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REVIEW CRITIQUE ON THE INFLUENCERS OF THE BUSINESS PERFORMANCE AND THEIR RESOLUTIONS

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ABSTRACT

Business Performance is dependent on various factors affecting the viability of the commercial environment. There are factors responsible for the performing behaviour of the revenue units. The same factors are focused by this paper to reach on the conclusion that the influencers must have to be addressed in any business organization. The possible impact of the influencers and their responses to the business performance is taken by the study a key area for the evaluation and methodology.

Keywords: *Business, Performance, Influencers of Business Performance, Factors Affecting performance.*

1. Introduction

The maturing of information technology (IT) hardware and the phenomenal changes in consumers' online purchase behavior has led to concomitant growth in the information services industry. According to the Small and Medium Enterprise Administration (Ministry of Economic Affairs), the number of firms in the information and communication sector has increased from 15,948 (turnover TWD744.345 billion) in 2007 to 15,906 (turnover TWD780.113 billion) in 2008, 15,985 (turnover TWD780.409 billion) in 2009, and 16,555 (turnover TWD853.621 billion) in 2010 (SMEAMOEA, 2012). We observe that even during the global economic crisis in 2008 and 2009, the number of firms (and their turnover) continues to increase or is maintained at a stable level. This evidence can explain the increasingly competitive environment and the rapid change in the operating environment in this sector. Entrepreneurs need to pay more attention to the provision of digital content and information services if they are to experience growth of turnover growth created by online shopping, software and hardware maintenance.

This paper aims at providing firms in the information services sector a reference for business performance improvement and offer suggestions to help firms to better identify the relevant factors affecting business performance. This study expects to help firms strengthening their resource allocation, avoiding waste, and achieving optimal scale of production and high efficiency. The research results obtained by applying a data envelopment analysis (DEA) can help the inefficient decision-making units (DMUs) to benchmark their reference DMUs of performance in order to strengthen the improvement in performance indicators. This paper can analyze and identify the common features of benchmark companies through a combination of their business characteristics and their efficiency, and provide effective operating strategies for information services firms in this field.

In addition, this paper explores and compares the annual operating efficiency for information services firms in order to develop the most suitable operating strategies and identify the efficient firms that the inefficient firms can refer to so that they can find out their own core competitiveness to improve their operating efficiency. From our findings, we will be able to identify, in the current information services industry, the firms with better operating performance and their main products and services in order to provide inefficient firms with learning references. The application of the operating efficiency matrix and the comparison of market shares between efficient and inefficient firms can help firms to establish their own ideal operating scale and area of competitiveness. The inefficient firms may adjust their business management strategies towards a products- or services-oriented market to enforce their importance in the global information industry market.

2. Literature review

2.1 Application of DEA in various fields

DEA has been applied in various fields since Charnes *et al.* (1978) and Banker *et al.* (1984) presented improved versions. Duffy *et al.* (2006) try to show the potential of DEA as a benchmarking method in long-term care andprovide background information on the long-term care industry. Sofianopoulou (2006) uses cellular manufacturing to evaluate the operational characteristics of 12 alternative production scenarios and employs DEA to evaluate the efficiency of each scenario. Wang *et al.* (2008) combine DEA with the analytic hierarchy process (AHP) to form a DEAHP for weight derivation and aggregation in the AHP in order to reach better priority estimates and decision conclusions. Chen and Chen (2009) use DEA and the Malmquist productive index to evaluate the efficiency of the wafer fabrication industry in Taiwan. The empirical data used in the study are sourced from the stock exchange market group (SEM group) and the over-the-counter market group (OTC group). Grosskopf *et al.* (2009) compare the technical efficiency of charter school primary and secondary campuses with that of comparable campuses in traditional Texas school districts. Min and Joo (2009) assess the comparative strengths and weaknesses of leading third-party logistics providers (3PLs) in the USA with respect to their financial efficiency during the period 2005–2007. Using a DEA, they measure the financial efficiency of 12 leading 3PLs in the USA relative to their key competitors. Pestieau (2009) suggests a definition and a way to measure the performance of the public sector (education, health care and railways transport) by using the notion of productive efficiency and the ‘best practice’ frontier technique. Kao and Hwang (2010) apply DEA to assess the impact of information technology (IT) on firm performance in a banking industry. Hilmola (2011) evaluates public transportation efficiency in larger cities by applying DEA. Sufian (2011) examines and benchmarks the efficiency of the Korean banking sector by using a DEA approach.

2.2 Application of DEA in efficiency assessment of the information services industry

Concerning performance assessment in the information services industry, Serrano-Cinca *et al.* (2005) propose a new method for DEA model selection based on multivariate statistical analysis to assess efficiency in 40 dot com firms. Three areas of Internet activities are included: e-tailers, content/communities, and search/portals. Human resources (number of employees), assets, and expenditure are the selected inputs; a webmetric (unique visitors) and revenue are the chosen outputs for ranking dot com firms and to highlight their strengths and weaknesses. E-tailers are more efficient in achieving revenue while search/portals and content/communities are better at obtaining unique visitors. Bernroider and Stix (2006) address the area of decision making for information systems (IS) and present an approach combining two eminent concepts: the utility ranking method (URM) and the DEA. The results can be seen to support the decision maker in justifying and communicating the model outcomes. The proposed method is illustrated using a real-life case study concerning an enterprise resource planning (ERP) software selection problem. Lee (2010) uses a DEA model to analyze the efficiency of B2C controls installed by three groups of organizations: financial firms, retail firms, and information services providers. The inputs are controls for system continuity, access controls, and communication controls; the outputs are volume, sophistication, and information contents. The results indicate that retail firms and information services providers implement B2C controls more efficiently than do financial firms. Song (2010) uses a DEA model and window analysis to study operating efficiency based on the 2002–2008 panel data. This paper collects 15 Chinese online game industries that are listed on the Shanghai and Shenzhen stock markets as evaluation samples. Liquid assets, fixed assets, staff salaries, administrative expenses, and financial expenses are the selected input indicators; total profit and net investment income are the output indicators. The overall operating efficiency of China's online game industry is good, but the revenue scale of many firms does not reach the optimal level. The number of companies in China's online game industry has increased slowly and it is in an era of oligopolistic competition.

