African Journal of Business Management Vol. 5(26), pp. 10508-10523, 28 October, 2011
Available online at http://www.academicjournals.org/AJBM
DOI: 10.5897/AJBM11.438
ISSN 1993-8233 ©2011 Academic Journals

Full Length Research Paper

Assessing Taiwan financial holding companies' performance using window analysis and Malmquist productivity index

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Accepted 16 May, 2011

Performance evaluation is the important approach for enterprises to give incentive and restraint to their operators and it is also an important channel for enterprise stakeholders to get the performance information. The purpose of this study is to analyze current evaluation system for Taiwan Financial Holding Companies. This research tries to measure the performance on thirteen financial holding companies in Taiwan for the period 2003 to 2009. The result presented the proposed method is practical and useful. Also the study result represented that the combined method had certain scientific and rationality. The evaluation model indicates that this method be more reasonable and easier to grasp than other methods. As a result, it is easier to popularize this evaluation method in enterprises. The study thus presents a complete assessment model that helps managers to identify items for improvement, while simultaneously promoting cost and time efficiencies in financial Holding Companies.

Key words: Financial holding companies, data envelopment analysis (DEA), window analysis, malmquist productivity indexes.

INTRODUCTION

Performance evaluation is a necessary and beneficial process, which provides annual feedback to company about job effectiveness and efficiency. The performance evaluation and optimal design of weapon systems are multiple criteria decision making problems (Paradi and Schaffnit, 2004). In order to compete in today's competitive environment, many organizations have recognized benchmarking as being of strategic important in the drive for better performance and commitment to achieving a competitive advantage (Wu et al., 2006). Currently, the performance evaluation have already become the important means of investigating employee's performance; performance evaluation could contribute to the realization of a business' target, exaltation of business performance and improvement of employees' behavior, promotion of ability. Over the past few decades, performance analysis has received significant attention. Many studies have investigated the method about performance evaluation (Chalasani and Sounderpandian, 2004; Wynn-Williams, 2005; Gleich et al., 2008; Maiga and Jacobs, 2004; Wu et al., 2010). Some literatures identified the different key performance indicators, including tangible and intangible aspect (Mukherjee et al., 2002; Chin et al., 2001; Himes, 2007; Jones and Kaluarachchi, 2008; Welch and Mann, 2001; Wainwright et al., 2005; Robson and Prabhu, 2001). It is essential for the application of performance measurement that a company's tangible and intangible targets are defined in a way that is more appropriate to the requirements and objects of this targets and that its strategy is more extensively operationalized, quantified and linked in a mutually supplementing way.

Accurate business performance evaluation is a key to success for enterprises. The performance evaluation and optimal design of weapon systems are multiple criteria decision making problems (Paradi et al., 2011). In order to compete in today's competitive environment, many organizations have recognized benchmarking as being of strategic important in the drive for better performance and commitment to achieving a competitive advantage. The problem of the complexity of performance evaluation makes the development and the application of standard models more difficult, while at the same time actually presents a motivation for the development of new, more flexible models, which, again, can be adapted to specific interest positions of those who compare the alternatives.

In this paper we apply a new approach based on frontier production function to research the productivity growth of financial holding companies Performance in Taiwan. The research framework is that of data envelopment analysis (DEA). DEA is a nonparametric method in operations research and economics for the estimation of production frontiers. It is used to empirically measure productive efficiency of decision making units. There are also parametric approaches which are used for the estimation of production frontiers.

Under such a competitive environment, port performance measurement is not only a powerful management tool for port operators, but also constitutes a most important input for informing regional and national port planning and operations. Kumbhakar and Lovell (2000) stated that cross-sectional data provide a snapshot of producers and their efficiency and panel data provide more reliable evidence on their performance, because they enable us to track the performance of each producer through a sequence of time periods. In order to overcome this potential problem associated with an analysis based on cross-sectional data, in this paper, DEA window analysis is, for the first time, applied to the port industry to deduce efficiency trends. Then, this paper continues conduct Malmquist productivity index (*MPI*) to estimate technological changes. *MPI* is defined using non-parametric distance functions, which determine how far a firm is from its optimal production given the observed output and applied input. *MPI* can decompose the productivity growth into two mutually exclusive components: technical efficiency change and technical change overtime, which measures the change in efficiency frontier shift, respectively (Froot and Klemperer, 1989).These are: (i) technical efficiency change (*E*); (ii) technological change (*P*); (iii) pure technical efficiency change (*PT*); (iv) scale efficiency change (*S*); and (v) total factor productivity (*M*) change.

DATA ENVELOPMENT ANALYSIS (DEA) MODEL

DEA is a mathematical linear programming, approach based on the technical efficiency concept, it can be used to measure and analyze *TE* of different entities: productive and non productive, public and private, profit and nonprofit seeking firms (Hsiao et al., 2010). The main advantages of DEA that makes it suitable for measuring the efficiency of vehicle inspection agencies are: (i) it allows the simultaneous analysis of multiple outputs and multiple inputs, (ii) it does not require an explicit a priori determination of a production function, (iii) efficiency is measured relative to the highest observed performance rather than against some average and (iv) it does not require information on prices (Odeck, 2000). Since the financial holding companies in Taiwan are part of the public sector where economic behavior is uncertain and there is no price information on the services produced, the window analysis and Malmquist productivity index based on DEA approach is well suited for productivity measurement in this sector. It is a non-parametric approach that calculates efficiency level by doing linear program for each unit in the sample. DEA measures the efficiency of the decision-making unit by the comparison with best producer in the sample to derive compared efficiency.

As we have seen, DEA is based on *TE* concept whose Equation (1):

$$\text{Technical efficiency (TE)} = \frac{\sum weighted\ output}{\sum weighted\ input} \quad (1)$$

Mathematically, we can express the stated relation by the following Equation (2):

$$E_k = \frac{\sum_{j=1}^{M} U_j O_{jk}}{\sum_{i=1}^{N} V_i I_{ik}} \quad (2)$$

E_k: TE for the DMU_k (between 0 and 1); k: Number of DMU_k in the sample (k=1,…K); N: Number of the inputs used ($i=1,\cdots,N$); M: Number of outputs ($j=1,\cdots,M$); O_{jk}: The observed level of output j from DMU_k; I_{ik}: The observed level of input i from DMU_k; V_i: The weight of input i; U_j: The weight of output j.

