter 5 described the data sample and illustrated in some detail the methodological approaches followed in the empirical analysis. In particular, the chapter focused on the use of non-parametric deterministic approaches to the evaluation of productive efficiency (DEA and FDH) and technological change (MPI). In addition, the most recent literature on the issue of statistical inference in non-parametric studies was discussed, with a focus on the so-called 'Two-Step' approach and the bootstrap method. The chapter also outlined the 'Three-Step' approach for the analysis of the determinants of efficiency in European banking, implemented in the empirical analysis. Finally, Chapter 6 presented the main findings of the empirical investigation.

7.1 Has Large European Bank Productive Efficiency Improved and Converged since the Creation of the SMP?

The empirical analysis aimed to answer the main research question of this thesis, that is: in a productive context, has large European bank productive efficiency improved and converged since the creation of the SMP?

The first part of the empirical analysis estimated the DEA efficiency scores of five main European banking systems, namely France, Germany, Italy, Spain and the UK, relative to their own national frontiers, over the period 1993 – 1997.

According to the country estimates, French and German banks present relatively high levels of average inefficiency (the majority of banks in the samples cluster around average inefficiency levels of 20%). These results suggest that there are substantial cost saving opportunities obtainable in the French and German banking systems. The Italian banking system shows a relatively low average level of inefficiency (around 9.5%, confirmed by the frequency distribution of the average efficiency scores) with constant improvement (from 11.3% inefficiency 1993 to 8.8% in 1997). Very similar results are achieved by the Spanish banking system, which shows overall inefficiency levels constantly lower than 10% over the period. Finally, the overall efficiency levels in the UK banking system seems to be relatively high and stable over time, with the majority of banks in the industry displaying average inefficiency levels of around 8%. According to country estimates, these European countries seem to have increased the average level of productive efficiency of their banking systems during the period under investigation. The most efficient banking sectors appear to be those of Spain, the UK and Italy, while in the French and German banking systems there seems to exist still substantial cost savings opportunities. The scale inefficiency estimates for each country in the sample seem to amount to around 5% and be relatively stable over time.

The analysis of productivity changes evidence that these five European countries have experienced different trends, possibly attributable to varying competitive conditions in their respective banking systems. In particular, the French and German banking sectors showed productivity decline over the 1993-97 period (-1% and –3.2%

respectively); whereas the results relative to the Italian and Spanish banking sector show a steady improvement in the MPI (+3.4% and +1.6% respectively); finally, the results for the UK banking system suggest only a slight productivity gain (+0.4%).

Turning to pooled European estimates, overall, the DEA results show relatively low average efficiency levels; nevertheless, it is possible to detect a slight improvement over the period of analysis, both relative to the common European frontier (average EU efficiency scores increased from 0.61 in 1993 to 0.68 in 1997) and for almost all banking systems in the sample, with the exception of Italy. However, the results show that the efficiency gap among countries grew even wider over the period 1993 -1997. These results partially contrast with those found investigating each banking market separately, suggesting perhaps that most European banks are benchmarking their cost efficiency at the domestic level.

The pooled results of the Malmquist Index analysis find evidence of productivity growth during the period under investigation. This productivity growth seems to have been brought about by a deterioration of the performance of the best practice institutions and convergence towards best practice on the part of the remaining banks. Moreover, this improvement in productive efficiency appears to result mostly from a sharp increase in scale efficiency (+20% over the period) rather than in pure technical efficiency (+2.5% over the period). It may be possible to relate these results to the restructuring of the EU banking systems, in particular to the wave of M&A activity during the period under observation: this trend towards consolidation is possibly reflected in the substantial scale efficiency change. On the other hand, the small but positive technical efficiency change may be thought of as reflecting the efforts of EU banks towards cutting costs.