3. Methodology

This paper applies the DEA to evaluate the overall technical efficiency, pure technical efficiency and scale efficiency of companies in the information services industry. A detailed analysis of the contribution of inputs/outputs in calculating efficiency and their potential for improvement can help inefficient firms to configure a suitable improvement benchmark model. The DEA, proposed by Farrell (1957), uses a linear programming approach to establish the frontier curves of a group of evaluated units, named decision-making units (DMUs). The DMUs on the frontier curves are efficient and can constitute reference DMUs for the inefficient DMUs which have relative efficiency scores measured by the ratio of the DMUs’ distance to the frontier curves. This method, after several improved versions by Charnes *et al.* (1978) and Banker *et al.* (1984), can receive multiple inputs and outputs; the assumption of constant returns to scale (CRS) has also been changed into variable returns to scale (VRS). Seiford and Thrall (1990), Ali and Seiford (1993), Lovell (1993), Lovell (1994), Charnes *et al.* (1995) and Seiford (1996) provide more detailed reviews of the methodology.

3.1 Charnes-Cooper-Rhodes (CCR) model

Farrell's efficiency measurement concept of multiple inputs and a single output was developed by Charnes *et al.* (1978) who convert it to the concept of multiple inputs and multiple outputs. They utilize a linear combination to estimate the efficiency frontier from the ratio of two linear combinations and measured the relative efficiency of each DMU in constant returns to scale (CRS). The efficiency score of the CCR model corresponds to the overall technical efficiency of an evaluated unit. If the efficiency score equals 1, the evaluated unit is efficient (optimal performance) and in constant returns to scale (CRTS); if the efficiency score is less than 1, the evaluated unit needs some improvement (Lee, 2009; Lin *et al.*, 2009; Montoneri *et al.*, 2011).

3.2 Banker-Charnes-Cooper (BCC) model

The scope of the CCR model ratio and application was widened by Banker *et al.* (1984). The so-called, "BCC model" changes the CCR to a variable returns to scale (VRS) hypothesis, breaks down technical efficiency into pure technical efficiency and scale efficiency, and measures its efficiency and returns to scale (RTS). The scale efficiency is also called allocative efficiency or price efficiency, which refers to the ability of finding an optimal ratio for a configuration of fixed inputs and outputs. The constant returns to scale (CRTS) represents outputs which directly reflect input levels. The increasing returns to scale (IRTS) represents the notion that DMUs can increase input resources in order to increase the output performance. The decreasing returns to scale (DRTS) represents the notion that DMUs should reduce input resources and adjust the output configuration (Montoneri *et al.*, 2011).

According to Samoilenko and Osei-Bryson (2008), the DEA is a widely used non-parametric data analytic tool; its discriminatory power depends on the homogeneity of the domain of the sample. However, in practice, the DMU sample can consist of two or more naturally occurring subsets, thus exhibiting signs of heterogeneity. Because the nature of the relative efficiency of a DMU is likely to have an impact on its membership in a particular subset of the sample, the discriminatory power of DEA can be limited. Samoilenko and Osei-Bryson (2008) propose a three-step methodology allowing for an increase of the discriminatory power of DEA in the presence of heterogeneity in a sample.

This paper uses the CCR and BCC models of the DEA to calculate the relative efficiency score of the different evaluated units, such as the overall technical efficiency, pure technical efficiency, and scale efficiency. In addition, the slack variable analysis is conducted, and this paper calculates the number of times a referral is made, identifies the referral was, and determines the referred objects that evaluate units refer to as efficient units. An exploration of input and output items' contribution in calculating efficiencies makes it possible to find out each firm's own key performance indicators. A combination of all these factors makes it possible to identify improvement policies for the inefficient evaluated units, and thus enhancing their operating performance and market competitiveness.

3.3 Correlation coefficient analysis

As mentioned by Lin *et al.* (2009), the Pearson correlation coefficient test is often used to verify whether the correlation is high among variables. A closer relationship between two variables means that their correlation coefficient is higher, while less correlated variables have a lower correlation coefficient. Generally speaking, if the Pearson correlation coefficient is high than 0.8, the two variables' correlation degree is very high; if the coefficient is between 0.6 and 0.8, the two variables' correlation degree is high; if the coefficient is between 0.4 and 0.6, the two variables' correlation degree is medium; if the coefficient is between 0.2 and 0.4, the two variables' correlation degree is low; if the coefficient is lower than 0.2, the two variables' correlation degree is very low.

4. Empirical implementation

4.1 Research data

The research objects of this paper first include 11 companies listed on the Taiwan Stock Exchange (TSE), 32 companies on the OTC and 8 companies in the emerging stock market in Taiwan (ROTC) in the information services sector. Of these 51 companies, one company in the OTC group is excluded from the data due to the lack of detailed operating expenses. Therefore, the related annual financial statements of 11 TSE-listed, 31 OTC and 8 ROTC companies from 2009 to 2010 are used as the data reference to assess efficiency. For the consideration of empirical cross-period efficiency and productivity analysis, the 50 firms need to have complete data for these two years. Their financial data are accessed from the companies' annual reports, the Taiwan

Market Observation Post System (TMOPS) and the Taiwan Economic Journal Data Bank (TEJ). As the databases of the information services firms are confidential, this paper does not reveal their names in presenting the information from the original databases. Rather, codes are assigned to represent individual firms, such as D1, D2, D3, D4, D5... and D50.

4.2 Choice of input and output items

4.2.1 Input items

I1. Marketing expenses (in thousand TWD): This refers to the necessary expenses to maintain a firm's operation. With greater investment in marketing, the company can more easily present its key products to customers, allowing the customers to gain information of the firm's products leading to familiarity and customer loyalty for the product. The value of this item is taken from the income statement of the TEJ database.

I2. R&D expenses (in thousand TWD): A firm's sustainable operation depends on continuous R&D and innovative growth in: products, production processes, and service quality. This will help to maintain and increase customer loyalty. In addition, high R&D expenses will indirectly indicate whether the firm is the leader in the market. Therefore, it also refers to the necessary expenses to maintain firm's operation. The value of this item is taken from the income statement of the TEJ database.