To measure *TE* for DMU_k by using linear program, the following problem must be solved which is Equation (3):

$$\begin{aligned} &Max.TE \\ &\quad S.to \\ &\quad Ek \le 1 \quad k = 1, 2, \cdots K \end{aligned} \quad (3)$$

Where *TE* is either maximizing outputs from given inputs, or minimizing inputs for a given level of outputs. The above problem cannot be solved as stated because of difficulties associated with nonlinear (fractional) mathematical programming. Charnes et al. (1978) have developed a mathematical transformation which converts the above nonlinear programming to linear one.

Modified linear programming by the following Equation (4):

$$Max\sum_{j=1}^{M}U_jO_{jk}$$
$$s.t.$$
$$\sum_{i=1}^{N}V_iI_{ik}=1$$
$$\sum_{j=1}^{M}U_jO_{jk}\le\sum_{i=1}^{N}V_iI_{ik}$$
$$U_j,V_i\ge\varepsilon>0 \quad (4)$$

Window analysis

Based on rule of thumb, the number of DMU_k should be greater than double the sum of inputs and outputs. In order to overcome the constraint of limited DMU_k in this study, the Window Analysis Method proposed by Charnes et al. (1978) is adopted. Windows analysis is a time dependent version of DEA. In order to capture the variations of efficiency over time, Charnes et al. (1978) proposed a technique called 'window analysis' in DEA. Window analysis assesses the performance of a DMU_k over time by treating it as a different entity in each time period. This method allows for tracking the performance of a unit or a process.

The basic idea is to regard each DMU_k as if it were a different DMU_k in each of the reporting dates. Then each DMU_k is not necessarily compared with the whole data set, but instead only with alternative subsets of panel data. The windows analysis is based on the assumption that what was feasible in the past remains feasible forever, and that the treatment of time in windows analysis is more in the nature of an averaging over the periods of time covered by the window (Tulkens and van den Eeckaut, 1995). DEA is initially used to analyze cross-sectional data, where a given DMU_k is compared with all other DMU_k that produce during the same time period and where the role of time is ignored. However, this can be rather misleading since a dynamic context may give rise to seemingly excessive use of resources that are intended to produce beneficial results in future periods. As such, panel data prevail over cross-sectional data in that not only do they enable a DMU_k to be compared with other counterparts, but also because the movement of efficiency of a particular DMU_k can be tracked over a period of time. In so doing, panel data are more likely to reflect the real efficiency of a DMU_k.

We briefly introduce the meaning of window analysis. Assume there are *N* alternatives, $l=1,\cdots,N$, and each alternatives has data for period 1 to M, $m=1,\cdots,M$. The window length is fixed to be *K*, the data from period $1,2,\cdots,K$ will form the first row, and the data from period $2,3,\cdots,K,K+1$ will form the second row, and so on. One more periods on the right will need to be shifted, and a total of $M-K+1$ window rows exists. Each window is represented by $i=1,\cdots,M-K+1$, and the ith window consists of the data in periods $j=i,\cdots,i+k-1.$ There are K sets of data to be evaluated. Therefore, there are a total of $N\times K$ DMU_k in that window.

In order to apply window analysis, DEA is used to evaluate the performance of all DMU_k in the same window, and the efficiency, $E_{i,j}^{l}$, of each *DMU* will be entered in the right window position. The procedure will be repeated $M-K+1$ times to obtain all the efficiency values in all windows. Window analysis used all the efficiency values of an alternative to generate some statistics values. There includes average efficiency (M_l), variance among efficiencies of alternative l (V_l), Column range ($CR_{l,m}$), and the total range for alternative $l(TR_l)$ (Chung et al., 2007).

The average efficiency (M_l) of alternative l is obtained by the following Equation (5):

$$M_l=\frac{\sum_{t=1}^{M-k+1}\sum_{j=1}^{i+k-1}E_{i,j^l}}{K\times(M-K+1)},\quad l=1,\cdots,N \quad (5)$$

The variance among efficiencies of alternative l, V_l, is calculated by the following Equation (6):

$$V_l=\frac{\sum_{i}^{M-K+1}\sum_{j}^{i+k-1}(E_{i,j}^{l}-M_l)^2}{K\times(M-K+1)-1},\quad l=1,\cdots,N \quad (6)$$

The variance of efficiency reflects the fluctuation of efficiency values for each alternative. If an alternative has a higher average efficiency and small variance, its ranking can be higher compared to other alternatives.

Column range, $CR_{l,m}$, can be used to compare the fluctuations of efficiencies among the alternatives. In each alternative, because the data of the first period $(m=1)$ and last period $(m=M)$ are being analyzed in only the first and the M-K+1 window only one efficiency value is obtained for each of the two windows, the efficiencies in the first and last periods will not be included in the calculation of CR values. For the other periods, the data of each alternative is used at least twice and at least two efficiency values are available for calculating *CR* values.

$CR_{l,m}$ is the difference between the largest and the smallest efficiencies for alternative l in period *m* by the following Equation (7):

$$CR_{l,m} = Max(E^l_{i,m}) - Min(E^l_{i,m})$$
$$i = \max(m-k+1,1),\cdots,\min(m, M-K+1)$$
$$m = 1,\cdots,M \tag{7}$$

$CR_{l,m}$ can be used to evaluate the stability of efficiency of an alternative in each period. Then, CR_l is the overall column range for alternative l, and it shows the greatest variation in efficiency of an alternative over different periods by the following Equation (8):

$$CR_l = Max_{m=2,\cdots,M-1}(CR_{l,m}) \tag{8}$$

Finally, in order to understand the stability of an alternative over different periods, we can use total range to evaluate it. Total range is the difference between the maximum and minimum efficiency values of alternatives in all windows. The total range (TR) for alternative l is Equation (9):

$$TR_l = Max(E^l_{i,j}) - Min(E^l_{i,j})$$
$$i = 1,\cdots,M-K+1$$
$$j = i,\cdots,i+K-1 \tag{9}$$

Window analysis of DEA has been adapted in many academic fields, such as industry analysis. Carbone (2000) explains how window analysis can be used in a semiconductor manufacturing environment to identify areas of best practice within a fabricator. Cullinane et al. (2004) apply DEA Windows analysis to container port production efficiency. Chung and Hwang (2005) use window analysis to evaluate Taiwan's bulk shipping firms' performance. Shahooth and Battall (2006) use data envelopment analysis and window analysis in measuring and analyzing the relative cost efficiency of 24 Islamic banking institutions. Chang et al. (2007) applied window analysis to analyze dynamical efficiencies of Taiwan's TFT-LCD firms for the period from 2001 - 2005.

