Technical Efficiency in Mega European Bank Mergers and Acquisitions[1]

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Abstract

The role of mergers and acquisitions to improve banking efficiency is an important topic. This paper examines technical efficiency in 100 mega European bank M&A events during 1996—2003, focusing on the efficiency analysis of different M&A participant roles (acquirers, vendors, targets, and non-M&A banks). It also compares technical efficiency in terms of efficiency growth rate, short-term efficiency changes and the relationship to different M&A frequencies. Banks with higher technical efficiency levels tend to engage in M&A activities more frequently, and this may help them to improve their technical efficiency in the short term. Meanwhile banks with medium technical efficiency levels are mostly targets for M&A activities. Banks with low technical efficiency will have the lowest possibility to be involved in M&A events, and their technical efficiency is more volatile. However, over the period, these non-M&A banks improve their technical efficiency at the highest rate. Overall, M&A activities seem to be driven by differences in technical efficiency.

Keywords:
Technical efficiency; mergers and acquisitions (M&As); acquirer banks; target banks; vendor banks; stochastic frontier approach (SFA).

1. Introduction.

European banks have consolidated the fragmented European banking markets via successful mergers and acquisitions (M&As). Substantial literature has examined various kinds of banking efficiencies and some of them relate banking efficiency with bank M&A effects.

General banking literature has shown evidence that M&As may not be able to improve the banking efficiency of the acquirer banks or the target banks as expected. For example, Cuesta and Orea (2001) find that it takes about ten years for banks to recover their technical efficiency level to the same as in the pre-M&A year. Most literature

[1] This paper is a part from an unfinished chapter of my PhD thesis. I would like to thank my supervisors Professor David Dickinson and Professor David Gowland for their insightful discussions and valuable help. All the remaining errors are my own.

does not find that bigger bank size necessarily relates to better efficiency performance. However, scale economy and scope economy may be achievable through M&As. Lang and Welzel (1996) indicate that bank technology progress is improved via cost efficiency: "aggregate technical progress ε_t can then be calculated as the elasticity of total cost C with respect to time t, i.e., ε_t=dlnC/dt = (dC/dt)/(1/C)." They not only find both economies of scale and scope for German small cooperative banks, but also discover these banks benefit from cost reduction due to technical progress. Moreover, they find that German cooperative banks disappear at a speed of at least 5% each year due to bank merger

From the aspect of bank M&As participant roles, Vander Vennet (1996) explains the inefficient management hypothesis that lower efficiency banks are more likely to be targeted while higher-efficient banks are more possible to be acquirers. Haynes and Thompson (1999) also find that lower efficiency level is the main reason for banks being acquired and reorganized. Lang and Welzel (1996) point out that the majority of German bank mergers are among those small German cooperative banks. Bank managers pursue larger bank size to achieve better economies of scope and scale, and create or expand market power. The acquirer banks are likely to improve efficiency via a successful bid.

In terms of M&A motivations, Haynes and Thompson (1999) draw attention to four potential ways that horizontal mergers between non-diversified banks may affect bank performance. The four ways are: economies of scale, selective rearrangement of assets, transferring asset control power to better qualified managers, and renegotiation of employment contracts.

The banking efficiency may be a result of M&A effects or may be the motivations driving M&A strategies. There is no literature has given a clear answer to specify one of these relationships. We intend to fill this gap by exploring these two ambiguous causality relationships. We will firstly examine technical efficiency as part of M&A effects. Thus we will give detailed technical efficiency analysis in terms of the general efficiency trend, the M&A participant roles (acquirers, targets, vendors and non-M&A), efficiency changes and efficiency growth rates, and M&A frequency effects on technical efficiency. On the other aspect, we will also use our technical efficiency results to explain banks M&A motivations by specifying the characteristics for different types of banks.

Our data sample covers the top 100 mega European banks during 1996—2003 with M&A information. The biggest 100 European banks have total assets ranging from $19,696 million to $1,105,378 million. This paper unfolds as follows. Section two reviews definitions on bank M&As. Section three explains the tests rationale for technical efficiency model. Section four analyses the results in the order of different groupings to give comprehensive explanations for the above two causality relationships. Finally, it concludes.

2. *Definitions for Mergers and Acquisitions.*

The M&A information for data sample used in this paper is from ZEPHYR[2]. There are various types of mergers and acquisitions (M&As) according to the definitions in ZEPHYR and INVESTOPEDIA[3] website. We need to clarify the definitions of each M&A participants, acquisitions, mergers and takeover before further study on this M&A topic.

The **Bidder** (or **Acquirer**) is the entity that makes the purchase or offer to purchase in **acquisitions** and acquiring **minority stakes**. The **Target** is the entity being purchased, or the entity in which a stake is being purchased. The **Vendor** is the entity that sells or disposes of the Target entity. Almost 98% of M&A deals have vendor banks' involvement according to the information from ZEPHYR, which is a professional company providing online banking M&A data resources.

Acquisition is a deal where the Bidder ends up with 50% or more of the votes of the Target. The Bidder now has control[4] of the Target. Acquisitions can either be friendly or unfriendly. Friendly acquisitions occur when the target firm agrees to be acquired; unfriendly acquisitions do not have the same agreement from the target firm. With reference to the definition in ZEPHYR, a true **Merger** is not very often seen and many acquisitions are described as mergers. A merger is a one-for-one share swap for shares in the new company. The Investopedia website defines that a merger could be a combination of two or more companies, but the swap of stocks is done mutually by agreement. ZEPHYR codes a merger as an acquisition when the swap is not on equal terms. But in the case of a real merger, ZEPHYR will put the original companies as Bidder and Target in no particular order. Many mergers occur as 'partnerships', which is especially common in law firms. **Takeover** is an action that an acquiring firm makes a bid for a target. When the target is publicly traded, the acquiring company can make an offer for the outstanding shares. A welcome takeover means a friendly takeover that favours all involving parties. It normally goes smoothly because each party involved agrees on the deal. On the contrary, if the target does not wish to be taken over, it is an unwelcome or hostile takeover. Most of the M&A deals from ZEPHYR are acquisition types, which only differ in the percentages of stakes being acquired.

3. *Banks Technical Efficiency Tests Rationale.*

[2] This is a M&A information resource from Bureau van Dijk Electronic Publishing (BvDEP) website (www.bvdep.com).l

[3] www.investopedia.com It is one of those popular sites which provide online tutorials for investments.