I3. Total assets (in thousand TWD): This item includes current assets, long-term investments, fixed assets, intangible assets, and other small assets. All the firm's assets, regardless of type, are key elements in the operations process; they bring economic benefits and maintain a stable operation for the firm. A firm with sufficient assets can avoid the dilemma of financial difficulties. The value of this item is taken from the balance sheet of the TEJ database.

I4. Total number of employees (in persons): Creative employees can develop innovative products and attract potential customers; hence, high quality manpower is one of the key points in the performance assessment of the information services industry. The value of this item is taken from the company profile of the TEJ database.

4.2.2 Output items

O1. Net operating revenue (in thousand TWD): This refers to the gross revenue minus sales returns and discounts. The value of this item is taken from the income statement of the TEJ database.

O2. Operating profits (in thousand TWD): This refers to the net operating revenue minus operating costs and operating expenses. The value of this item is taken from the income statement of the TEJ database.

O3. Current net income (in thousand TWD): This is the balance of the operating profits plus the non-operating revenue minus the non-operating expenditure and income tax. The value of this item is taken from the income statement of the TEJ database.

O4. Cash flow from operating activities (in thousand TWD): This is the current net income in the income statement with certain adjustments made to items, either additions or subtractions. The calculation of this item is based on a cash basis concept rather than an accrual basis concept. Cash flow is usually the most effective and robust profitability indicator, as well as an immediate and measurable indicator of liquidity. The value of this item is taken from the statement of cash flow of the TEJ database.

The calculation of the abovementioned output items 1-3 is based on the accrual concept; the output item 4 is calculated on a cash basis concept. The four outputs can measure the results of a firm's operations and cash flows during a specific period (usually one year); they are the final performance of all a firm's operating activities.

4.3 Descriptive statistics and correlation coefficient analysis

The results of the descriptive statistics of inputs and outputs, Pearson's correlation coefficients analysis, and variance inflation factor (VIF) diagnostics are listed in Tables 1 to 3. The inputs and outputs are all significantly positively correlated, reaching a statistically significant level of 1%. The VIF diagnostics among the input and output items indicate that there is no high degree of collinearity problems among them since the values are distinctly lower than 10.

Table 1. Descriptive statistics[a]

Variables	Mean	Median	Minimum	Maximum	Std. Deviation	Skewness	Kurtosis
Net operating revenues (O1)	1,596,612	750,367	10	10,257,804	2,099,526	2.308	5.453
Operating profits (O2)	150,878	57,903	-137,188	1,426,791	275,037	2.528	6.783
Current net income (O3)	178,556	59,480	-135,496	1,404,394	322,203	2.251	4.275
Cash flow from operating activities (O4)	196,082	55,782	-170,915	1,626,129	356,235	2.113	4.146
Marketing expenses (I1)	174,328	66,387	0	1,532,948	288,106	2.999	9.965
R&D expenses (I2)	94,695	35,199	0	684,694	157,413	2.623	6.593
Total assets (I3)	2,090,890	989,047	66,757	23,771,465	3,522,650	4.036	18.575
Total number of employees (I4)	309	226	8	1,885	302	3.119	13.396

Note: [a] The number of observations is 100 which is composed of 50 firms in two periods.

Table 2. Pearson correlation coefficients between inputs and outputs[a]

Inputs \ Outputs	Net operating revenues (O1)	Operating profits (O2)	Current net income (O3)	Cash flow from operating activities (O4)
Marketing expenses (I1)	0.768 (0.000)[b]	0.468 (0.000)	0.635 (0.000)	0.372 (0.000)
R&D expenses (I2)	0.258 (0.010)	0.848 (0.000)	0.676 (0.000)	0.504 (0.000)
Total assets (I3)	0.639 (0.000)	0.318 (0.001)	0.605 (0.000)	0.383 (0.000)
Total number of employees (I4)	0.652 (0.000)	0.577 (0.000)	0.661 (0.000)	0.446 (0.000)

Notes: [a] The number of observations is 100 which is composed of 50 firms in two periods.
[b] The value inside parentheses is p value which denotes the significant level.

Table 3. Variance inflation factor (VIF) diagnostics among the input and output items

Dependent variable (Input)	Independent variable (Outputs)	Tolerance	VIF
Total assets (I3)	Net operating revenues (O1)	0.492	2.034
	Operating profits (O2)	0.210	4.752
	Current net income (O3)	0.211	4.736
	Cash flow from operating activities (O4)	0.341	2.930
Dependent variable (Output)	**Independent variable (Inputs)**	**Tolerance**	**VIF**
Net operating revenues (O1)	Marketing expenses (I1)	0.366	2.729
	R&D expenses (I2)	0.632	1.583
	Total assets (I3)	0.609	1.641
	Total number of employees (I4)	0.301	3.321

4.4 Empirical results and analysis

4.4.1 Efficiency analysis

Tables 4 and 5 present some efficiency scores and reference DMUs of evaluated DMUs in 2009 and 2010 respectively. The DMUs are listed in a descending order of CCR score (that is, the overall technical efficiency). This paper also uses a BCC model of DEA to evaluate DMUs' pure technical efficiency (denoted as the BCC score) and scale efficiency (denoted as the scale score). The results show that in 2009, a total of 13 DMUs show overall technical efficiency; 23 DMUs show pure technical efficiency, and 16 DMUs are scale efficient. In 2010, a total of 18 DMUs show overall technical efficiency; 29 DMUs show pure technical efficiency, and 18 DMUs are scale efficient. In 2009, the average overall technical efficiency of all the DMUs is 0.651; that of the inefficient DMUs is 0.528. In 2010, the average overall technical efficiency of all the DMUs is 0.649; that of the inefficient DMUs is 0.526. Compared to 2009, 5 more DMUs become efficient in overall technical capacity in 2010; 6 more DMUs become pure technical efficient and 2 more DMUs become scale efficient in 2010. However, the average efficiency scores of the inefficient DMUs decline slightly in 2010.