Results from an analysis of some consistency conditions as defined by Bauer *et al.* (1997) suggest that many of the 'best practice' and 'worst practice' banks tend to remain so over time and, therefore, satisfy the condition requiring stability over time. On the other hand, an analysis of the consistency of efficiency measures with standard non frontier measure of performance seem to suggest that DEA efficiency is at best weakly related to the chosen indicators of firm performance. This general result perhaps suggests the need to apply alternative methodologies in order to draw more consistent inference from the efficiency estimates.

The results of the conventional Tobit analysis of the determinants of European bank efficiency note that there does not appear to be a strong relationship between variation in bank equity (E/TA) and efficiency levels. In contrast, ROAE is positively related to bank efficiency; that is profitable banks appear more efficient. However, this relationship is only found to hold in two of the years under analysis. The results also suggest that commercial banks are no more efficient than their savings and co-operative bank counterparts. The positive and statistically significant sign on the QUOT variable (a relationship found in all our yearly estimates) indicates that listed banks are more efficient than their non-listed counterparts.

The bootstrapped results offered little evidence to suggest that the average capital ratio (E/TA) and the Return on Average Equity (ROAE) explain the variation in bank efficiency levels. These results contrast with the positive relationship between both ROAE and E/TA and efficiency levels found in some of our non-bootstrapped estimates and in previous studies. This may suggest that inference on the determinants of bank efficiency drawn from non-bootstrapped regression analysis may be biased and misleading.

Finally, both the bootstrap and the conventional Tobit results presented in this empirical analysis suggest that most of the efficiency differences found across European banking systems are due to country-specific aspects of the banking technology. This can be thought of as reflecting both the legacy of different banking regulations and the different managerial strategies implemented to face up to the new challenges brought about by information technology, financial innovation and greater competition within the European banking market. These results lead us to conclude that country-specific factors appear still to be important determinants in explaining differences in bank efficiency levels across Europe. This, in turn, suggests that the EU SMP environment has not had a major effect to date in promoting a convergence of bank efficiency levels. Overall, the results suggest that since the implementation of the EU's Single Market Programme there has been a small improvement in bank efficiency levels, although there is little evidence to suggest that these have converged.

7.2 Limitations of the Research

The limitations of the DEA methodology and some of the problems that may arise in conducting efficiency analysis using DEA are well known among researchers [see Coelli *et al.* (1998)]. The principal limitation concerns the fact that non-parametric approaches do not allow for random error. If random error exists, measured efficiency may be confounded with these random deviations from the true efficient frontier. Other important limitations have been summarised in Section 5.3.1.5. However, it is important to highlight that the basic DEA models have been improved in a number of ways in recent years and some of the recent advances overcome important limitations inherent in the earliest models [see Sections 4.3.3 and 5.3.1.5].

Although the aforementioned empirical analysis attempted to take into consideration one of the main criticisms faced by researchers using non-parametric methodologies to estimate productive efficiency, that is the difficulty of drawing statistical inference, the implementation of bootstrapping methodology in a DEA framework is still in its early stages of development. As a consequence, there are no previous studies in the area to confirm the robustness of the results.

In order to minimise possible bias arising from different accounting practices, this study employed the accounting definitions, as presented by IBCA Bankscope, for the choice of the input and output variables; however, this imposed strong restrictions on variables one was able to use, not least because of the various accounting criteria used in the five countries under investigation. It is also important to remember that the sample included only large banks, in order to obtain a relatively homogeneous group of banks, both in terms of asset size and range of banking activities.

As reviewed in Chapter 4, one of the main problems faced by researchers investigating banks' cost efficiency relates to difficulties in the definition and measurement of the concept of bank output. Even today, there is no all-encompassing theory of the banking firm: in particular, there is no agreement on the explicit definition and measurement of banks' inputs and outputs. Following the modern empirical literature (see, among others, Molyneux *et al.*, 1996; Mester, 1996), we used the intermediation approach; however, it would be interesting to investigate whether the choice of a different approach (production, value-added or user cost approach) would influence the findings. As well, it would be interesting to investigate whether using parametric estimation techniques, such as the Stochastic Frontier Approach (SFA), the Distribution-Free Approach, (DFA), and the Thick Frontier Approach (TFA), on the same data set yielded similar results.