[4] A majority of shares and a majority of votes may be different. Some companies have voting and non-voting shares, or shares with more or less votes than others.

3.1. Stochastic Frontier Approach to Estimate Technical Efficiency Incorporating M&A Information.

Stochastic frontier approach (SFA) is one of the most popular semi-parametric methods used in efficiency study. It constructs a best efficiency frontier and compares each observation's efficiency level with the best efficiency frontier. The distances between the best efficiency line and each firm's efficiency frontier indicate the inefficiencies (Kumbhakar & Lovell, 2000). We follow the technical efficiency model originated by Battese and Coelli (1995). The general model form can be expressed as a production function (1) and an efficiency function (2). A specified model with banking variables (3) and (4) will be explained later.

The production function is:

(1) $\mathbf{Y_{it} = x_{it}\beta + (V_{it} - U_{it})}$,i=1,...,N, t=1,...,T.

Where

Y_{it} is the logarithm of the production of the i-th bank in the t-th time period;

x_{it} is a kx1 vector of the logarithm of input quantities of the i-th bank in the t-th time period;

β is an vector of unknown parameters and will be estimated via the Frontier4.1 software;

V_{it} are random variables which are assumed to be iid. $N(0,\sigma_V^2)$, and independent of the U_{it};

U_{it} are non-negative random variables which are assumed to account for technical inefficiency in production and are assumed to be independently distributed as truncations at zero of the $N(m_{it},\sigma_U^2)$ distribution;

The efficiency function is:

(2) $\mathbf{m_{it} = z_{it}\delta,}$

where

m_{it} is the mean of technical inefficiency;

z_{it} is a p×1 vector of variables which may affect the efficiency of a bank;

δ is an 1×p vector of parameters to be estimated.

σ_V^2 and σ_U^2 are the variances of the two error components. They are not directly estimated in the FRONTIER4.0[5] programme but are measured through σ^2 and γ, for

[5] We use the FRONTIER 4.1 programme for efficiency estimation. This is a computer programme specially designed to apply different SFA models and is written by Tim Coelli. For the programme guide please refer to Coelli (1997).

which we have $\sigma^2=\sigma_V^2+\sigma_U^2$ and $\gamma=\sigma_U^2/(\sigma_V^2+\sigma_U^2)$ [6]. Technical efficiency is then estimated by:

$$TE = \exp\{- U_{it}\}$$

Following the SFA models by Kumbhakar (1990) and Battesse and Coelli (1992), Cuesta and Orea (2001) apply a stochastic distance function which is closely related with technical efficiency and allows multiple-inputs and multiple-outputs without price information. They test the temporal variation of technical efficiency of Spanish savings banks during 1985—1998. The production approach treats both deposits and loans as bank outputs. In this paper, we simplify the situation for bank production technology and apply the intermediation approach that banks have multiple-inputs but only produce one type of output: loans. Total deposits are one of the main inputs in this case. Normally people consider three types of inputs for banks [Casu and Girardone (2002) & (2005), Turati (2001), Vander Vennet (2002)]: capital, labour and deposits. Three variables are used to measure them in the production function: fixed assets (FA), personnel expense (PE) and total deposits (DE).

Meanwhile, the efficiency function has three efficiency factors which are presumed to have direct effects on banks technical efficiency. They are: the ratio of liquid assets over total assets (LA/TA), the ratio of total securities over total assets (TS/TA), and total assets (TA). Liquid assets mainly include cash and short-term securities which can be turned into cash quickly and cheaply. Total securities refer to different security investments a bank owns, and these are banking businesses which may differ from the traditional loan lending business. As bigger banks may have more liquid assets and total securities, this will result in the size effects in the efficiency estimation. Hence we consider the proportions of LA/TA and TS/TA to avoid the size effects, and total assets itself to capture the pure size effects, if there is any. Table 1 lists out all variable explanations.

There is no unique way to analyse M&A effects on banking efficiency. Fixler and Zieschang (1993) use immediate post-merger data, while Rhoades (1993) compares performance that begins four years after the completion of M&As. Dickerson et al. (1997) specify an M&A dummy variable which is equal to one in the year if a firm engaged in mergers. This is a convenient way to emphasize the M&A event and simplify the post-M&A effects. But this method fails to specify the situation when a bank is involved in multiple M&As within one observation in the time period. Haynes and Thompson (1999) intend to explore the anticipated post-M&A lagged productivity changes. They apply a $MERGER_{it}$ as M&A event indicator, which is followed by a

[6] The Frontier4.0 uses maximum likelihood technique to search value for γ. Coelli (1997) explains that "the parameter, γ, must lie between 0 and 1 and thus this range can be searched to provide a good starting value for use in an iterative maximization process…". And "if the null hypothesis, that γ equals zero, is accepted, this would indicate that σ_u^2 is zero and hence that the U_{it} term should be removed from the model, leaving a specification with parameters that can be consistently estimated using ordinary least squares." Furthermore, we can say that the technical efficiency is assumed to be at the 100% full efficiency level in the null hypothesis.

series of five-year M&A dummies to capture the lagged effects.

To discover the M&A effects, we will incorporate three event dummy variables MAs, CONs and AVTs in the model. MAs is a series of three dummies indicating the number of M&A events for a bank within one year. MA1 equals to one when a bank has only one M&A happens in the corresponding year with all other MAs equals to zero. Meanwhile MA2 equals to one when a bank has two M&As in that year and all other MAs equals to zero. Our sample has one bank with the highest record of five M&As within one year. Hence we have MA3 equals to one to include banks have three or more M&As within one year. On the other hand, when a bank does not get involved into any M&A in one year, it has all the three MAs equal to zero.