The column "Refs" indicates the number of times in which a DMU acts as a peer. Tables 4 and 5 show that D19 is the most popular reference (20 times) for the pure technical efficient DMU in 2009; in 2010, it is D50 (17 times). In 2009, the top five reference DMUs in descending order are: D19(20), D20(19), D9(14), D35(14) and D47(10); in 2010 they are: D50(17), D9(16), D35(16), D19(14) and D28(12). These all show good pure technical efficiency. Three DMUs: D9, D19 and D35, are among the top five during 2009 and 2010. Table 7 summarizes some characteristics of DMUs related to core products and market shares. It reveals that D9 and D35 provide services and products related to online games and PC games (100%). In 2009, their net operating incomes represent 2.6% and 8.9% of the market in the information services industry and they are ranked 13th and the 3rd, respectively. In 2010, their net operating incomes represent 2.5% and 9.5% of the market and both have the same rank as in 2009. D19, established in 2007, is a unique digital book publisher from Taiwan with sales to Amazon's Kindle Store. D19, which provides services and products related to 3D digital content, is a small, relatively new company; it remains among the top five during 2009 and 2010 even though it has a lower market share. This paper concludes that the three companies (D9, D19, and D35) provide clear primary products and services and concentrate their efforts on their proper industry instead of wasting resources in diversification of their business.

The column, "Peers", indicates the number of peers taken by this DMU; that is, the number of reference DMUs in this DMU's reference set. The average number of reference DMUs in the pure technical inefficient DMUs' reference set in 2009 is 4.22; the average number in 2010 is 4.62. In 2009, D10, D14, D24 and D29 are the inefficient DMUs with the most number of peers (six). In 2010, D44 is the DMU which has the most number of peers (seven), followed by D1, D24, D29 and D32 (six). The data from 2009 and 2010 also show that the inefficient DMUs refer to several efficient DMUs and use their strengths as role models. Table 6 summarizes the main products and market share of the inefficient DMUs having more than six peers and their reference DMUs. The upper half of this table lists the characteristics of the reference DMUs which are referred to more than or equal to three times; the lower half of this table lists the characteristics of the inefficient DMUs having more than six peers. It is observed that more than 90% of these selected reference DMUs concentrate on one single product as their main product (almost all are related to online/PC games). D34 and D50 are the exceptions. In contrast, the inefficient DMUs in Table 6 show diversification of their main products. This paper concludes that firms in the information services industry should be advised to concentrate their resources and effort on one single product which should be related to online/PC games.

Table 4. DMUs' efficiency scores and reference DMUs in 2009[a]

Unit name [b]	CCR score	CCR rank	BCC score	BCC rank	Scale score	BCC Refs [c]	BCC Peers	BCC Reference DMUs			
D3	1.000	1	1.000	1	1.000	5	0	D3			
D9	1.000	1	1.000	1	1.000	14	0	D9			
D19	1.000	1	1.000	1	1.000	20	0	D19			
D21	1.000	1	1.000	1	1.000	3	0	D21			
D22	1.000	1	1.000	1	1.000	1	0	D22			
D34	1.000	1	1.000	1	1.000	2	0	D34			
D35	1.000	1	1.000	1	1.000	14	0	D35			
D37	1.000	1	1.000	1	1.000	1	0	D37			
D38	1.000	1	1.000	1	1.000	1	0	D38			
D46	1.000	1	1.000	1	1.000	1	0	D46			
D47	1.000	1	1.000	1	1.000	10	0	D47			
D48	1.000	1	1.000	1	1.000	7	0	D48			
D49	1.000	1	1.000	1	1.000	4	0	D49			
D7	0.997	14	1.000	1	0.997	1	0	D7			
D2	0.936	15	0.936	25	1.000	0	1	D48			
D30	0.874	16	0.874	28	1.000	0	3	D19	D48	D9	
D32	0.849	17	1.000	1	0.849	5	0	D32			
D6	0.845	18	0.845	33	1.000	0	3	D19	D21	D3	
D20	0.700	19	1.000	1	0.700	19	0	D20			
D28	0.700	20	1.000	1	0.700	3	0	D28			
D23	0.699	21	0.928	27	0.753	0	2	D19	D20		
D33	0.668	22	1.000	1	0.668	7	0	D33			
D36	0.619	23	0.989	24	0.626	0	3	D20	D32	D40	
D31	0.600	24	0.755	39	0.794	0	4	D19	D33	D47	D48

D24	0.572	25	0.861	32	0.664	0	6	D19 D20 D3 D40 D50 D9
D45	0.570	26	0.872	29	0.654	0	5	D19 D20 D32 D47 D9
D16	0.568	27	0.868	30	0.654	0	4	D19 D20 D32 D9
D50	0.567	28	1.000	1	0.567	4	0	D50
D13	0.563	29	1.000	1	0.563	7	0	D13
D17	0.537	30	0.828	34	0.649	0	4	D19 D20 D21 D35
D39	0.526	31	0.694	40	0.759	0	5	D19 D28 D33 D35 D49
D18	0.499	32	0.660	42	0.756	0	4	D19 D47 D48 D9
D41	0.499	33	1.000	1	0.499	2	0	D41

Table 4. DMUs' efficiency scores and reference DMUs in 2009[a] (continued)

Unit name [b]	CCR score	CCR rank	BCC score	BCC rank	Scale score	BCC Refs [c]	BCC Peers	BCC Reference DMUs
D44	0.493	34	0.683	41	0.722	0	5	D19 D20 D33 D35 D47
D14	0.484	35	0.768	38	0.630	0	6	D19 D20 D28 D32 D35 D40
D15	0.482	36	0.930	26	0.518	0	2	D13 D20
D40	0.448	37	1.000	1	0.448	5	0	D40
D5	0.437	38	0.579	44	0.754	0	5	D13 D33 D35 D47 D9
D27	0.414	39	0.577	45	0.718	0	4	D19 D20 D33 D47
D11	0.396	40	0.627	43	0.631	0	5	D13 D19 D20 D35 D47
D4	0.351	41	0.476	48	0.736	0	5	D19 D20 D3 D48 D9
D43	0.345	42	1.000	1	0.345	1	0	D43
D10	0.328	43	0.572	46	0.574	0	6	D19 D20 D35 D49 D50 D9
D25	0.320	44	0.812	35	0.394	0	5	D13 D19 D35 D50 D9
D42	0.312	45	0.861	31	0.362	0	5	D20 D3 D34 D49 D9
D26	0.300	46	0.787	36	0.382	0	2	D13 D35
D12	0.299	47	0.773	37	0.387	0	4	D20 D35 D41 D9
D8	0.281	48	0.444	49	0.634	0	5	D13 D19 D20 D35 D47
D1	0.263	49	0.328	50	0.802	0	5	D20 D35 D47 D48 D9
D29	0.211	50	0.478	47	0.442	0	6	D19 D20 D33 D35 D40 D9
Average of all DMUs	0.651		0.856		0.747			
Average of inefficient DMUs	0.528		0.734		0.627		4.22	

Notes: [a] CCR or BCC in this table means the values of the column are calculated by CCR or BCC model.
[b] DMUs are ranked by descending order of CCR score.
[c] The value of 1 means this efficient DMU refer to itself.