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Appendices

Appendix 1: Review of US Studies on Scale and Scope Efficiency

Author	Year	Data	Model	Findings
◊ Alhadeff	1954	Data drawn from the FED of San Francisco for the years 1938-50 on 210 Californian banks	Financial Ratios with Earning Assets as Output	Increasing return to scale for large and small banks and constant return to scale for mid-sized banks.
◊ Horoviz	1963	Data from Annual Reports of the Federal Deposit Insurance Corporation	Financial Ratios with Earning Assets as Output	Average cost decrease from the smallest bank to the largest and economies of scale for small and large banks and constant return to scale for mid-sized banks.
◊ Schweiger and McGee	1961	6,233 Federal Reserve Member Banks in 1958	Multiple Regression Analysis	Large banks seem to have a cost advantage over small and medium-sized banks.
◊ Gramley	1962	270 Tenth Federal Reserve District small unit banks over the period 1956-59.	Multiple Regression Analysis	'*Real*' economies of scale were responsible for the negative relationship between unit costs and bank size.
◊ Benston	1965(a)	From the FCA program of the Federal Reserve Bank of Boston, for the period 1959-61.	Cobb-Douglas Cost Function	Significant economies of scale existed for demand deposits and mortgage loans. Time deposits and instalment loans showed significant diseconomies of scale. Branch banks have higher operating costs than unit banks.
◊ Benston	1965(b)	From the FCA program of the Federal Reserve Bank of Boston, for the period 1959-61.	Cobb-Douglas Cost Function	Economies of scale exist for branch banks.
◊ Greenbaum	1967	From the Fifth and Tenth Federal Reserve Districts, for 413 and 745 banks respectively	Weighted Output Index	Evidence of U-shaped average cost curve, indicating that average cost declined for small sized banks, but increased for large banks. Branch bank operating costs seemed to be higher than unit bank costs.

Appendix 1 (continued)

Author	Year	Data	Model	Findings
◊ Bell and Murphy	1968	From the FCA program of the Federal Reserve Banks of New York, Philadelphia and Boston for 283 banks	Cobb-Douglas Cost Function	Economies of scale exist for demand deposits and real estate loans. Slight diseconomies of scale exist for time deposits and instalment loans. Branch banks have higher operating costs than unit banks.
◊ Schweitzer	1972	A large sample of small banks from the Ninth Federal Reserve District, for 1964, from the Call and Income data	Cobb-Douglas Cost Function	Evidence of a U-shaped cost curve. Economies of scale appear to exist for banks with total assets of less than $3.5m.
◊ Murphy	1972	FCA data for 1968 on 967 banks	Cobb-Douglas Cost Function	Banks seemed to be characterised by constant returns to scale.
◊ Daniel, Longbrake and Murphy	1973	FCA data for 1968 on 967 banks	Cobb-Douglas Cost Function	Larger banks can improve operating efficiency by using computer technology.
◊ Kalish and Gilbert	1973	FCA data for 1968 on 898 banks	Cobb-Douglas Cost Function	Evidence of U-shaped average cost curve. Unit banks have the lowest operating costs, followed by affiliated banks and branch banks.
◊ Longbrake and Haslem	1975	FCA data for 1968 on 967 banks	Cobb-Douglas Cost Function	Unit banks have the lowest average operating costs; all banks have economies of account size; the number of branch bank offices did not affect the cost of producing demand deposit services.
◊ Mullineaux	1975	FCA data for 1970 from the Federal Reserve Bank of Boston, New York and Philadelphia	Cobb-Douglas Cost Function	The larger economies of scale are found for unit banks.