CON is a controlling power dummy used to measure whether a bank gets overwhelming controlling power through an M&A event. Theoretically, a party needs to acquire over 50% shares to have the dominating controlling power over the target bank. But the fact is that in many occasions, 20%--40% of holding stakes can mean the dominating controlling position in the new merged firm. The acquirer banks have CONs equal to one depends on the M&A deal size and the percentage of target stakes they are holding; sometimes, the M&A deal is just accumulating the holding stakes and may not yet reach a dominating level[7]. For example, in the case of minority acquisitions, there are just a small proportion of the target bank shares being acquired. So the acquirer banks need to continuously purchase and accumulate the holding percentage of the target banks' shares to reach the dominating level if they want.[8] Hence we have CON1 equals to one indicating a bank has aggregated over 20% target banks' shares to obtain the main control in the new entity via an M&A and CON2 equals to zero. In the other case, if a bank obtaining controlling power in two M&As within a year, it has CON2 equals to one and CON1 equals to zero. Therefore, when banks do not obtain any controlling power via an M&A, CONs equal to zero. Vendor banks are the third party in an M&A event to sell its holding stakes of target banks to the acquirer banks. They may remain controlling power on the target banks depending on how many proportion of target shares they still have. Accordingly, target banks may just have part of shares being taken over thus remain independency. But for our data sample, we have CONs equals to zero for both vendor and target banks.

AVTs are a series of seven M&A participant role dummies representing the frequency of being acquirers, vendors and targets: AC1, AC2, VE1, VE2, VE5, TA1 and TA2. Similar with the other two series of M&A dummy settings, the numbers in the dummies indicate the frequency of being the corresponding M&A roles within one year. When banks have no M&A at all, it has all the seven dummies equal to zero.

The forth series of dummies we consider for our model is the group of regional

[7] The original information from ZEPHYR shows the percentage of acquisition in an M&A deal.

[8] For example, the German bank Bankgesellschaft Berlin AG continuously acquired shares of the Czech Republic bank Zivnostenska Banka AS from the German vendor bank BHF Bank AG in 1997 and 1998 and obtained the dominating position over the target bank in 1998.

dummies representing the 12 regions and countries. The 100 sample banks spread out in 16 European countries. Following Abraham and Van Dijcke (2002) and Lindblom (2001), we can have two regional bank groups: the Benelux group (BNL) and the Scandinavian (DFS) group. Hence the 16 nations are categorized into 12 regions and countries sub-groups as: Austria, BNL (Belgium, Netherlands and Luxembourg), DFS (Denmark, Finland and Sweden), France, Germany, Greece, Ireland, Italy, Portugal, Spain, UK and Czech Republic. The corresponding dummy explanations are listed in Table 1.

We try different ways to accommodate the four groups of dummies in the model to obtain justified model estimation and technical efficiency scores. If they justify the model by being included in the production function, it indicates that they influence banking production procedure directly. If they justify the model by being accommodated in the efficiency function, it presumes that they have direct effects on the technical efficiency. The best justified model is shown as (3) and (4).

(3) $$\ln LN_{it} = \beta_0 + \sum_{j=1}^{3} \beta_j \ln x_{ijt} + \sum_{l=1}^{7} \beta_l AVT_{ilt} + (V_{it} - U_{it})$$

(4) $$m_{it} = \delta_0 + \sum_{n=1}^{3} \delta_n MA_{\text{int}} + \sum_{r=1}^{2} \delta_r CON_{irt} + \sum_{k}^{12} \delta_k R_{ikt} + \sum_{s=1}^{3} \delta_s z_{ist} + e_{it}$$

(i = 1,2,……, 100; t = 1, 2, ……,8[9].)

Where

x_j (j =1, 2, 3) are the three input variables;
z_s (s = 1, 2, 3) are the three efficiency factors;
e_{it} is the random shocks.

Detailed variables explanation and model estimation results are listed in Table 1, and will be analysed in Section 4.

3.2.Technical Efficiency Analysis Rationale.

Before we explain the technical efficiency rationale in details, we first introduce the efficiency growth rate which can be applied to every sub-group in the later analysis. Because the M&A effects have been incorporated into technical efficiency estimation via dummy variables, the direct way to reflect the dynamic trend across the eight observed years is to compare the efficiency scores changes. Besides comparing the absolute values of efficiency scores, we further construct an efficiency growth rate to embody the improvement in efficiency. The growth rate is to divide the changes of technical efficiencies in two sequential years by the efficiency score of the previous year. The formula is as following:

[9] T=1 refers to year 1996, and year 2003 is t=8.

$$\text{Efficiency Growth Rate} = \frac{TE_{i(t+1)} - TE_{it}}{TE_{it}}$$

A positive rate means an improvement of technical efficiency from the previous year, while a negative rate indicates the deteriorating situation in technical efficiency from previous year. This general calculation thus can be applied to all banks in the sample, no matter merged or not. The calculation results and t-ratios are shown in Table 6 and Table 8.

The main target of this paper is to explore the two ambiguous causality relationships between technical efficiency and M&As. First of all, we intend to discover the technical efficiency effects from bank M&A activities. There are many possible ways to analyse M&As efficiency effects. Vander Vennet (1996) examines effects of M&As on the efficiency and profitability of EC credit institutions during 1988-1993. He classifies the sample according to the degree of managerial leverage in acquirer banks, and the degree of operation integration. In this paper, we start from the efficiency model to explore the *general technical efficiency trend*. Then we will explore three aspects on the relationship between bank M&As and technical efficiency. They are the *regional effects, M&A participant roles and M&As frequency.* From the other prospective, the discrepancies of technical efficiencies capture *M&As motivations.* We will focus on the characteristics of each type of M&A participant roles in terms of technical efficiency. Once the technical efficiency features are distinguished, a bank's M&A motivations and strategies could be identified.

Firstly, we estimate the technical efficiency for 100 mega banks in Europe during 1996—2003 by applying the above model (3) and (4). The data sample covers the top 100 mega banks in the enlarged 25 countries European Union. The 100 banks are finally selected from 16 EU countries during the eight years according to available information. The appendix lists out the country distribution of the 100 mega banks. The general bank accounting data are obtained from BankScope[10], and the M&A information and data including participant banks, deal size, deal types, completed time are from ZEPHYR. We will have general analysis on the estimated model and technical efficiency across banks and years.

We have the following three aspects to explore on the relationship between M&A events and technical efficiency.

- We investigate the regional effects on technical efficiency. Our model estimation of technical efficiency scores already includes the regional effects since the incorporation of regional dummies. Hence the analysis of regional

[10] BankScope is an online data resource from Bureau van Dijk Electronic Publishing (BvDEP) Company (www.bvdep.com).

subgroups will further spell out the banking characteristic in each European region.