Table 5. DMUs' efficiency scores and reference DMUs in 2010[a]

Unit name [b]	CCR score	CCR rank	BCC score	BCC rank	Scale score	BCC Refs [c]	BCC Peers	BCC Reference DMUs
D2	1.000	1	1.000	1	1.000	1	0	D2
D3	1.000	1	1.000	1	1.000	2	0	D3
D5	1.000	1	1.000	1	1.000	1	0	D5
D6	1.000	1	1.000	1	1.000	1	0	D6
D7	1.000	1	1.000	1	1.000	1	0	D7
D9	1.000	1	1.000	1	1.000	16	0	D9
D19	1.000	1	1.000	1	1.000	14	0	D19
D21	1.000	1	1.000	1	1.000	7	0	D21
D22	1.000	1	1.000	1	1.000	1	0	D22
D30	1.000	1	1.000	1	1.000	3	0	D30
D34	1.000	1	1.000	1	1.000	5	0	D34
D35	1.000	1	1.000	1	1.000	16	0	D35
D37	1.000	1	1.000	1	1.000	2	0	D37
D38	1.000	1	1.000	1	1.000	1	0	D38
D39	1.000	1	1.000	1	1.000	1	0	D39
D46	1.000	1	1.000	1	1.000	1	0	D46
D47	1.000	1	1.000	1	1.000	7	0	D47
D48	1.000	1	1.000	1	1.000	5	0	D48
D28	0.990	19	1.000	1	0.990	12	0	D28
D49	0.880	20	1.000	1	0.880	1	0	D49

D44	0.617	21	0.654	45	0.944	0	7	D19 D28 D35 D37 D47 D48 D50
D23	0.591	22	1.000	1	0.591	2	0	D23
D50	0.573	23	1.000	1	0.573	17	0	D50
D17	0.566	24	0.896	33	0.632	0	4	D19 D21 D35 D50
D11	0.542	25	1.000	1	0.542	1	0	D11

Table 5. DMUs' efficiency scores and reference DMUs in 2010[a] (continued)

Unit name[b]	CCR score	CCR rank	BCC score	BCC rank	Scale score	BCC Refs[c]	BCC Peers	BCC Reference DMUs
D45	0.541	26	1.000	1	0.541	1	0	D45
D31	0.540	27	0.658	44	0.820	0	4	D19 D47 D48 D9
D41	0.537	28	1.000	1	0.537	2	0	D41
D18	0.530	29	0.753	40	0.704	0	5	D19 D47 D48 D50 D9
D8	0.518	30	1.000	1	0.518	2	0	D8
D14	0.497	31	0.898	32	0.554	0	4	D19 D21 D35 D50
D24	0.480	32	0.787	36	0.610	0	6	D19 D28 D30 D34 D50 D9
D33	0.477	33	0.758	39	0.630	0	5	D28 D34 D35 D50 D9
D32	0.451	34	0.760	38	0.593	0	6	D19 D28 D3 D34 D35 D50
D4	0.442	35	0.680	43	0.651	0	4	D28 D35 D50 D9
D16	0.442	36	0.830	34	0.532	0	5	D19 D23 D50 D8 D9
D15	0.435	37	1.000	1	0.435	1	0	D15
D13	0.395	38	0.960	30	0.412	0	2	D35 D9
D20	0.394	39	0.688	42	0.572	0	4	D21 D35 D47 D50
D27	0.348	40	0.505	47	0.690	0	5	D19 D28 D48 D50 D9
D42	0.335	41	0.821	35	0.408	0	4	D28 D35 D50 D9
D12	0.318	42	1.000	1	0.318	1	0	D12
D43	0.312	43	1.000	1	0.312	1	0	D43
D25	0.288	44	0.784	37	0.367	0	4	D19 D21 D35 D9
D26	0.269	45	0.899	31	0.299	0	2	D35 D9
D10	0.263	46	0.740	41	0.356	0	5	D19 D21 D28 D35 D50
D1	0.263	47	0.413	49	0.636	0	6	D21 D28 D35 D41 D47 D9
D29	0.226	48	0.481	48	0.470	0	6	D28 D30 D34 D35 D50 D9
D36	0.225	49	0.271	50	0.830	0	4	D19 D47 D50 D9
D40	0.183	50	0.620	46	0.295	0	5	D19 D28 D35 D50 D9
Average of all DMUs	0.649		0.877		0.725			
Average of inefficient DMUs	0.526		0.707		0.570		4.62	

Notes: [a] CCR or BCC in this table means the values of the column are calculated by CCR or BCC model.
[b] DMUs are ranked by descending order of CCR score.
[c] The value of 1 means this efficient DMU refer to itself.