Appendix 1 (continued)

Author	Year	Data	Model	Findings
◊ Mullineaux	1978	FCA data for 1971 on 892 banks and for 1971 on 859 banks	Cobb-Douglas Cost Function	Banks in branching States had constant returns to scale, while increasing returns were found in unit banking states
◊ Benston, Hanweck and Humphrey	1982	FCA data for the period 1975-78 on 747 to 852 banks	Translog Cost Function	Evidence of scale economies in branch banks; diseconomies of scale found for unit banks over $50 million in deposit size. Evidence of U-shaped cost curve.
◊ Benston, Berger, Hanweck and Humphrey	1983	FCA data for 1978 on commercial banks up to $1 billion in deposits	Translog Cost Function	Evidence of scale economies for branch banks at the banking office level for all sizes and for unit banks at office level only up to $75-$100 billion deposits. Constant return to scale for small unit banks at firm level. Slight evidence of scope economies either for unit and branch banks.
◊ Clark	1984	Data on 1205 unit banks for the period 1972-77	Translog (Box-Cox transformation) and Cobb-Douglas (Box-Cox transformation)	Limited evidence of scale economies. The scale elasticity seems independent from the choice of the cost function and from the output definition.
◊ Gilligan and Smirlock	1984	Data from the FED of Kansas City for the period 1973-78 on more than 2700 unit banks	Translog Cost Function	Evidence of scale economies in banks with less than $25 million deposits

Appendix 1 (continued)

Author	Year	Data	Model	Findings
◊ Gilligan, Smirlock and Marshall	1984	FCA data for 1978 on 714 commercial banks	Translog Cost Function	Evidence of scale economies for banks with up to $25 millions deposits; diseconomies of scale for large banks. Evidence of economies of scope
◊ Shaffer	1985	Data from Inc. Div. Rep. (FED) for 1979 on 1160 unit commercial banks	Translog Cost Function	Slight evidence of scale economies for all size. Scope economies not relevant.
◊ Hunter and Timme	1986	Data from Bank Compustat for the period 1972-82 on 91 BHC operating in 28 States	Translog Cost Function	Evidence of scale economies on with respect to operational costs
◊ Kim	1986	Data on 17 Israeli commercial banks for the period 1979-82	Translog Cost Function	Evidence of scale economies and increasing return to scale at plant level. Evidence of scope economies.
◊ Shaffer and David	1986	Data from the Call and Income Reports on the 100 largest US banks with asset size over $1 billion	Translog Cost Function	Evidence of economies of scale for large banks
◊ Berger, Hanweck and Humphrey	1987	FCA data for 1983 on 413 branch banks and 214 unit banks	Translog Cost Function	Evidence of economies of scale for banks up to $50 million, diseconomies of scale above $50 millions. Evidence of scope economies only for very small banks
◊ Kolari and Zardkoohi	1987	FED-FCA data for the period1979-1983	Translog Cost Function	Economies of scale for banks with up to $50million deposits and decreasing return to scale beyond $50 million. Diseconomies of scope in general; economies of scope in loans and deposits.

Appendix 1 (continued)

Author	Year	Data	Model	Findings
◊ Hunter, Timme and Yang	1990	Data from the Call and Income Reports on 311 largest US commercial banks	Translog Cost Function	Results suggested that large banks would be better off if they would break up production into groups of specialist banks. No strong evidence on cost subadditivity.
◊ Noulas, Ray and Miller	1990	Data from the Income and Condition Reports on 309 branch banks with assets over $1 billion	Translog Cost Function	Evidence of scale economies for banks with assets between $1 billion and $3 billion, diseconomies of scale for banks with assets above $3 billion.
◊ Evanoff and Israilevich	1991	Data on 164 commercial banks from the biggest 500 holding companies for the period 1972-87	Translog Cost Function	Evidence of scale economies for banks with assets up to $2.5 billion, diseconomies of scale for banks with assets above $3.5 billion.
◊ Mester	1992	Data from Reports on Condition and Income on 328 branch banks with more than $1 billion of assets	Translog Cost Function	Evidence of global scale economies for all size banks. Significant scope economies