- Bank M&A participant roles can be classified as: acquirer banks, target banks[11], vendor banks, and non-M&A banks. As the target banks in our sample are not fully acquired, they still have their own independent consolidated statements when we select consolidated bank statements from the BankScope data resource. Hence, we can have a comparative study on average performance and efficiency volatility base on M&A participant roles. We especially investigate the short-term efficiency changes from one-year pre-M&A to the M&A year, and from the M&A year to one-year post-M&A for the three types of M&A banks. We further evaluate the technical efficiency growth rates for the four sub-groups to see at what speed each type of banks improve their technical efficiency.

- The whole sample can also be categorized according to the frequency of M&A events during the eight-year period. There are banks not have M&A, have only one M&A and have more than one M&As during 1996 –2003. Thereafter, we can see whether M&A frequency is necessarily influencing banking efficiency or not, and if M&A events will help to improve banking efficiency when comparing banks have and do not have M&A.

The other angle of analysis is to explore how technical efficiency will affect banks M&A motivations. Are the technical efficiency discrepancies the reasons deciding banks' M&A strategies? We will investigate banks motivations for M&As from their characteristics in terms of technical efficiency based on the previous sub-groups estimation results.

4. *Results Analysis.*

4.1. General Analysis on Technical Efficiency Estimation.

4.1.1. Technical Efficiency Model

The test results for the estimated model (3) and (4) are presented in Table 1. Mean efficiency for the entire sample is 0.6453. The calculated variances for the two main error components are: $\sigma_v^2 = 0.1168$ and $\sigma_u^2 = 1.8307$.

[11] We need to note that there is just one overlapping M&A in our sample; HSBC Holding Company acquired CCF in 2000, and CCF is still keeping its own independent consolidated bank statement. All the other M&A deals are participated by one of the sample banks with other banks which are not in the sample.

Table 1. Model Variables & Estimation Results.

Coefficients	Std.	t-ratio	Variables	Explanation
Production Function (3)				
			LnLN	Natural log of Total loans
$\beta_0 = 11.1136$	0.84	13.16		
$\beta_1 = 0.4850$	0.22	2.18	LnFA	Natural log of Fixed assets
$\beta_2 = 0.8735$	0.30	2.88	LnPE	Natural log of Personnel Expenses
$\beta_3 = -1.6987$	0.25	-6.77	LnDE	Natural log of Total deposits
$\beta_4 = -0.0119$	0.02	-0.71	AC1	Being acquirer once in one year
$\beta_5 = -0.0394$	0.02	-1.61	AC2	Being acquirer twice in one year
$\beta_6 = 0.1535$	0.02	7.62	VE1	Being vendor once in one year
$\beta_7 = 0.0586$	0.03	1.75	VE2	Being vendor twice in one year
$\beta_8 = -0.0750$	0.03	-2.63	VE5	Being vendor five times in one year
$\beta_9 = -0.0512$	0.04	-1.15	TA1	Being target once in one year
$\beta_{10} = 0.0283$	0.08	0.34	TA2	Being target twice in one year
Efficiency Function (4)				
$\delta_0 = -2.4557$	0.61	-4.04		
$\delta_1 = 0.8018$	0.98	0.82	MA1	=1, One M&A in one year; =0, if not.
$\delta_2 = -4.3379$	1.13	3.84	MA2	=1, Two M&As in one year; =0, if not.
$\delta_3 = -1.3171$	0.76	1.73	MA3	=1, Three and more than three M&As in one year; =0, if not.
$\delta_4 = -0.0776$	1.15	-0.07	CON1	=1, if have controlling power via one M&A in one year; =0, if not.
$\delta_5 = -1.2174$	0.77	-1.58	CON2	=1, if have controlling power via two M&A in one year; =0, if not.
$\delta_6 = -4.8327$	1.53	-3.17	RA	Regional dummy for Austria
$\delta_7 = -2.3190$	0.54	-4.32	RB	Regional dummy for BNL
$\delta_8 = -7.4720$	1.70	-4.40	RD	Regional dummy for DFS
$\delta_9 = -3.6510$	1.34	-2.72	RF	Regional dummy for France
$\delta_{10} = 0.5770$	0.90	0.64	RGM	Regional dummy for Germany
$\delta_{11} = -0.3839$	1.04	-0.37	RGC	Regional dummy for Greece
$\delta_{12} = 1.7766$	0.56	3.15	RIE	Regional dummy for Ireland
$\delta_{13} = 0.5750$	0.27	2.14	RIT	Regional dummy for Italy
$\delta_{14} = -6.4267$	0.71	-9.06	RP	Regional dummy for Portugal
$\delta_{15} = 1.3067$	0.31	4.22	RS	Regional dummy for Spain
$\delta_{16} = 1.7150$	0.40	4.28	RU	Regional dummy for U.K.
$\delta_{17} = 1.8746$	0.42	4.41	RC	Regional dummy for Czech Republic.
$\delta_{18} = -3.1953$	1.17	-2.73	LA/TA	Liquid assets / Total assets.
$\delta_{19} = 1.9784$	0.68	-2.90	TS/TA	Total securities / Total assets.
$\delta_{20} = -0.8994$	0.93	-0.97	TA	Total assets.
Other parameters:				
$\sigma^2 = 1.9475$	0.26	7.36		$\sigma^2 = \sigma_u^2 + \sigma_v^2$
$\gamma = 0.94$	0.01	81.81		$\gamma = \sigma_u^2 / \sigma_u^2 + \sigma_v^2$

The mean technical efficiency for the whole sample is 0.6453, which is lower than some other research on banking efficiency in specific European countries. For example, Cuesta and Orea (2001) estimate technical frontier on a panel of Spanish savings banks and find average technical efficiency 0.903. Resti (1997) constructs cost frontier for Italian banks and gets average cost efficiency 0.70. Since we have a cross-country sample, the average technical efficiency is pulled down by some banks with low efficiency in various European regions. We will have further discussion on regional effects later.

We can see that increasing capital and labour inputs can result in higher loan production. Meanwhile, when those mega banks absorb more deposits, they may use them on security investments rather than loan production. The AVT dummies in the production function show that only the vendor role in M&As has significant effects on banks' loan production. Vendor banks sell target banks' shares to acquirer banks, thus they can use deal premiums to produce more loan. However, frequently selling other banks' shares may result in higher transaction costs and will reduce loan production.

The efficiency function shows that banks with higher proportion of liquid assets will have higher technical efficiency, while more businesses in securities investment may reduce technical efficiency. And bigger banks do not necessarily have better technical efficiency. Other dummy variables will be analysed in section 4.2 together with the sub-groups analysis.