Table 6. Characteristics of inefficient DMUs and their reference DMUs

Reference DMUs and their Characteristics[b] \ Inefficient DMUs[a]			In 2009				In 2010		
			D10	D14	D24	D29	D44	D1	D32
	Market share (2009, 2010)	Main products							
D3	-[c]	-[c]			✓[d]				(✓)[d]
D9	2.6%, 2.5%	Online games (100%)	✓		✓ (✓)	✓ (✓)		(✓)	
D19	0.000529%, 0.000012%	3D digital contents (100%)	✓	✓	✓ (✓)	✓	(✓)		(✓)
D20	1.1%, 0.6%	Online games (90.7%), other (7.2%), sales revenue (2.1%)	✓	✓	✓	✓			
D21	-	-						(✓)	
D28	1.3%, 2.3%	Labor income (96%), sales		✓	(✓)	(✓)	(✓)	(✓)	(✓)

			D10	D14	D24	D29	D44	D1	D32
		revenue (4%)							
D30	-	-			(✓)	(✓)			
D32	-	-		✓					
D33	-	-				✓			
D34	1.9%, 1.3%	Other (69.9%), personal computers (24.5%), automation equipment (3.6%)			(✓)	(✓)			(✓)

Table 6. Characteristics of inefficient DMUs and their reference DMUs (continued)

Reference DMUs and their Characteristics [b]		Inefficient DMUs [a]	In 2009						
			D10	D14	D24	D29	D44	D1	D32
					In 2010				
D35	8.9%, 9.5%	Game software (98%), other (1.7%), magazines (0.3%)	✓	✓		✓ (✓)	(✓)	(✓)	(✓)
D37	-	-					(✓)		
D40	0.3%, 0.2%	Game software (99.5%), educational software (0.5%)		✓	✓	✓			
D41	-	-						(✓)	
D47	-	-					(✓)	(✓)	
D48	-	-					(✓)		
D49	-	-	✓						
D50	0.4%, 0.5%	3D CAD / CAM (60.1%), CAE professional applications (23.8%), consultancy services (8.3%)	✓		✓ (✓)	(✓)	(✓)		(✓)

Inefficient DMUs' characteristics

	Market share (2009, 2010)	Main products
D10	0.4%, 0.3%	Other (33.9%), internet marketing (32.4%), network services (16.6%)
D14	0.2%, 0.3%	Internet advertising and marketing (55.1%), news graphics authorized services (10.8%), news graphics library (10.5%)
D24	0.2%, 0.3%	System integration services revenues (73.5%), information transfer income (15.7%), maintenance services (10.9%)
D29	0.3%, 0.4%	System integration services (53%), labor income (47%)
D44	1.2%, 1.9%	Network integration information management (40.9%), system platform (31.6%), storage equipments (18.6%)
D1	2.1%, 2.0%	Computer maintenance revenue (35.8%), system integration services (31%), banking terminal system (20.1%)
D32	0.3%, 0.3%	Peripheral and system integration (68.2%), consultancy and maintenance services (24.4%), computer system management software (7.2%)

Notes: [a] The inefficient DMUs having number of peers more than 6 in 2009 and 2010 are included in this table; they are D10, D14, D24, D29 in 2009 and D24, D29, D44, D1, D32 in 2010.
[b] Only the characteristics of reference DMUs having been referred to more than or equal to three times are listed.
[c] Data are omitted for the reference DMUs having been referred to less than three times.
[d] ✓ or (✓) mean that the inefficient DMUs refer to this reference DMU in 2009 or 2010, respectively.

Table 8 shows the average efficiency and ranking for information services firms for 2009–2010. The results demonstrate that there are 12 firms that reach the average overall technical efficiency of 1 every year, 18 firms reach the average pure technical efficiency of 1 every year, and 15 firms reach the average scale efficiency of 1 every year. 12 DMUs maintain all their efficiency scores of 1 every year; they are: D3, D9, D19, D21, D22, D34, D35, D37, D38, D46, D47 and D48. Table 7 shows that five of them (D19, D21, D37, D38, D46) belong to small-scale firms and have a market share smaller than 1.7% except for D37 (4.2%). This means that even small firms can obtain an important market share. Six of the overall technical efficient DMUs (D9, D19, D21, D22, D35 and D47) focus on one single product related to games software or digital content. Table 8 also indicates that D7, D2, D30, D6, D39 and D5 make obvious progress and become efficient in 2010. D7, which is pure technical efficient but scale inefficient in 2009, make progress in scale efficiency in 2010. D2, D30, and D6, which are pure technical inefficient but scale efficient in 2009, make progress in pure technical efficiency in 2010. D39 and D5 make progress in both pure technical efficiency and scale efficiency in 2010. On the contrary, D49, being overall technical efficient, pure technical efficient and scale efficient in 2009, regresses in 2010 due to the decline of its scale efficiency score from 1.000 in 2009 to 0.880 in 2010. In fact, D49 divides its business into system integrations, automation control systems and industrial computers and accordingly capital reduction at the end of April, 2010. As a result, it loses a lot of market share, showing a decrease from 6.5% in 2009 to 3.9% in 2010.

D13's rank in pure technical efficiency falls significantly (from 1 to 30) in 2010 even though its pure technical efficiency only falls slightly (from 1.000 to 0.960) because 29 DMUs become pure technical efficient in 2010. The ranks of D20, D40 and D36 in pure technical efficiency also fall significantly (from 1 to 42 for D20; from 1 to 46 for D40; from 24 to 50 for D36) in 2010 due to the decline of their pure technical efficiencies (from 1.000 to 0.688 for D20; from 1.000 to 0.620 for D40; from 0.989 to 0.271 for D36).