Appendix 2: Review of European Studies on Scale and Scope Efficiency

Author	Year	Data	Model	Findings
◊ Lévy-Garboua and Renard (France)	1977	Data on 94 banks on 1974	Cobb-Douglas Cost Function	Evidence of increasing return to scale.
◊ Gouch (UK)	1979	Data on building societies for the period 1972-76	Linear Average Cost Function	No evidence of economies of scale.
◊ Cooper (UK)	1980	Data on building societies for 1977	Cobb-Douglas Cost Function	Evidence of scale economies for societies with asset size less than £100 million; diseconomies of scale for larger societies.
◊ Barnes and Dodd (UK)	1983	Data on building societies for the period 1970-78	Linear Average Cost Function	No evidence of economies of scale.
◊ Fanjul and Maravall (Spain)	1985	Data on 83 commercial banks and 54 savings banks for 1979	Cobb-Douglas Cost Function	Significant cost economies with respect to accounts per branch and deposits per account; constant return to scale relating to the number of branches.
◊ Dietsch (France)	1988	Data on 243 banks for 1986	Translog Cost Function	Limited evidence of overall scale economies; however there ware significant potential scale economies to be obtained.
◊ Cossutta *et al.* (Italy)	1988	Data on 226 banks for 1984	Translog Cost Function	Evidence of scale economies at office level for medium-large sized office and for large banks. Constant return to scale for all other sizes. Evidence of scope economies.

Appendix 2: (continued)

Author	Year	Data	Model	Findings
◊ Lanciotti e Raganelli (Italy)	1988	Data on 359 commercial banks for 1984	Translog Cost Function/Box-Cox Transformation	Evidence of scale economies.
◊ Hardwick (UK)	1989	Data on 97 building societies for 1985	Translog Cost Function	Evidence of economies of scale for societies with assets under £280 million and diseconomies of scale for those with assets over £1500 million.
◊ Baldini e Landi (Italy)	1990	Data on 294 banks for 1987	Translog Cost Function	Evidence of scale economies when the number of offices is fixed; no evidence of scope economies.
◊ Cardani *et al.* (Italy)	1990	Data on 94 banks for 1986.	Econometric estimate of Cost Frontier	Evidence of scale economies for small banks.
◊ Landi (Italy)	1990	Data on 295 banks for 1987	Translog Cost Function	Evidence of scale economies for all bank sizes. Evidence of scope economies only if separate production needs more branches. Reductions of branches imply cost saving of scope economies.
◊ Hardwick (UK)	1990	Data on 97 building societies for 1985	Translog Cost Function	Evidence of statistically significant scale economies for societies with assets under £5500 million. No evidence of scope economies.
◊ Conigliani *et al.* (Italy)	1991	Data on 256 banks for the period 1975-90.	Translog Cost Function	Evidence of scale economies only for small size banks and for banking groups. Scope economies not relevant in general but positive for banking groups.

Appendix 2: (continued)

Author	Year	Data	Model	Findings
◊ Gathon and Grosjean (Belgium)	1991	Data on 24 private banks from the Association Belge des Banques and Annual Reports.	Translog Cost Function	Evidence of scale diseconomies for the four big banks (assets beyond 50 million BF); scale economies in all other banks.
◊ Pallage (Belgium)	1991	Data on 57 commercial banks, 24 savings banks and 3 public credit institutions	Translog Cost Function	Evidence of scale economies for small institutions; decreasing return to scale when size grows. Evidence of scope economies for the five big banks.
◊ Conti e Maccarinelli (Europe, US and Japan)	1992	Commercial banks among the first 2,000 in size in the world	Correlation Analysis	Evidence of scale economies for small banks.
◊ Martin and Sassenou (France)	1992	Data on French banks for 1987	CES-Quadratic Function	Small banks benefit from large economies of scale and scope. Bigger banks incur relatively large scale diseconomies depending on their output scale and their degree of specialisation.
◊ Drake (UK)	1992	Data on 76 building societies for 1988	Translog Cost Function	Evidence of mild economies of scale for societies in the £120-500 million asset size range. No evidence of economies of scope.
◊ Glass and McKillop (UK)	1992	Data from the Bank of Ireland for the period 1972-90	Hybrid Translog Cost Function	The bank was characterised by overall diseconomies of scale; product specific scale economies were reported to be decreasing for investments and increasing for loan.