4.1.2. General Movement of Technical Efficiency.

Table 2. Annual Average Technical Efficiency,

	Y1-96	Y2-97	Y3-98	Y4-99	Y5-00	Y6-01	Y7-02	Y8-03	AVE.	STD.
Ave.	0.5906	0.6094	0.6236	0.6304	0.6509	0.6686	0.6853	0.7032	**0.6453**[12]	**0.0595**[13]
Std.	0.2192	0.2083	0.2091	0.2082	0.1992	0.1767	0.1802	0.1748	0.1864	

From Table 2, we can observe the general trend of average technical efficiencies have been improving from 0.59 to 0.70 through the eight sample years. The standard deviations across observed banks have been decreasing. This firstly indicates that these *European banks have been improving their performance and reducing the gap in-between themselves and their peer groups*. This may not obviously lead to the conclusion of consolidated European banking market, but at least implies the increasing similarities of European banks efficiency performance. Furthermore, this probably reflects the growing competition in European banking market.

4.2. M&A Effects on Technical Efficiency.

[12] The average technical efficiency score for the entire sample is 0.6453.
[13] It is the standard deviation across 100 banks over the time period, namely the TE volatility for the whole sample.

4.2.1. Regional Effects on Technical Efficiency.

Table 3. 100 Banks Technical Efficiency Regional Effects

Countries/Regions	Banks No.	Ave. Regional TE	Ave. Std. [14]	t-ratio
Austria	2	0.4642	0.002	-2.96
BNL[15]	12	0.6136	0.05	-12.19
DFS[16]	7	0.8603	0.02	0.65[17]
France	22	0.5863	0.07	-7.01
Germany	5	0.5698	0.03	-5.70
Greece	4	0.4592	0.10	-2.91
Ireland	4	0.7643	0.06	1.98
Italy	11	0.7397	0.06	2.76
Portugal	3	0.6866	0.10	7.58
Spain	15	0.6562	0.08	31.64
UK	13	0.6703	0.05	13.19
Czech Republic	2	0.4087	0.06	-2.50

The estimated model with regional dummies in the efficiency function shows that ten out of twelve regions have strong regional effects on technical efficiency. The regional effects from Austria, BNL, DFS, France and Portugal are positively linked with technical efficiency, while Ireland, Italy, Spain, UK and Czech Republic have negative regional effects on banks technical efficiency.

Table 3 shows the average technical efficiency in each country and region. The Scandinavian group DFS has the best efficiency performance. The average technical efficiency for 13 UK big banks ranks the fifth, right after Scandinavia, Ireland, Italy and Portugal. The bank that has the highest average technical efficiency score 0.9020 is the French bank Dexia Crédit Local SA. The bank has minimum technical efficiency score 0.1733 is BNP Paribas Securities Services SA. The French bank Caisse Centrale du Crédit Immobilie has the most volatile technical efficiency performance in the sample with cross time standard deviation 0.3968, its technical efficiency scores range from 0.0078 in 1996 to 0.9205 in 2003.

4.2.2. M&A Participant Roles Effects on Technical Efficiency.

[14] As this is the standard deviation across time and observations, it has the indication of volatility.
[15] BNL: Belgium, Netherlands, and Luxembourg.
[16] DFS: Denmark, Finland and Sweden.
[17] Note that the null hypothesis for technical efficiency is 100% full efficiency. The estimation for DFS group is statistically insignificant, which means we can't reject the null hypothesis that the DFS group has the best efficiency performance.

a). Technical Efficiency for Each M&A Participant Roles**.**

We can find several interesting results from Table 4 grouping the sample banks according to their participant roles in M&As. Generally, across the eight years, they all follow the trend of improving technical efficiency and decreasing variance from each other. The vendors group seems benefit mostly from selling the target banks' shares thus has the highest average technical efficiency score 0. 7377 and the smallest efficiency volatility 0.0511 over the eight years. This is compatible with the previous model estimation that *vendor banks achieve higher technical efficiency by producing more loans through M&A activities.* Acquiring banks have the advantages of obtaining more stakes and growing into bigger size. Thus they manage to achieve the second highest technical efficiency 0.6698. Target banks' average technical efficiency 0.6376 is just below the sample mean level 0.6453. Banks without any M&A activity have the lowest average technical efficiency 0.6243, and the biggest efficiency volatility 0.0619.

Vander Vennet (1996) explains the inefficient management hypothesis that *lower efficiency banks are more likely to be targeted, while higher efficiency banks are more probably to acquire other banks shares.* Wall and Gup (1989), Rose (1989), and Haynes and Thompson (1999) also find evidence for this hypothesis[18]. Our findings for the acquirer banks and target banks average technical efficiency are consistent with these studies. In addition, our findings include the vendor banks efficiency performance. Thus, the inefficient management hypothesis may be amended as *higher efficiency banks are more likely to* ***trade*** *target banks shares, while lower efficiency banks are more probably to be targeted.*

Cuesta and Orea (2001) indicate that merged banks will be more efficient than non-merged banks after an approximate eight to ten years post-M&A period. Our analysis finds that non-M&A banks have the lowest average technical efficiency. This is a supplement finding to the inefficient management hypothesis that *banks with the lowest technical efficiency scores normally have no interests or are not capable to get involved in M&A yet*. The further indication is that some banks in non-M&A group may be struggling not to be acquired, providing the above inefficient management theory for target banks is true. Thus banks have no M&A may be in a dilemma to improve their technical efficiency. Moreover, the non-M&A sub-group banks do not have stable efficiency performance as they have the biggest standard deviation 0.0619 across annual average technical efficiency over the time period.

In short, different technical efficiency levels decide different banking strategies. Or we can say different participant roles in M&As can be regarded as results of discrepancy in technical efficiency scores.

Table 4. Banks Technical Efficiencies According to M&A Participant Roles

[18] Hannan and Rhoades (1987) do not support the hypothesis.