Malmquist productivity indexes (*MPI*)

The MPI were developed by Caves et al. (1982) based on the distance functions developed by Malmquist (Caves et al., 1982; Fethi and Pasiouras, 2010). Färe et al. (1994) decomposed the productivity growth into two mutually exclusive components: Technical efficiency change and technical change overtime, which measures the change in efficiency frontier shift, respectively (Froot and Klemperer, 1989). The *MPI* expressed in DEA efficiency measures is defined as the ratio of the efficiency measures for the same production unit in two different time periods or between two different observations for the same period (Lin et al., 2009; Odeck, 2000). The study uses DEA approach outlined by Färe et al. (1994) to construct the best-practice frontier for thirteen financial holding companies in Taiwan.

The *MPI* for any unit between a period of 0 and 1 with frontier technology of period i as a reference, $M_i(0,1)$, can be calculated by using DEA measures obtained by solving the LP-problems (Odeck, 2000), which is Equation (10):

$$M_i(0,1) = \frac{E_{i1}}{E_{i0}}, \quad i = 0,1 \in T \tag{10}$$

The i is the frontier technology, E_{i0} is the input (output) efficiency measure for a unit observed in period 0 and E_{i1} is input (output) efficiency for the same units observed in period 1 with technology i. The index, $M_i(0,1)$, shows the relative change in technical efficiency, and T represents the time period for them DMU_k.

Malmquist productivity indexes are based on nonparametric-parametric approach, which can capture the productivity change in economic growth using specific production function. The mathematics concept is borrowed from Odeck (2000). The denominator shows the proportional adjustment of the observed input vector of the unit in period 1 for observed outputs to be on the same frontier function. The denominator is always between 0 and 1, while the numerator can be greater than 1. It follows that when $M_i(0,1)$ > 1, then productivity has increased. If $M_i(0,1)$< 1 then the productivity has decreased and if $M_i(0,1)$=1 then productivity is unchanged. This holds irrespective of the reference technology (Odeck, 2000). Then, we can transform mathematics concept into a diagram, which is shown in Figure 1. The first year is t_0, and the second year is t_1. The model included one input variable (x) and one output variable (y). In the first year t_0, unit K_0 is observed with the combination (y_0, x_0), the corresponding benchmark units on the frontier are $K_1(y_0, x_{00})$ and $K_2(y_0, x_{10})$. The efficiency measures E_{00} and E_{10} are equal to the ratios (x_{00}/x_0) and (x_{10}, x_0). Therefore, the *MPI* can be written as Equation (11) which indicates that the *MPI* is the change in productivity between the two periods:

$$M_i(t_0,t_1) = \frac{E_{i1}}{E_{i0}} = \frac{x_{i1}/x_1}{x_{i0}/x_0} = \frac{y_1/x_1}{y_0/x_0} \tag{11}$$

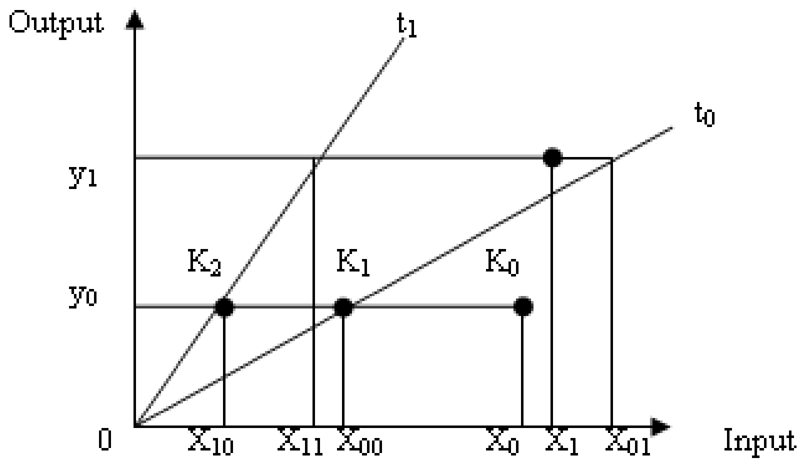

Figure 1. The MPI and its components (Odeck, 2000).

In relation to Figure 1, the *MPI* can be decomposed into two parts, the first is the technical efficiency change (*E*) and the second is technological change (*P*), which is Equation (12):

$$M_i = E_i \times P_i, \quad i = 0,1$$

$$P_i(t_0, t_1) = \frac{E_{01}}{E_{11}} = \frac{x_{01}/x_1}{x_{11}/x_1} = \frac{x_{12}}{x_{22}}$$

$$E_i(t_0, t_1) = \frac{E_{11}}{E_{00}} = \frac{x_{11}/x_1}{x_{00}/x_0} = \frac{(y_1/x_1)(y_1/x_{11})}{y_0/x_0 \quad y_0/x_{00}} = \frac{x_{11}}{x_{00}} \quad (12)$$

Using these models, and the Fare et al. (1994) approach, it is thus possible to provide four efficiency/productivity indices for each firm and a measure of technical progress over time. These are: (i) technical efficiency change (*E*) (that is relative to a constant returns-to-scale technology); (ii) technological change (*P*); (iii) pure technical efficiency change (PT) (that is relative to a variable returns-to-scale technology); (iv) scale efficiency change (*S*); and (v) total factor productivity (M) change. Recalling that M indicates the degree of productivity change, then if M > 1 then productivity gains occur, whilst if M < 1 productivity losses occur. Regarding changes in efficiency, technical efficiency increases (decreases) if and only if *E* is greater (less) than one. An interpretation of the technological change index is that technical progress (regress) has occurred if P is greater (less) than one.

An assessment can also be made of the major sources of productivity gains/losses by comparing the values of *E* and *P*. If *E* > *P* then productivity gains are largely the result of improvements in efficiency, whereas if *E* < *P* productivity gains are primarily the result of technological progress. In addition, an indication of the major source of efficiency change can be obtained by recalling that overall technical efficiency is the product of pure technical efficiency and scale efficiency, such that *E* = *PT* × *S*. Thus, if *PT* > *S* then the major source of efficiency change (both increase and decrease) is improvement in pure technical efficiency, whereas if *PT* < *S* the major source of efficiency is an improvement in scale efficiency.