Table 7. DMUs' main products proportion and market share

Unit name	Quadrant in matrix [a]	BCC average rank [b]	Firm's scale [c]	Proportion of main products	Market share 2009	rank	2010	rank
D3	1	1	Big	Computer equipment (75.9%), consumables for computer peripheral products (8.1%), maintenance service income (7.6%)	2.5%	14	2.0%	16
D9	1	1	Big	Online games (100%)	2.6%	13	2.5%	13
D19 [d]	1	1	Small	3D digital contents (100%)	0.0%	50	0.0%	50
D21	1	1	Small	Online games and game software (100%)	0.7%	30	0.9%	25
D22	1	1	Big	Software outsourcing services (100%)	0.4%	35	0.4%	37
D34	1	1	Big	Other (69.9%), personal computers (24.5%), automation equipment (3.6%)	1.9%	16	1.3%	20
D35	1	1	Big	Game software (98%), other (1.7%), magazines (0.3%)	8.9%	3	9.5%	3
D37	1	1	Small	Workstation and server host (43.4%), NET software/ hardware and communications (28.2%), application software and services (25.3%)	4.2%	8	5.0%	5
D38	1	1	Small	Personal computers (33.4%), server (20.7%), technical services (14.6%)	1.7%	17	2.0%	15
D46	1	1	Small	Commercial software (45.1%), rental income (29%), computer books (25.8%)	0.6%	32	0.5%	35
D47	1	1	Big	E-commerce (90.7%), other (9.3%)	10.9%	2	12.3%	1
D48	1	1	Big	Workstation (26.2%), server and data storage equipment (25.5%), software technology (23.3%)	3.7%	9	3.5%	10
D7	1	1	Small	Agent products (92.5%), homemade products (6.5%), other (1.1%)	3.6%	10	4.1%	7
D49	2	1	Big	System integration income (64%), automated control system (27.6%), industrial computers (5.1%)	6.5%	4	3.9%	8
D28	1	1	Big	Labor income (96%), sales revenue (4%)	1.3%	19	2.3%	14
D50	1	1	Small	3D CAD / CAM (60.1%), CAE professional applications (23.8%), consultancy services (8.3%)	0.4%	34	0.5%	31
D41	1	1	Big	Online game revenues (93.6%), labor income (4%), sales revenue (1.3%)	4.8%	5	5.1%	4
D43	1	1	Big	Sales revenue (67.3%), labor income (32.4%), other operating income (0.4%)	11.1%	1	10.7%	2
D13	3	19	Big	Game machines (56.7%), online game (41.7%), other (1.6%)	4.4%	7	3.5%	11

D2	1	20	Big	Peripheral and system integration (85.7%), maintenance of computer equipments (14.3%)	3.4%	11	3.7%	9
D15	1	21	Big	Online game revenue (101.3%), game machines (-1.3%) [e]	1.2%	22	1.4%	19
D23	2	22	Big	Online games and game software revenues (100%)	0.2 %	47	0.5 %	33
D30	1	23	Small	Handwriting input products (47%), products of optical character recognition (36.4%), software license revenue (11%)	0.4 %	38	0.4 %	38
D45	2	24	Big	PC and BIOS (95.7%), other (4.3%)	1.0%	25	1.1%	24
D6	1	25	Small	Network products (37.3%), computer software (20.8%), storage equipments (12.8%)	0.7%	29	0.6 %	29
D12	1	26	Big	Network services (86.4%), consultancy services (13.6%)	1.0%	24	1.2%	22

Table 7. DMUs' main products proportion and market share (continued)

Unit name	Quadrant in matrix [a]	BCC average rank [b]	Firm's scale [c]	Proportion of main products	Market share 2009	rank	2010	rank
D32	3	27	Small	Peripheral and system integration (68.2%), consultancy and maintenance services (24.4%), computer system management software (7.2%)	0.3%	43	0.3%	40
D33	4	28	Big	Sales revenue (59.8%), labor income (40.2%)	1.6%	18	1.1%	23
D17	1	29	Small	3D MCAD (33.4%), maintenance services (30.9%), other (20.7%)	0.5%	33	0.5%	34
D16	3	30	Small	Security applications (43.5%), other (33.8%), handwriting recognition software applications (22.3%)	0.2%	49	0.2%	49
D39	1	31	Small	Software products and services (47.7%), network equipments (23.4%), information storage systems (22.2%)	0.8%	26	0.5%	32
D20	3	32	Small	Online game revenues (90.7%), other (7.2%), sales revenue (2.1%)	1.1%	23	0.6%	28
D26	1	33	Big	Digital audio-visual equipments (95.6%), other (4.4%)	3.4%	12	3.2%	12
D42	4	34	Big	Electronic data interchange services (68.9%), project income (29.4%), equipments and facilities management (1.6%)	1.2%	20	1.3%	21
D14	1	35	Small	Internet advertising and marketing (55.1%), news graphics authorized services (10.8%), news graphics library (10.5%)	0.2%	45	0.3%	44
D24	4	36	Small	System integration services revenues (73.5%), information transfer income (15.7%), maintenance services revenue (10.9%)	0.2%	46	0.3%	43
D11	1	37	Small	Online game revenues (94.9%), license revenue (4.6%), other (0.5%)	0.8%	27	0.9%	27
D40	3	38	Small	Game software (99.5%), educational software (0.5%)	0.3%	39	0.2%	48
D25	4	39	Small	PageManager (57.1%), Biacard / Barcode (24.8%), ODM / maintenance / outsourcing (8.3%)	0.2%	48	0.2%	47
D5	1	40	Big	Consultancy and maintenance services (38.4%), workstations and servers (17.7%), storage equipments (14.3%)	4.4%	6	4.5%	6
D8	2	41	Small	Online game revenues (56.9%), rental income (42.2%), license revenue (0.9%)	0.3%	44	0.3%	41
D18	2	42	Big	License revenue (48.4%), game development income (37.7%), art designing services (13.9%)	0.4%	37	0.5%	36
D31	3	43	Big	Knowledge management services (67.4%), consumer finance (19.8%), e-commerce (12.7%)	0.6%	31	0.6%	30
D44	4	44	Small	Network integration information management (40.9%), system platform (31.6%), storage equipments (18.6%)	1.2%	21	1.9%	18
D10	2	45	Smal	Other (33.9%), internet marketing (32.4%), network services (16.6%)	0.4	36	0.3	42

			l		%		%	
D36	4	46	Small	License revenue (39.6%), online games (34.5%), game machines (24.8%)	0.3%	41	0.3%	45
D4	2	47	Big	Application software systems (73.7%), system integration services (26.3%)	0.7%	28	0.9%	26
D27	4	48	Small	System integration services (51.8%), maintenance services (39.7%), solenoid valve and components (8.4%)	0.3%	40	0.2%	46
D29	4	49	Small	System integration services (53%), labor income (47%)	0.3%	42	0.4%	39
D1	2	50	Big	Computer maintenance revenue (35.8%), system integration services (31%), banking terminal system (20.1%)	2.1%	15	2.0%	17
				Average	2.0%		2.0%	

Notes: [a] The definition of matrix comes from Figure 1.
[b] The BCC average rank comes from Table 8, which is the rank order of the average pure technical efficiency during the period 2009-2010.
[c] Firms' scale is defined according to the descending order of their total number of employees; the firms ranked in top 50% are classified as relative "Big" scale and the others are as relative "Small" scale.
[d] D19's net operating incomes in 2009 and 2010 represent 0.000529% and 0.000012% of the market in information services industry, respectively.
[e] The percentage data come from official website of Taiwan Economic Journal (http://www.tej.com.tw/twsite/) which has no further indications about why the percentage is more than 100% or less than 0%.