	Y1-96	Y2-97	Y3-98	Y4-99	Y5-00	Y6-01	Y7-02	Y8-03	AVE.	STD[19].
Acquirers										
AVE. TE	0.6085	0.6183	0.6397	0.6697	0.6786	0.6939	0.7103	0.7396	**0.6698**	**0.0539**
STD. TE	0.2270	0.2275	0.2087	0.2044	0.1948	0.1942	0.2031	0.1817	0.2002[20]	
t-ratio	-10.63	-14.15	-64.47	-13.51	-9.64	-6.30	-4.45	-2.76		
Vendors										
AVE. TE	0.6863	0.7005	0.7101	0.7384	0.7506	0.7548	0.7719	0.7890	**0.7377**	**0.0511**
STD. TE	0.1070	0.1097	0.1063	0.0757	0.0696	0.0754	0.0792	0.0806	0.0749	
t-ratio	-7.66	-5.43	-4.47	-2.81	-2.37	-2.24	-1.80	-1.47		
Targets										
AVE. TE	0.6124	0.6105	0.6408	0.6265	0.6358	0.6534	0.6508	0.6708	**0.6376**	**0.0545**
STD. TE	0.2229	0.2212	0.1905	0.1836	0.1872	0.1753	0.1818	0.1932	0.1861	
t-ratio	-11.78	-11.20	-80.63	-19.91	-38.30	-43.04	-63.92	-12.90		
Non-M&A										
AVE. TE	0.5681	0.5906	0.6031	0.6044	0.6277	0.6488	0.6684	0.6837	**0.6243**	**0.0619**
STD. TE	0.2342	0.2190	0.2259	0.2267	0.2169	0.1877	0.1895	0.1870	0.1988	
t-ratio	-5.59	-7.48	-9.41	-9.66	-21.14	-100.03	-14.36	-8.23		

b). M&A Effects on Short-term Technical Efficiency Changes.

Not many studies compare pre- and post-M&A banking efficiency changes. Haynes and Thompson (1999) analyse the post-M&A banking efficiency by imposing a series of five-year post-M&A dummies to evaluate the anticipated lagged structure on bank performance. They find that if acquirer banks had better efficiency than the targets before acquisition, they will reduce the efficiency level soon after the completion of acquisition. However, they do not clearly define their M&A percentage and participant roles and they are enforcing a post-M&A lagged structure. We compare the changes before and after M&A in a different way. As our data have the limitation that there is only one inside sample[21] M&A event, for most of the M&As, we cannot evaluate the performance of all the different parties from the same deal[22]. Also our data do not provide enough information for us to trace each M&A event for a long enough time panel before and after M&A. Thus we look at the short-term technical efficiency changes for M&A events following the M&A participant roles defined above. The change from pre-M&A year to M&A year can give indication of M&A motivations, while the post-M&A performance shows the M&A effects. Table 5 summarizes the changes in the technical efficiencies when comparing one year pre-MA and the MA year, the MA year and one year in post-MA period.

[19] It is the standard deviation of the average yearly TE scores, not the average of standard deviation across banks.
[20] It is the standard deviation of the yearly TE scores for banks in the sub-group.
[21] The British bank HSBC acquired the French bank CCF in 2000.
[22] This leaves a research gap for further research to compare the efficiency changes of each party inside the same M&A deal.

The model estimation shows that the controlling power dummies CONs are not statistically significant in the efficiency function. This means acquirer banks with controlling power via M&As will not necessarily improve their technical efficiency over the eight years. Table 5 indicates that M&As still benefit most acquirer banks in improving their technical efficiency in the short term. Most vendor banks also have continuous improvements in their technical efficiency around the M&A years. The statistically insignificant target role dummies in the production function means being a target will not have any effects on loan production. Hence target banks may not be able to improve their technical efficiency through more loan output in the M&A years. They generally have the trend of decreasing technical efficiency in the M&A years and improving it afterwards.

Table 5. Technical Efficiency Comparison in Pre-MA, MA and Post-MA Years.

M&A role/M&A deals [23]	1 year pre-MA & MA year	MA year & 1 year post-MA
18 Acquirers / 30 MA deals	Most increase TE except 12 deals.	Most increase TE except 3 deals.
23 Vendors / 40 MA deals	Most increase TE except 2 deals.	Most increase TE except 16 deals[24].
11 Targets / 12 MA deals	Most decrease TE except 3 deal.	Most increase TE except 1 deal.

Cuesta and Orea (2001) find a concave ten-year post-M&A curve for efficiency movement for Spanish saving banks; banks technical efficiencies decrease in the first five years after M&A event, then raise up to the pre-M&A level in the second five-year. On the other hand, Haynes and Thompson (1999) find productivity gains following M&As in UK building societies and the post-merger gains increase substantially under the pressure of cost minimizing. They find differences in inherent characteristics for the acquiring group and the non-acquirers. We also find that M&As have the short-term effects of improving most banks' technical efficiency. Our analysis shows that from the M&A year to one-year post M&A period, more than 80% of acquirers manage to improve their technical efficiency, more than half of those vendor banks have lower technical efficiency in 40% of all deals, and nearly all target banks will improve their technical efficiency right after the M&A years. Our research discovers a different pattern of the short-term post-M&A efficiency trend. This may be the result from the complexity of the data sample. There are in total 35 out of 100 banks in the sample get involved in 82 M&A deals. Thereafter the sample includes the situation when banks have more than one M&A in the same year or different years, or have two sequential M&As in sequential years. Other literature may merely look at acquirer banks, or focus on the post-M&A performance for some specific acquisition regardless of any following M&A in their post-M&A periods and the various M&A roles a bank may be.

c). Technical Efficiency Growth Rate for Different M&A Participant Roles.

[23] The number of participant banks and deals in Table 5 include overlapping information for banks and deals. Banks can play different roles in different deals, and can participant in more than one M&A within one year excluding the case when they are taken over completely. However, as our bank statements are all consolidated, target banks in our sample just sell small proportion of their shares and remain independence. Hence it is possible for them to get involve with different M&As. Please also refer to the Appendix.

[24] 16 deals by 14 banks, there are two banks play the vendor roles twice within the same year.

There is no literature study the dynamic aspect of banking efficiency yet. We look at the growth rate of technical efficiency across the sample by different M&A participant roles. In our sample, vendor banks have the highest average technical efficiency 0.7377 but grow at the lowest speed 2.13% each year. This is consistent with their smallest efficiency volatility. On the contrary, non-M&A banks have the lowest average technical efficiency 0.6243 over the years, but grow at the highest speed 12.70% every year. Hence they have the highest efficiency volatility. Thus we can say that banks with low technical efficiency have great improvement potential even though they do not necessarily develop through M&A.