There are many different research applied *MPI* to evaluate the cross-period efficiency. Worthington (1999) employed *MPI* productivity growth which is decomposed into technical efficiency change and technological change for two hundred and sixty-nine Australian credit unions. Odeck (2000) used *MPI* to analyze efficiency and productivity growth of the Norwegian Motor Vehicle Inspection Agencies for the period 1989 to 1991. Zheng et al. (2003) investigated the productivity performance of SOEs using data envelopment analysis and a *MPI* based on a sample of about 600 state enterprises from 1980 to 1994. Chen and Ali (2004) proposed a new approach which not only reveals patterns of productivity change and presents a new interpretation along with the managerial implication of each Malmquist component, but also identifies the strategy shifts of individual DMU_k based upon isoquant changes. Pastor and Lovell (2005) propose a global *MPI* and that give a single measure of productivity change. Zelenyuk (2006) found a theoretically justified method of aggregating *MPI* over individual decision making units into a group *MPI*. Wei et al. (2007) used *MPI* decomposition to investigate energy efficiency of China's iron and steel sector during the period from 1994 to 2003. Liu and Wu (2007) used *MPI* to analyze the total factor productivity change in China's logistics industry with panel data of logistics listed corporation from 1999 to 2006. Liu and Wang (2008) employ data envelopment analysis to measure the *MPI* of semiconductor packaging and testing firms in Taiwan from 2000 to 2003. Barros (2008) estimates changes in total productivity, breaking this down into technically efficient

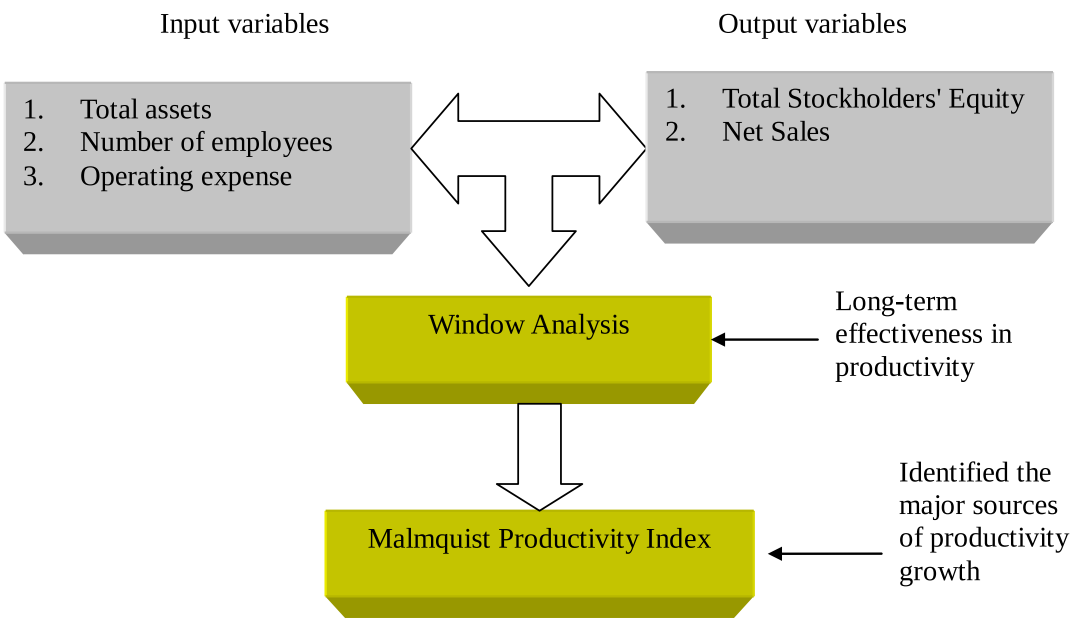

Figure 2. Research framework.

change and technological change, by means of data envelopment analysis applied to the hydroelectric energy generating plants of EDP - the Portugal Electricity Company. Rezitis (2008) investigate the effect of acquisition activity on the efficiency and total factor productivity of Greek banks.

RESEARCH DESIGN

We further propose our research framework and describe our variable measurement and sample selection.

Research framework

This research tries to measure the performance on thirteen financial holding companies in Taiwan for the period 2003 to 2009 (Figure 2). The outputs to the model are two well known measures of overall performance: total stockholders' equity and net sales determines the relative efficiencies of the first tier industries in our sample in using the two inputs, total assets, number of employees and operating expense, to generate the two outputs. This allows identification of efficiency differentiators, which proves very useful for inefficient industries because it allows them to spot their weaknesses and improve performance. This study applies the DEA approach to reveal the extent to which inputs can be augmented while maintaining the same level of outputs. We employ window analysis to find out the long-term effectiveness in productivity. Finally, we adopt the *MPI* to identify the major source of productivity growth and separate the catching effect from efficiency changes over time due to technological advancements by using *MPI*. This study uses a DEA model to establish a foundation for measuring the efficiency of thirteen financial holding companies in Taiwan.

Variable measurement and sample selection

Frontier models require the identification of inputs (resources) and outputs (transformation of resources). Several criteria can be used in their selection. The first of these, an empirical criterion, is availability. Secondly, the literature survey is a way of ensuring the validity of the research and thus represents another criterion to be taken into account. The samples of this research are thirteen financial holding companies in Taiwan, which are Hua Nan, Fubon, Cathay, China Development, E. Sun, Yuanta, Mega, Taishin, Shin Kong, Waterland, SinoPac, Chinatrust and First. The period time of this research DMU_s is from 2003 to 2009 (Appendix 1). There are a total of 91. We use three input variables and two output variables. The input variables are total assets, number of employees, operating expense and operating expense and the output variables are total stockholders' equity and net sales. The sources of data are from the bureau of Taiwan Economic Journal Database.

EMPIRICAL RESULTS

Our study only developed a performance evaluation system of Taiwan financial holding companies. Here, we conduct the correlation analysis, window analysis and Malmquist productivity indexes analysis. In this study, 13 financial holding companies' listed companies were selected as the study samples. The financial data used in the study were derived from the Taiwan Economic Journal Database. The tools used in data processing and analysis are EXCEL2003, DEAP 2.1 and SPSS Statistics16.0.

Correlation analysis

A remark concerns the “isotonicity” relations which are assumed for DEA and involves when an increase in any input does not result in a decrease in any output. Consequently, the values of some factors may have to be inverted before they are entered into the analysis

Table 1. Correlation analysis.

Variable	Total assets	No. of employees	Operating expense	Total stockholders' equity	Net sales
Total assets	1				
Number of employees	0.822**	1			
Operating expense	0.890**	0.839**	1		
Total stockholders' equity	0.755**	0.520**	0.691**	1	
Net sales	0.747**	0.951**	0.765**	0.512**	1

*Correlation is significant at the 0.05 level (2-tailed); ** correlation is significant at the 0.01 level (2-tailed).

(Charnes et al., 1978). This study applies coefficient of correlation (r) to test the "isotonicity". The correlations of the input/output data (correlation ratio) are show as Table 1.It explains the relation of *DMU*. It shows that all relationships between input variables and output variables are significant. From the correlation analysis, it indicates that the five factors satisfy the requirement of isotonicity and are already represented and suitable for our research.