Appendix 2: (continued)

Author	Year	Data	Model	Findings
◊ Rodriguez, Alvarez and Gomez (Spain)	1993	Data on 64 Spanish savings banks for 1990	Hybrid Translog Cost Function	Evidence of scale and scope economies for medium-sized savings banks and diseconomies of scale for larger institutions.
◊ Dietsch (France)	1993	Data on 343 French banks for 1987	Translog Cost Function	Strong evidence of economies of scale across all output ranges; scope economies were not observed at a high level for all combinations of outputs.
◊ McKillop and Glass (UK)	1994	Data on 89 building societies (local, regional and national) for 1991	Hybrid Translog Cost Function	Evidence of significant augmented economies of scale for both national and local societies, but only constant return to scale for those societies that are regionally based. No evidence of economies of scope or cost complementarities.
◊ Drake (UK)	1995	Data on 76 UK building societies for 1988	Translog Cost Function	No evidence of scale economies when expense-preference behaviour is taken into account. Lack of evidence on the existence of scope economies.
◊ Lang and Welzel (Germany)	1996	Data on over 700 German co-operative banks	Translog Cost Function	Evidence of scope economies especially for large banks
◊ Molyneux *et al.* (UK)	1996	Data on 201 French, 196 German, 244 Italian and 209 Spanish banks for 1988	Hybrid Translog Cost Function	The results indicated noticeable differences in cost characteristics across European banking markets; scope and scale economies appeared to be evident in each country over a wide range of bank output levels.

Appendix 2: (continued)

Author	Year	Data	Model	Findings
◊ European Commission	1997	Balance sheet and income statement data from 1987(295 banks) to 1994 (1451 banks), obtained from the IBCA Bankscope database for 10 EU countries	Translog Cost Function	The analysis showed that in all countries there was evidence of both economies and diseconomies of scale. The preponderance of increasing return to scale was found generally with the small banks, particularly in the case of Germany and France. The study found strong evidence of significant and apparently large economies of scope for the biggest banks.
◊ Casu and Girardone (Italy)	1998	Data on 32 banking groups and 78 bank parent companies and subsidiaries for 1995	Translog Cost Function	Slight evidence on the existence of scale economies; strong evidence on the existence of scope economies, especially for banking groups.

Appendix 3 Descriptive Statistics of Input and Output Variables

Table A3.1 Descriptive Statistics of Input and Output Variables (mil ECU, 1993)

	MEAN	MED.	ST.DEV.	MIN	MAX	Q1	Q3
FRANCE							
Total A	5603	1987	15530	109	94557	1256	3162
Total B	7317	1355	21714	228	125582	572	3426
Total G	11147	3083	31783	455	182589	2132	5509
Total C	1126	329	2920	79	20526	225	603
GERMANY							
Total A	6982	2299	16397	377	114027	1532	45263
Total B	4991	1426	11963	118	86068	934	3240
Total G	9879	3614	22610	441	175069	2489	6652
Total C	907	298	2149	79	15886	204	585
ITALY							
Total A	4697	1111	9694	304	6183	643	3383
Total B	4472	1117	8647	270	43371	693	4047
Total G	7952	2092	15295	482	76943	1273	5912
Total C	974	261	1829	79	10769	161	751
SPAIN							
Total A	2850	1129	5165	59	30739	510	2731
Total B	3629	863	1991	49	45575	415	2819
Total G	6191	2064	12509	146	74114	891	5723
Total C	742	237	1477	23	7454	113	707
UK							
Total A	9585	725	22221	28	136165	180	6289
Total B	4394	206	13353	8	77915	42	2225
Total G	13190	1354	31718	39	191216	249	7988
Total C	1708	75	6317	2	48663	16	510

NOTE: Total A = Total Assets; Total B = Total Other Earning Assets, Total G = Total Customers and Short Term Funding (Deposits); Total C = Total Costs (Interest Expenses + Non-Interest Expenses + Personnel Expenses).