Table 6. Technical Efficiency Growth Rates in M&A Participant Roles Group

	(Y2-Y1) /Y1	**(Y3-Y2) /Y2**	**(Y4-Y3) /Y3**	**(Y5-Y4) /Y4**	**(Y6-Y5) /Y5**	**(Y7-Y6) /Y6**	**(Y8-Y7) /Y7**	**AVE.[25]**
Acquirers								
AVE. TE GR	0.0206	0.0873	0.0553	0.0264	0.0266	0.0128	0.0725	**0.0430**
STD. TE GR	0.0544	0.2406	0.0953	0.0785	0.0384	0.0160	0.2074	
t-ratio	0.91	1.97	4.52	1.58	1.62	0.42	2.46	
Vendors								
AVE. TE GR	0.0212	0.0167	0.0509	0.0184	0.0056	0.0128	0.0232	**0.0213**
STD. TE GR	0.0458	0.0630	0.1035	0.0465	0.0412	0.0217	0.0494	
t-ratio	230.69	3.70	1.72	6.54	0.36	1.50	11.81	
Targets								
AVE. TE GR	-0.0035	0.1307	-0.0162	0.0127	0.0369	-0.0019	0.0242	**0.0261**
STD. TE GR	0.0374	0.3025	0.1008	0.0489	0.0842	0.0347	0.0503	
t-ratio	-0.12	1.25	-0.38	0.95	3.43	-0.07	12.36	
Non-M&A								
AVE. TE GR	0.4164	0.0268	0.0670	0.0747	0.2586	0.0111	0.0347	**0.1270**
STD. TE GR	2.5757	0.1800	0.3514	0.1539	1.4311	0.0393	0.1039	
t-ratio	1.44	0.27	1.11	1.43	1.97	0.10	0.38	

4.2.3. M&As Frequency Effects on Technical Efficiency.

a). M&As Frequency Effects.

In the efficiency function, the M&A frequency dummy MA1 is insignificant while MA2 and MA3 are both statistically significant. The negative signs for coefficients of high M&A frequency dummies actually mean positive effects on technical efficiency. This indicates that higher M&A frequency will improve banks technical efficiency. The sub-group analysis in Table 7 is in agreement with the model estimation. Table 7 shows that frequent M&As benefit banks in two aspects: achieving the highest average sub-group technical efficiency 0.6943 and the lowest efficiency volatility 0.0510 across time. Banks with only one M&A has the average technical efficiency at a

[25] The average technical efficiency growth rates for each subgroup.

medium level 0.6706. Non-M&A banks have the lowest average technical efficiency 0.6243 and the highest volatility 0.0619. Hence, *banks staying away from M&A or avoiding frequent M&As does not indicate that they have much more stable technical efficiency performance than those frequently have M&A activities. Alternatively, we can say frequent M&As can help to improve technical efficiency and reduce the efficiency volatility.*

Table 7. Banks Technical Efficiency According to M&A Frequency

	Y1-96	**Y2-97**	**Y3-98**	**Y4-99**	**Y5-00**	**Y6-01**	**Y7-02**	**Y8-03**	**AVE.**	**STD[26].**
Frequent M&As										
AVE. TE	0.6430	0.6569	0.6723	0.6959	0.7030	0.7123	0.7230	0.7478	**0.6943**	**0.0510**
STD. TE	0.2068	0.2075	0.1867	0.1842	0.1782	0.1787	0.1896	0.1742	0.1818	
t-ratio	-154.25	-29.66	-12.12	-6.01	-5.15	-4.29	-3.57	-2.46		
One M&A										
AVE. TE	0.6186	0.6277	0.6472	0.6559	0.6821	0.6964	0.7081	0.7284	**0.6706**	**0.0604**
STD. TE	0.1547	0.1551	0.1499	0.1250	0.1231	0.1043	0.1126	0.0988	0.1179	
t-ratio	-14.28	-21.11	-185.10	-32.33	-8.64	-5.95	-4.65	-3.27		
Non-M&A										
AVE. TE	0.5681	0.5906	0.6031	0.6044	0.6277	0.6488	0.6684	0.6837	**0.6243**	**0.0619**
STD. TE	0.2342	0.2190	0.2259	0.2267	0.2169	0.1877	0.1895	0.1870	0.1988	
t-ratio	-5.59	-7.48	-9.41	-9.66	-21.14	-100.03	-14.36	-8.23		

b). Technical Efficiency Growth Rate for Different M&A Frequencies.

Table 8. Technical Efficiency Growth Rates in M&A Frequency Group

	(Y2-Y1) /Y1	**(Y3-Y2) /Y2**	**(Y4-Y3) /Y3**	**(Y5-Y4) /Y4**	**(Y6-Y5) /Y5**	**(Y7-Y6) /Y6**	**(Y8-Y7) /Y7**	**AVE.**
Frequent M&As								
AVE. TE GR	0.0265	0.0716	0.0405	0.0195	0.0165	0.0090	0.0598	**0.0348**
STD. TE GR	0.0574	0.2345	0.0945	0.0708	0.0450	0.0212	0.1959	
t-ratio	3.21	1.94	7.04	1.28	0.90	0.35	2.39	
One M&A								
AVE. TE GR	0.0598	0.0896	0.0292	0.1238	0.0429	0.0203	0.0395	**0.0579**
STD. TE GR	0.1289	0.0880	0.1529	0.1186	0.0716	0.0296	0.0835	
t-ratio	30.69	2.82	1.02	1.88	2.87	0.54	2.15	
Non-M&A								
AVE. TE GR	0.4164	0.0268	0.0670	0.0747	0.2586	0.0111	0.0347	**0.1270**
STD. TE GR	2.5757	0.1800	0.3514	0.1539	1.4311	0.0393	0.1039	
t-ratio	1.44	0.27	1.11	1.43	1.97	0.10	0.38	

[26] It is the standard deviation of the average yearly TE scores, not the average of standard deviation across banks.

Table 8 shows that the non-M&A banks efficiency growth rate (12.70%) is about four times of the frequent M&A banks group (3.48%) and two times of the one M&A banks group (5.79%). In short, *the more frequently banks have M&As, the smaller annual efficiency growth rate they have.*

Hence, Table 8 further confirms the results from Table 7 that M&A events stimulate banks to achieve higher and more stable technical efficiency over the years. This is especially true when a bank has multiple sequential M&A events within a year or in two sequential years. Non-M&A banks improve their efficiency at the highest speed thus they have high technical efficiency volatility.