Window analysis

DEA window analysis can be done by Excel Solver via visual basic application. Microsoft Company, 2003 Microsoft Company, (2003). Excel. Seattle, USA. In this paper, we assume constant returns to scale; that is, as all inputs double, all outputs will double. The window analysis enables us to identify the best and the worst industries in a relative sense, as well as the most stable and variable industries in DEA scores. The overall efficiency for each DMU_k is calculated by using *CCR* model, and the DEA window analysis is applied. The efficiency scores reported above are from panel data analyses, where the observations for thirteen financial holding companies in Taiwan in different years are treated as separate observations and all measured against each other. This may not be a reasonable assumption because of technological improvements happening over the 7 year period under analysis and that could make the comparison of units in different years unfair or unrealistic. The results above indicate this expected general tendency of improvements over time. To deal with the problem of unfair comparisons occurring when including all 7 years in the same analysis, we suggest using a window rather than a panel data approach, with a window width of 3 years. This means that observations are only compared to other observations within a 3-year time span.

The scores for an industry in different years within the same window show how the efficiency of an industry changes from one year to another. The column view shows the efficiency for the same year but measured against different windows, and illustrates the impact of changing the units used to generate the frontier. We can get the values of mean, standard deviation, column range and total range from the window analysis result. According to the value of mean, we can understand the long-term effectiveness in productivity. The variance of efficiency reflects the fluctuation of efficiency values for each alternative. Column range, $CR_{l,m}$, can be used to compare the fluctuations of efficiencies among the alternatives. In order to understand the stability of an alternative over different periods, we can use total range to evaluate it. Total range is the difference between the maximum and minimum efficiency values of alternatives in all windows.

The information in Table 2 can be used to compare the performance of the different Financial Holding Companies as illustrated in Figure 3. Figure 3 shows the average efficiency score for the different financial holding companies for each window in the analysis. Observing the average efficiency values, China Development Financial holding company is the highest with a mean of 0.974, followed by Cathay Financial holding company and Fubon Financial holding company. On top of that, Hua Nan Financial holding company has the lowest standard deviation of 0.029. Regarding the *CR* value, the best financial holding company is First financial holding company, and the second best is Hua Nan financial holding company. Hua Nan financial holding company also has the best *TR* value of 0.093, followed by Taishin financial holding company and E. Sun financial holding company.

We conduct DEA Malmquist productivity approach to identify the major source of productivity growth and separate the catching effect from efficiency changes over time due to technological advancements. The DEA Malmquist productivity approach shows that in-depth information can be obtained by analyzing each individual component of *MPI*. Such analyses are sometime very critical in capturing an industry's performance comprehensively. Through an analysis of the components of the, we reveal the managerial implication of each component. The results from these analyses are then further examined using the *MPI* approach and its decomposition. Hence we saw the separation of the catching up effect from the frontier shift and we clearly observed how the frontier shift is the determinant for productivity growth, with the catching up being neutral or negative depending on the assumptions used. From the results of *MPI*, we know that industrial industrialist not only enhance their

Table 2. 2003 to 2009 total efficiency-window analysis.

	2003	2004	2005	2006	2007	2008	2009		Mean efficiency	Standard division	Total range
Hua Nan	0.410	0.377	0.415					0.401	0.375	0.029	0.093
		0.372	0.409	0.351				0.377			
			0.389	0.333	0.385			0.369			
				0.322	0.378	0.370		0.357			
					0.393	0.384	0.336	0.371			
$CR_{1,m}$	x	0.006	0.027	0.029	0.014	0.014	x	CR_1	0.029		
Fubon	0.797	0.930	1.000					0.909	0.939	0.072	0.203
		0.926	1.000	0.964				0.963			
			0.856	0.844	1.000			0.900			
				0.830	1.000	0.976		0.935			
					1.000	0.973	0.991	0.988			
$CR_{2,m}$	x	0.004	0.144	0.134	0.000	0.002	x	CR_2	0.144		
Cathay	0.997	1.000	1.000					0.999	0.970	0.058	0.181
		1.000	1.000	0.949				0.983			
			1.000	0.849	1.000			0.950			
				0.819	0.969	1.000		0.929			
					0.971	1.000	1.000	0.990			
$CR_{3,m}$	x	0.000	0.000	0.130	0.031	0.000	x	CR_3	0.130		
China Development	0.954	1.000	1.000					0.985	0.974	0.042	0.114
		1.000	1.000	1.000				1.000			
			1.000	1.000	0.886			0.962			
				1.000	0.900	0.913		0.938			
					1.000	0.958	1.000	0.986			
$CR_{4,m}$	x	0.000	0.000	0.000	0.114	0.045	x	CR_4	0.114		
E. Sun	0.436	0.422	0.397					0.418	0.370	0.035	0.109
		0.413	0.390	0.357				0.386			
			0.348	0.342	0.357			0.349			
				0.333	0.351	0.331		0.339			
					0.381	0.358	0.327	0.356			
$CR_{5,m}$	x	0.010	0.048	0.024	0.030	0.027	x	CR_5	0.048		

Table 2. Contd.

Yuanta	0.336	0.329	0.314					0.326	0.420	0.123	0.287
		0.363	0.344	0.299				0.335			
			0.336	0.292	0.535			0.388			
				0.305	0.571	0.560		0.478			
					0.579	0.568	0.563	0.570			
$CR_{6,m}$	x	0.034	0.030	0.013	0.044	0.009	x	CR_6	0.044		
Mega	0.743	0.718	0.811					0.757	0.664	0.107	0.418
		0.704	0.795	0.741				0.747			
			0.710	0.663	0.393			0.589			
				0.663	0.640	0.560		0.621			
					0.681	0.598	0.548	0.609			
$CR_{7,m}$	x	0.014	0.100	0.078	0.287	0.038	x	CR_7	0.287		
Taishin	0.394	0.389	0.310					0.364	0.341	0.031	0.103
		0.400	0.298	0.354				0.351			
			0.331	0.328	0.337			0.332			
				0.320	0.331	0.316		0.322			
					0.347	0.332	0.331	0.337			
$CR_{8,m}$	x	0.011	0.033	0.034	0.017	0.017	x	CR_8	0.034		
Shin Kong	1.000	0.916	0.862					0.926	0.951	0.052	0.138
		0.976	0.936	0.952				0.955			
			0.872	0.899	1.000			0.924			
				0.883	1.000	1.000		0.961			
					1.000	1.000	0.960	0.987			
$CR_{9,m}$	x	0.060	0.074	0.069	0.000	0.000	x	CR_9	0.074		
Waterland	1.000	0.652	0.680					0.777	0.637	0.117	0.517
		0.626	0.654	0.627				0.636			
			0.683	0.647	0.560			0.630			
				0.653	0.565	0.504		0.574			
					0.648	0.579	0.483	0.570			
$CR_{10,m}$	x	0.026	0.030	0.026	0.088	0.075	x	CR_{10}	0.088		
SinoPac	0.345	0.352	0.392					0.363	0.381	0.078	0.339
		0.346	0.387	0.411				0.382			

Table 2. Contd.