Table A3.2 Descriptive Statistics of Input and Output Variables (mil ECU, 1994)

	MEAN	MED.	ST.DEV.	MIN	MAX	Q1	Q3
FRANCE							
Total A	5194	2043	14078	114	90119	1222	3201
Total B	6521	1355	18754	177	111217	577	3092
Total G	10400	3178	29076	275	171215	2352	4946
Total C	848	290	2132	70	14341	193	515
GERMANY							
Total A	76100	2594	16974	529	112168	1760	4903
Total B	5412	1642	13187	104	90169	1034	3459
Total G	10545	3828	23883	711	183284	2690	6876
Total C	883	311	1948	117	13552	210	591
ITALY							
Total A	4526	996	9082	261	50245	602	3542
Total B	4204	1047	8145	238	46358	649	3033
Total G	7628	1915	14574	413	81553	1227	5840
Total C	829	223	1525	66	8312	133	676
SPAIN							
Total A	2914	1124	5216	59	29730	496	2765
Total B	3432	925	7228	23	40961	398	3374
Total G	6082	2153	11708	183	64767	955	5797
Total C	576	193	1123	19	6201	95	535
UK							
Total A	9270	986	19804	28	114648	187	7790
Total B	4582	210	13659	5	79311	44	2623
Total G	12941	1415	29180	35	168269	247	9823
Total C	1139	72	2877	1	15791	13	579

NOTE: Total A = Total Assets; Total B = Total Other Earning Assets, Total G = Total Customers and Short Term Funding (Deposits); Total C = Total Costs (Interest Expenses + Non-Interest Expenses + Personnel Expenses).

Table A3.3 Descriptive Statistics of Input and Output Variables (mil ECU, 1995)

	MEAN	MED.	ST.DEV.	MIN	MAX	Q1	Q3
FRANCE							
Total A	5621	246	15602	177	96301	1212	3542
Total B	7026	1554	19771	264	121182	738	3411
Total G	11101	3555	30445	490	183321	2580	5774
Total C	1020	323	2751	103	17285	223	540
GERMANY							
Total A	7833	2666	18973	611	135805	1864	5128
Total B	5787	1675	15303	145	117031	1086	3192
Total G	10998	3703	27808	809	231740	2786	6403
Total C	855	302	1993	125	1437	203	605
ITALY							
Total A	4563	983	9746	189	66985	612	3467
Total B	3765	1045	7171	233	43897	561	2837
Total G	7151	1915	13917	439	83009	1079	5379
Total C	868	229	1706	74	11139	131	635
SPAIN							
Total A	3047	1182	5282	24	27455	551	2919
Total B	3733	1131	7677	24	38992	530	3308
Total G	6458	2328	12112	267	64911	995	6508
Total C	613	217	1177	11	6219	99	606
U.K.							
Total A	9643	463	19955	26	102337	168	8748
Total B	4636	200	13707	2	77651	39	2404
Total G	13152	1254	29231	31	153922	229	10878
Total C	1200	69	2955	2	14893	12	694

NOTE: Total A = Total Assets; Total B = Total Other Earning Assets, Total G = Total Customers and Short Term Funding (Deposits); Total C = Total Costs (Interest Expenses + Non-Interest Expenses + Personnel Expenses).