4.3. Motivations for M&As in terms of Technical Efficiency.

What motivate banks to take over other banks? Why banks will sell off their holding stakes of other banks? Why some banks would be happy to be acquired? Why some banks have never got involved into an M&A event? We mentioned in the beginning that there is an ambiguous causality relationship between technical efficiency and M&A events. The previous section analyses technical efficiency as the effects from banks M&A activities. In this section, we look at banks M&A motivations from the aspect of technical efficiency. Table 9 summarizes the previous technical efficiency sub-grouping results. It implies that each party's M&A motivations are actually driven by the discrepancies of technical efficiency. Investigating bank M&A motivations by identifying the features of different participant roles, we can distinguish banks M&A motivations and strategies more easily.

Table 9. Results Summary for M&A Motivations

	Acquirers	**Vendors**	**Targets**	**Non-M&A**
AVE. TE.	0.6698	0.7377	0.6376	0.6243
Volatility	0.0539	0.0511	0.0545	0.0619
Pre-MA→MA	Most increase TE	Most increase TE	Most decrease TE	/
MA→Post-MA	Most increase TE	Most increase TE	Most increase TE	/
TE Growth rate	4.30%	2.13%	2.61%	12.70%

	Frequent M&As	**One M&A**	**Non-M&A**
AVE. TE	0.6943	0.6706	0.6243
Volatility	0.0510	0.0604	0.0619
TE Growth rate	3.48%	5.79%	12.70%

First of all, we can separate non-M&A banks from M&A banks as they have the lowest technical efficiency 0.6243 and the highest volatility 0.0619. Thus their managers are working hard to improve their efficiency at the fastest speed 12.70% per year. In short, *when banks have very low technical efficiency and they improve efficiency at very high*

speed, they have the least possibility to be involved in M&A activities. And when these banks improve their efficiency up to the average level, they are likely to be targeted.

Generally speaking, t*he higher technical efficiency scores the banks have, the more likely and frequently they would get involved in M&A activities.* This is because frequent M&As will not be a volatile factor affecting technical efficiency, but will instead push them to improve their technical efficiency at a mild speed. This result may be from the reason that when banks take part in various M&As, the different M&A effects may cancel out each other. Therefore, the mild efficiency improvement speed for the frequent M&As group is a trade-off effect of multiple M&As.

Even though acquirer banks do not specially benefit from obtaining the controlling power in M&As to produce more loans thus raising technical efficiency, the strategy of acquiring more shares is still a kind of managerial preference and is lured by the positive influence of higher efficiency, increasing market power, growing profitability and fast efficiency growing speed.

Vendor banks are motivated to sell their holding stakes of target banks because they can benefit from the short-term income and lessen their pressure of holding poor performance banks' shares. Moreover, they use the income to produce more loans and improve their technical efficiency. This will effectively guarantee them a rather high efficiency performance.

Those banks that are being targeted normally have relatively low technical efficiency. As they are likely to improve their efficiency performance in the post-M&A years, they do not refuse to be taken over.

5. Conclusions.

This paper investigates banks mergers and acquisitions effects on technical efficiency, and how technical efficiency drive banks to act in different M&A roles. The sample covers 100 mega European bank M&A events during 1996—2003. Generally, our sample banks have increasing technical efficiency scores and efficiency similarities over the eight years. We find that banks with more capital and labour inputs will produce more loans, and higher proportion for liquid assets and lower percentage for security investment are presumed to have direct effects on improving technical efficiency.

Banks from Austria, Belgium, Netherlands, Luxembourg, Denmark, Finland, Sweden, France and Portugal have positive regional effects on their technical efficiency. Meanwhile, banks from Ireland, Italy, Spain, UK and Czech Republic have negative regional effects on technical efficiency.

One of the main contributions of this research is that we find vendor banks benefit mostly from selling target banks shares. They may use the M&A deal premium to increase their loan production immediately and achieve high technical efficiency. They have relatively stable technical efficiency performance, and most of them manage to improve their technical efficiency continuously through M&A events. However, being a vendor as frequent as five times a year will result in higher transaction costs rather than improving technical efficiency through higher loan production. Through M&A activities, acquirer banks do not have advantages to increase their loan production or improve their technical efficiency remarkably by obtaining the controlling power. However, they still manage to achieve a relatively high level of technical efficiency and keep it growing at a medium speed. Target banks normally do not have high technical efficiency but still have a mild efficiency growth rate. Technical efficiency for target banks will firstly decrease in the M&A years, then slowly pick up in the post-M&A years.

An interesting conclusion from our research is that *frequent M&As will benefit banks in higher technical efficiency and less efficiency volatility.* Non-M&A banks have the lowest technical efficiency and the biggest efficiency growth rate over the period. Hence they have relatively high efficiency volatility.

Overall, M&A activities seem to be driven by differences in technical efficiency. *Banks with high technical efficiency tend to trade target banks shares while banks with low technical efficiency are likely to be targeted*. Banks with the lowest technical efficiency levels are least likely to engage in any M&A activity.

The limitation for our study is that our 100 banks panel does not include too many in-sample M&A cases. Thus further research can investigate the situation when target banks are completely taken over (without independent consolidated financial statement after M&A), and compare the pre-M&A efficiency of the acquirers, vendors and targets and post-M&A efficiency of the vendors and new banks over a longer time dimension.

Appendix. Banks Distribution by M&A Roles.

Countries	Acquirers	Vendors	Targets	No-M&A	100 banks
Austria				2	2
Belgium				3	3
Denmark				1	1
Ireland	2	3		1	4[27]
Finland	1	1			1
France	1	1	3	18	22
Germany	1	2	1	3	5
Greece	1			3	4
Italy	4	5	3	3	11
Luxembourg	1		1	2	3
Netherlands	1	2		4	6
Portugal	1	2			3
Spain	2	3	2	10	15
Sweden	1			4	5
UK	2	3		9	13
Czech Republic				2	2
In Total	18	22	10	65	100

(There are some banks acting different roles in the same year or different years so that the total banks got involved in M&As during 1996—2003 are 35, within which 18 banks have only one M&A and 17 banks have more than one M&A events during the eight years.)

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