			0.351	0.365	0.641			0.452			
				0.363	0.389	0.324		0.359			
					0.405	0.341	0.302	0.349			
$CR_{11,m}$	x	0.006	0.041	0.048	0.251	0.018	x	CR_{11}	0.048		
Chinatrust	0.409	0.507	0.563					0.493	0.484	0.055	0.185
		0.502	0.555	0.579				0.545			
			0.489	0.502	0.437			0.476			
				0.502	0.437	0.452		0.464			
					0.457	0.473	0.394	0.441			
$CR_{12,m}$	x	0.005	0.074	0.077	0.020	0.021	x	CR_{12}	0.077		
First	0.429	0.303	0.364					0.365	0.382	0.047	0.153
		0.294	0.356	0.392				0.347			
			0.338	0.376	0.418			0.377			
				0.367	0.411	0.428		0.402			
					0.434	0.447	0.371	0.417			
$CR_{13,m}$	x	0.009	0.026	0.025	0.023	0.020	x	CR_{13}	0.026		

managerial skills but also increase and improve inno-vative performance and upgrade technology level.

Malmquist productivity indexes analysis

Malmquist indices for the period 2003 to 2009 are presented further for the sample of thirteen financial holding companies in Taiwan. Using this information, two primary issues are addressed in our computation of Malmquist indices of productivity growth over the sample period. The first is the measurement of productivity change over the period. The second is to decompose changes in productivity into what are generally referred to as a 'catching-up' effect (efficiency change) and a 'frontier shift' effect (technological change). In turn, the 'catching-up' effect is further decomposed to identify the main source of improvement, through either enhancements in technical efficiency or increases in scale efficiency (Worthington, 1999).

DEA allows for the estimation of total productivity change in the form of the Malmquist index. The results are presented in Table 3, with the Malmquist index, denoting total productivity change, is broken down into technically efficient change (the diffusion or catch-up component) and technologically efficient change (the innovation or frontier-shift component). Moreover, we break down technically efficient change into pure efficient change and scale-efficient change. The thirteen financial holding companies in Taiwan are ranked according to the results of column 5. In Table 2, we can see that the total productivity change score (the *MPI* presented in column 5) is higher than one for almost all periods, except for 2003/2004 and 2004/2005, showing that a large proportion of the thirteen financial holding companies in Taiwan experienced gains in total productivity in the six periods considered. The mean *MPI* is 0.995, which, since it is lower than one, signifies that for the thirteen financial holding companies in Taiwan, total productivity decreased from 2003 to 2009.

In Table 4, we can see that the total productivity change score (the *MPI* presented in column 5) is higher than one for Cathay, China Development, Yuanta, Taishin, Shin Kong, and Chinatrust, showing that a large proportion of the three industries

Figure 3. Window analysis results.

Table 3. Malmquist productivity index summary of annual means.

Year	Effch	Techch	Pech	Sech	Tfpch (*MPI*)
2003~2004	1.023	0.927	1.021	1.002	0.949
2004~2005	0.964	0.926	0.960	1.004	0.893
2005~2006	0.993	1.075	1.008	0.985	1.067
2006~2007	0.981	1.036	0.959	1.023	1.017
2007~2008	1.018	1.020	1.042	0.976	1.038
2008~2009	1.063	0.959	1.056	1.007	1.019
Mean	1.007	0.989	1.007	0.999	0.995

experienced gains in total productivity in the period considered. The mean *MPI* is 0.994, which, since it is lower than one, signifies that for the six high-tech Industries, total productivity decreased from 2003 to 2009. The change in the technical efficiency score (column 1) is defined as the diffusion of best-practice technology in the management of the activity and is attributed to investment planning, technical experience and management and organization in the thirteen financial holding companies in Taiwan. For the period under analysis, we can see that it is higher than one for Hua Nan, Cathay, China Development, Yuanta, Taishin, Shin Kong, Waterland, Chinatrust, and First, signifying that there was an increase in technical efficiency in the period. However, for Fubon, Sun, Mega and SinoPa, the change in technical efficiency is lower than one, signifying that there was a regression in this respect in the period.

The breakdown of the score for the change in technical efficiency into pure technical efficiency change (column 3) and scale-efficiency change (column 4) shows mixed results, with some plants obtaining simultaneous gains in both areas and others obtaining gains in one, but losses in the other. The improvement in pure technical efficiency, which signifies an improvement in managerial skills, shows that there was investment in organizational factors associated with the management of plants, such as a better balance between inputs and outputs, best-practice initiatives, more accurate reporting, an improvement in quality, and so on. The scale efficiency, which is the consequence of size, increases in the period for many plants, due to the increase in capacity utilization (Barros, 2008). It is important to note that the mean amount of technical efficiency improvement is 1.007 (mean), the mean value of pure technical efficiency change is 1.007 and the mean value of scale-efficiency change is 0.999. This is a relatively low improvement in efficiency.

Technological change (column 2) is the consequence of innovation, which is the adoption of new technologies, by best-practice hydroelectric plants (Barros, 2008). Its mean value is 0.989, and this index is lower than one for thirteen financial holding companies in Taiwan. The value of Technological change is larger than one for Cathay,

Table 4. Malmquist productivity index summary of financial holding companies means.

Financial holding company	Effch	Techch	Pech	Sech	Tfpch (*MPI*)
Hua Nan	1.000	0.982	1.000	1.000	0.982
Fubon	0.942	0.999	0.960	0.981	0.941
Cathay	1.004	1.037	1.000	1.004	1.041
China Development	1.046	0.963	1.065	0.982	1.008
E. Sun	0.987	0.933	1.000	0.987	0.921
Yuanta	1.056	1.014	1.051	1.005	1.072
Mega	0.996	0.946	1.000	0.996	0.943
Taishin	1.030	1.009	1.000	1.030	1.039
Shin Kong	1.000	1.097	1.000	1.000	1.097
Waterland	1.001	0.983	1.000	1.001	0.983
SinoPac	0.989	0.983	0.988	1.001	0.973
Chinatrust	1.038	0.971	1.033	1.005	1.009
First	1.000	0.950	1.000	1.000	0.950
Mean	1.007	0.989	1.007	0.999	0.995

Yuanta, Taishin and Shin Kong. This indicates that innovation improved in the period for Cathay, Yuanta, Taishin and Shin Kong, meaning that there was investment in new technologies (methodologies, procedures and techniques) and in the commensurate skills upgrades related to this. However, regarding the other financial holding companies showing a downward movement in terms of technological change, this is a primary area of concern.