Table A3.4 Descriptive Statistics of Input and Output Variables (mil ECU, 1996)

	MEAN	MED.	ST.DEV.	MIN	MAX	Q1	Q3
FRANCE							
Total A	5744	2283	15693	141	95318	1306	3586
Total B	7445	1550	21370	174	131772	629	3247
Total G	11548	3394	13572	6267	191592	2472	5583
Total C	960	318	2578	75	15103	205	524
GERMANY							
Total A	8480	2717	21171	673	159119	1813	5435
Total B	6376	1752	17827	138	145612	1111	3225
Total G	11872	3974	32356	901	284202	2735	6714
Total C	853	278	2081	61	16038	203	542
ITALY							
Total A	4756	1022	9636	313	53116	684	3608
Total B	4259	1169	8103	251	51184	689	2997
Total G	7490	1930	14405	451	82033	1146	5320
Total C	872	226	1649	88	9805	139	662
SPAIN							
Total A	2641	953	5017	16	28720	317	2383
Total B	3814	814	7113	8	43965	307	1863
Total G	5345	1738	11289	11	70394	678	4069
Total C	489	146	1066	21	6001	60	399
UK							
Total A	13897	1223	28147	30	124348	226	10776
Total B	6220	249	17303	8	95903	51	3076
Total G	18510	1572	38758	43	195884	296	16645
Total C	1488	71	3387	2	16822	14	707

NOTE: Total A = Total Assets; Total B = Total Other Earning Assets, Total G = Total Customers and Short Term Funding (Deposits); Total C = Total Costs (Interest Expenses + Non-Interest Expenses + Personnel Expenses).

Appendix 4 Mamquist TFP Index (DEA-like estimation method)

Following Färe *et al.* (1994), when panel data are available, it is possible to calculate the distance functions necessary to compute a Mamquist TFP index using DEA-like linear programs.

For the i-th firm, it is necessary to calculate for distance functions to measure the TFP change between two periods. This requires the solving of four linear programming (LP) problems. Färe *et al.* (1994) assumed a constant return to scale technology in their analysis as specified the required LP as:

$$\left[d_0^t(y_t, x_t)\right]^{-1} = \max_{\phi,\lambda} \phi, \tag{1}$$

$$\begin{aligned} \text{st } & -\phi y_{it} + Y_t\lambda \geq 0, \\ & x_{it} - X_t\lambda \geq 0, \\ & \lambda \geq 0, \end{aligned}$$

$$\left[d_0^s(y_s, x_s)\right]^{-1} = \max_{\phi,\lambda} \phi, \tag{2}$$

$$\begin{aligned} \text{st } & -\phi y_{is} + Y_s\lambda \geq 0, \\ & x_{is} - X_s\lambda \geq 0, \\ & \lambda \geq 0, \end{aligned}$$

$$\left[d_0^t(y_s, x_s)\right]^{-1} = \max_{\phi,\lambda} \phi, \tag{3}$$

$$\begin{aligned} \text{st } & -\phi y_{is} + Y_t\lambda \geq 0, \\ & x_{is} - X_t\lambda \geq 0, \\ & \lambda \geq 0, \end{aligned}$$

$$\left[d_0^s(y_t, x_t)\right]^{-1} = \max_{\phi,\lambda} \phi, \tag{4}$$

$$\begin{aligned} \text{st } & -\phi y_{it} + Y_s\lambda \geq 0, \\ & x_{it} - X_s\lambda \geq 0, \\ & \lambda \geq 0, \end{aligned}$$

Note that in LP's (3) and (4), where production points are compared to technologies from different time periods, the ϕ parameter need not to be greater than or equal to one, as it must when calculating Farrell output-orientated technical efficiencies. The data could lie above the feasible production set. This will mostly occur in LP (4), where a production point from period t is compared to technology in an earlier period, s. If technical progress has occurred, then a value of $\phi < 1$ is possible. It could also occur in LP (3), if technical regress has occurred, but it is less likely. The above four LPs must be solved for each firm in the sample.

The above approach can be extended by decomposing the technical efficiency change into scale and 'pure' technical efficiency components. This requires the solution of two additional LPs, which would involve repeating LPs (1) and (2) with the convexity restriction (N1' λ = 1) added to each. In other words, these two distance functions would be calculated relative to a variable returns to scale (VRS instead of a constant returns to scale (CRS) technology. It is then possible to use CRS and VRS values to calculate the scale efficiency measures residually. For the case of N firms and T time periods, this would increase the number of LPs from Nx(3T-2) to Bx(4T-2).