Conclusion

The performance is the "accomplishment" and "efficiency". The accomplishment means the exterior efficiency of the business, the efficiency means circulate level of business inner part (Neely et al., 1995). How to evaluate the performance scientifically and reasonably, and establish the performances evaluation model, have become the core contents of performances evaluation. Performance evaluation is the important approach for enterprises to give incentive and restraint to their operators and it is also an important channel for enterprise stakeholders to get the performance information (Luo, 2003).

The study analyzes the operation efficiency of thirteen financial holding companies in Taiwan for the period 2003 to 2009. The study has indicated how DEA approach is used to identify individual year that are less efficient that other comparable year in terms of output factors relative to input factors (Staub et al., 2010). The most recent style in measuring efficiency is data envelopment analysis, which is a linear program approach based on this concept. Data envelopment analysis measures the efficiency of decision making units by doing linear program for each in comparison to other units. Accordingly, the decision making units lie on frontier curve is efficient in choosing the optimal mixture of inputs to achieve the aimed level of outputs. Besides we make use of data envelopment analysis to advise inefficient units by doing certain change in inputs and /or outputs to improve their efficiencies.

This paper applies DEA Windows Analysis in order to determine the efficiency of the thirteen financial holding companies in Taiwan for the period 2003 to 2009 over time. This approach is advocated in favor of the commonly used cross-sectional data analysis. We have shown how this approach enables the calculation of efficiency scores even for a small number of different units and a fairly large number of variables. We can use DEA window analysis to evaluate the efficiency of different industries under a long term and obtain a best industry that is relatively more efficient for performance. The issue of how same period efficiencies should be defined in a window analysis was discussed and illustrated empirically. In a situation which industries has made a recent investment to achieve beneficial results in the future, or simply just as a result of random effects, the traditional cross-sectional approach may produce misleading results. This study concludes that the efficiency of the different industries can fluctuate over time to different extents. Observing the average efficiency values, China Development Financial holding company is the highest with a mean of 0.974, followed by Cathay Financial holding company and Fubon Financial holding company. On top of that, Hua Nan Financial holding company has the lowest standard deviation of 0.029. Regarding the *CR* value, the best financial holding company is first financial holding company, and the second best is Hua Nan financial holding company. Hua Nan financial holding company also has the best *TR* value of 0.093, followed by Taishin financial holding company and E. Sun financial holding company. In consequence, this validates the necessity for using DEA windows analysis in preference to an analysis based upon cross-sectional data.

Then, we conduct DEA Malmquist productivity approach to identify the major source of productivity growth and separate the catching effect from efficiency changes over time due to technological advancements. The DEA Malmquist productivity approach shows that in-depth information can be obtained by analyzing each individual component of *MPI*. Such analyses are sometime very critical in capturing an industry's performance comprehensively. Through an analysis of the components of the *MPI*, we reveal the managerial implication of each component. The results from these analyses are then further examined using the *MPI* approach and its decomposition. Hence we saw the separation of the catching up effect from the frontier shift, and we clearly observed how the frontier shift is the determinant for productivity growth, with the catching up being neutral or negative depending on the assumptions used. From the results of *MPI*, we know that industrial industrialist not only enhance their managerial skills but also increase and improve innovative performance and upgrade technology level.

Our work not only provides a good method to evaluate Financial Holding Companies, but also establishes the foundation to study performance evaluation method for Financial Holding Companies more deeply. In the future work, we will promote the performance evaluation model and put forward a more reasonable criteria weight model to improve evaluation efficiency and veracity for Financial Holding Companies. There are two extensions to this study can be undertaken. First, although the input side of the DEA model considered all relevant input dimensions in our industry, the output side bears re-examination. Our study only considered two industry performance measures (namely, number of patents and annual sales) due to certain limitations in the sample size associated with DEA implementation. Future studies should consider a more extensive set of business performance measures. Of particular interest would be a DEA model incorporating market-oriented measures such as market share and sales growth. Second, in evaluating the relative efficiency scores using DEA, we did not restrict any input or output weights. This may affect the results if certain input or output measures are more important than others. In future research, it may be interesting to identify such weights to reflect relative importance and integrate them into the analysis. This would provide more robust results and conclusions.

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APPENDIX

Appendix 1. Raw data

Financial holding company	Year	Total assets	Number of employees	Operating expense	Total stockholders' equity	Net profits
Hua Nan	2009	1,816,498,748	9,622	17,486,164	93,735,762	48,829,856
Fubon	2009	3,060,253,327	27,928	34,949,899	212,980,875	557,334,759
Cathay	2009	4,295,536,021	43,340	54,129,762	215,423,168	963,406,758
China Development	2009	288,132,895	1,988	5,727,058	131,878,104	15,777,909
E. Sun	2009	942,318,369	4,963	9,060,094	51,937,716	21,023,846
Yuanta	2009	538,680,842	4,704	14,937,306	115,460,236	27,703,939
Mega	2009	2,497,531,583	8,531	20,048,239	196,295,495	71,501,895
Taishin	2009	2,374,790,405	12,910	29,881,226	156,305,824	71,299,852
Shin Kong	2009	1,902,090,155	20,888	23,804,971	92,678,238	405,555,310
Waterland	2009	185,157,001	1,603	2,912,647	28,062,181	7,320,840
SinoPac	2009	1,127,999,959	7,642	15,744,978	82,863,003	34,021,926
Chinatrust	2009	1,760,586,010	9,983	30,292,331	149,814,775	66,172,028
First	2009	1,960,570,456	8,485	15,983,886	101,870,033	43,838,358
Hua Nan	2008	1,710,153,171	9,676	18,119,633	89,748,015	69,771,226
Fubon	2008	2,006,720,475	14,979	28,105,059	148,274,472	325,040,112
Cathay	2008	3,746,164,521	42,219	52,565,551	145,498,955	925,775,758
China Development	2008	289,113,713	2,064	5,180,632	114,233,144	11,978,443
E. Sun	2008	829,466,962	4,769	9,006,830	48,742,201	28,950,035
Yuanta	2008	519,628,155	4,704	14,814,209	108,102,418	29,049,320
Mega	2008	2,409,612,820	8,795	19,603,411	178,034,383	90,315,547
Taishin	2008	2,352,418,553	15,365	32,183,954	147,191,524	92,596,129
Shin Kong	2008	1,741,052,083	22,093	24,598,905	56,194,437	447,441,615
Waterland	2008	180,582,111	1,351	2,134,263	24,955,684	6,147,022
SinoPac	2008	1,109,617,301	8,113	17,166,911	81,688,013	49,918,900
Chinatrust	2008	1,725,505,485	10,113	30,836,697	140,266,771	89,480,416
First	2008	1,800,113,679	8,355	17,110,803	100,097,153	69,350,716
Hua Nan	2007	1,670,246,329	9,595	18,965,563	91,980,095	71,661,390
Fubon	2007	1,812,744,531	13,427	27,051,341	170,195,174	299,619,058
Cathay	2007	3,686,693,693	38,033	55,344,358	229,889,778	802,718,298
China Development	2007	365,265,241	2,147	6,563,648	142,327,629	22,973,467
E. Sun	2007	772,181,984	4,383	8,122,942	47,841,864	27,091,806
Yuanta	2007	539,724,739	4,704	14,886,645	109,095,044	33,256,439
Mega	2007	2,313,760,737	8,733	20,377,788	194,651,422	105,574,134
Taishin	2007	2,338,947,054	16,200	32,611,981	157,550,068	101,975,047
Shin Kong	2007	1,688,114,266	22,451	23,550,911	100,112,945	403,444,418
Waterland	2007	245,930,167	1,287	2,102,281	27,415,724	6,866,526
SinoPac	2007	1,123,616,058	8,483	18,291,674	86,375,493	65,287,948
Chinatrust	2007	1,687,754,328	10,810	31,498,056	143,157,240	92,829,118
First	2007	1,682,096,561	8,198	16,960,296	106,103,762	63,297,195
Hua Nan	2006	1,674,566,493	9,740	17,956,291	90,698,382	58,214,602
Fubon	2006	1,724,542,250	13,388	24,822,256	167,803,055	237,688,967
Cathay	2006	3,447,513,688	34,782	51,222,598	219,025,737	615,803,702
China Development	2006	371,975,745	2,109	6,279,022	161,038,753	26,627,664
E. Sun	2006	693,789,270	4,140	7,985,269	45,569,610	24,611,240
Yuanta	2006	427,800,773	4,747	7,803,760	36,557,234	18,527,322
Mega	2006	2,238,144,690	8,165	20,477,664	200,424,010	100,674,387
Taishin	2006	2,330,583,988	16,288	31,879,357	152,816,620	98,571,445
Shin Kong	2006	1,492,327,869	22,921	22,781,615	90,847,013	316,414,353

Appendix 1. Contd.

Waterland	2006	244,162,220	1,241	1,897,447	28,567,740	7,168,567
SinoPac	2006	1,125,434,403	8,076	18,386,599	85,732,498	57,228,605
Chinatrust	2006	1,705,957,938	9,697	31,237,536	123,387,345	99,211,317
First	2006	1,600,902,672	8,227	15,949,453	101,185,226	53,472,352
Hua Nan	2005	1,671,048,805	9,594	16,630,685	89,577,233	68,030,652
Fubon	2005	1,654,073,376	12,107	24,167,416	159,664,784	223,828,093
Cathay	2005	3,064,923,653	33,526	35,103,193	191,161,007	626,132,336
China Development	2005	280,586,666	1,872	5,637,311	131,029,358	22,571,706
E. Sun	2005	635,507,139	3,635	8,420,599	43,740,458	23,854,943
Yuanta	2005	387,316,358	4,968	8,744,044	39,774,972	18,640,655
Mega	2005	2,238,460,286	7,319	19,848,881	192,052,432	96,811,446
Taishin	2005	2,349,417,384	17,633	25,454,366	142,400,563	85,314,153
Shin Kong	2005	1,331,219,676	22,624	27,235,773	68,300,785	277,446,895
Waterland	2005	253,598,385	1,255	1,858,387	28,414,567	8,178,779
SinoPac	2005	1,098,806,302	8,085	18,563,887	90,707,672	52,884,548
Chinatrust	2005	1,716,615,026	9,268	31,804,034	145,655,099	87,778,634
First	2005	1,535,443,198	8,292	16,336,595	91,333,697	49,082,446
Hua Nan	2004	1,590,660,554	9,594	15,887,590	80,619,660	61,714,126
Fubon	2004	1,513,087,876	10,268	23,513,693	160,549,511	172,517,524
Cathay	2004	2,650,078,424	33,262	24,071,595	175,349,237	589,956,937
China Development	2004	260,376,829	1,934	4,708,297	118,406,009	15,514,497
E. Sun	2004	498,227,779	2,838	6,837,392	42,359,238	19,143,651
Yuanta	2004	366,522,724	4,740	7,891,163	41,893,877	17,913,060
Mega	2004	2,120,905,226	7,277	18,876,736	166,368,051	85,546,859
Taishin	2004	864,800,171	9,969	20,540,993	73,909,464	58,992,192
Shin Kong	2004	1,157,308,003	18,259	21,975,156	55,951,180	251,471,105
Waterland	2004	218,718,997	1,268	1,975,395	28,996,300	8,272,106
SinoPac	2004	1,020,612,377	8,016	17,880,969	88,044,904	45,830,243
Chinatrust	2004	1,428,979,357	8,653	30,181,041	100,925,419	76,286,127
First	2004	1,502,541,505	9,316	15,074,490	78,165,878	45,413,307
Hua Nan	2003	1,465,485,604	8,744	15,024,225	70,987,836	62,379,659
Fubon	2003	1,258,845,097	10,462	19,858,277	146,467,452	147,747,277
Cathay	2003	2,341,695,800	33,665	22,537,288	141,809,780	525,896,876
China Development	2003	265,026,125	1,994	4,792,167	114,970,795	14,432,810
E. Sun	2003	334,461,449	2,143	4,849,495	26,805,087	15,626,204
Yuanta	2003	312,023,335	4,043	6,976,997	35,121,610	15,919,080
Mega	2003	1,763,306,132	6,817	18,457,304	156,532,582	83,518,032
Taishin	2003	619,178,661	8,834	16,709,007	57,539,248	45,370,213
Shin Kong	2003	789,764,115	18,669	15,424,721	30,188,234	215,440,646
Waterland	2003	41,655,829	1,332	2,026,297	27,847,887	7,059,312
SinoPac	2003	526,166,624	5,005	11,706,376	47,093,738	27,521,304
Chinatrust	2003	1,213,212,557	9,080	25,153,054	94,003,764	63,134,011
First	2003	1,483,985,385	8,927	16,062,131	68,338,864	67,900,804