Table 8. Average efficiencies and ranks for information services firms from 2009 to 2010[a]

	CCR efficiency				BCC efficiency				Scale efficiency			
Unit name[b]	Rank in 2009	Rank in 2010	Average score	Rank of average	Rank in 2009	Rank in 2010	Average score	Rank of average	Rank in 2009	Rank in 2010	Average score	Rank of average
D3	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D9	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D19	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D21	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D22	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D34	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D35	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D37	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D38	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D46	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D47	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D48	1	1	1.000	1	1	1	1.000	1	1	1	1.000	1
D7	14	1	0.999	13	1	1	1.000	1	17	1	0.999	16
D49	1	20	0.940	15	1	1	1.000	1	1	21	0.940	17
D28	20	19	0.845	18	1	1	1.000	1	29	19	0.845	20
D50	28	23	0.570	24	1	1	1.000	1	40	33	0.570	39
D41	33	28	0.518	31	1	1	1.000	1	43	38	0.518	40
D43	42	43	0.329	42	1	1	1.000	1	50	48	0.329	50
D13	29	38	0.479	35	1	30	0.980	19	41	43	0.488	41
D2	15	1	0.968	14	25	1	0.968	20	1	1	1.000	1
D15	36	37	0.458	37	26	1	0.965	21	42	42	0.476	42
D23	21	22	0.645	22	27	1	0.964	22	24	32	0.672	29
D30	16	1	0.937	16	28	1	0.937	23	1	1	1.000	1
D45	26	26	0.556	26	29	1	0.936	24	32	37	0.598	34
D6	18	1	0.923	17	33	1	0.923	25	1	1	1.000	1
D12	47	42	0.308	45	37	1	0.886	26	47	47	0.352	48
D32	17	34	0.650	21	1	38	0.880	27	18	31	0.721	25
D33	22	33	0.573	23	1	39	0.879	28	30	29	0.649	30
D17	30	24	0.552	28	34	33	0.862	29	34	28	0.641	31
D16	27	36	0.505	33	30	34	0.849	30	33	39	0.593	35
D39	31	1	0.763	19	40	1	0.847	31	21	1	0.879	18
D20	19	39	0.547	29	1	42	0.844	32	28	34	0.636	33
D26	46	45	0.285	48	36	31	0.843	33	48	49	0.341	49
D42	45	41	0.323	43	31	35	0.841	34	49	44	0.385	45
D14	35	31	0.491	34	38	32	0.833	35	37	35	0.592	36
D24	25	32	0.526	30	32	36	0.824	36	31	30	0.637	32
D11	40	25	0.469	36	43	1	0.814	37	36	36	0.587	37
D40	37	50	0.316	44	1	46	0.810	38	44	50	0.372	47
D25	44	44	0.304	46	35	37	0.798	39	46	45	0.380	46
D5	38	1	0.719	20	44	1	0.790	40	23	1	0.877	19
D8	48	30	0.399	39	49	1	0.722	41	35	40	0.576	38
D18	32	29	0.515	32	42	40	0.707	42	22	24	0.730	23
D31	24	27	0.570	25	39	44	0.706	43	20	23	0.807	22
D44	34	21	0.555	27	41	45	0.668	44	26	20	0.833	21
D10	43	46	0.296	47	46	41	0.656	45	39	46	0.465	43
D36	23	49	0.422	38	24	50	0.630	46	38	22	0.728	24
D4	41	35	0.397	40	48	43	0.578	47	25	26	0.693	28
D27	39	40	0.381	41	45	47	0.541	48	27	25	0.704	27
D29	50	48	0.219	50	47	48	0.480	49	45	41	0.456	44
D1	49	47	0.263	49	50	49	0.371	50	19	27	0.719	26
Num of efficient DMUs	13	18		12	23	29		18	16	18		15

Notes: [a] CCR or BCC in this table means the values of the column are calculated by CCR or BCC model.
[b] DMUs are ranked by descending order of BCC efficiency's average score.

4.4.2 Improvement analysis from the results of the BCC model

Tables 9 and 10 present the potential for improvement in inputs and outputs and their contribution to calculating DMUs' efficiency scores in 2009 and 2010. In 2009, the average improvement values of all the DMUs for outputs O1, O2, O3 and O4 are: 38.8%, 32.0%, 129.1% and 39.2%, respectively; those for inputs I1, I2, I3 and I4 are: -3.7%, -11.3%, -2.3% and -14.0 %, respectively. The positive values of output items indicate the extent to which output performance is insufficient, given the current input resources. The negative or zero values of input items indicate by the percentage should be reduced under the current output performance. The results show that in 2009 and 2010, O3 (current net income) and O4 (cash flow from operating activities) are the items that should be improved the most. The input resource that should be reduced the most is I4 (total number of employees). On average, the pure technical inefficient DMUs needs to increase their current net income by about 2.4 times in 2009 and increase their cash flow from operating activities by about 1.4 times in 2010. Among the input items, it is suggested that the total number of employees should be reduced by 26.4% in 2009 and by 25.7% in 2010.

The column, "Contribution to calculating BCC efficiency scores" identifies the importance of different outputs and inputs while the efficient and inefficient DMUs hope to enhance their relative pure technical efficiency. According to the average values of all DMUs, O2 (operating profits, 27.3%) and O3 (current net income, 28.1%) are the major contributors to BCC scores among the outputs in 2009 and O1 (net operating revenue, 31.1%) is the major contributor in 2010; I3 (total assets) is the major contributor among the inputs both in 2009 (46.9%) and in 2010 (47.1%).

The data also shows that for the group of the efficient DMUs, O1 (net operating revenue, 34.2%) and O3 (current net income, 33.9%) are the major contributors in 2009, which is different from the result of the inefficient DMUs where O2 (operating profits, 39.4%) is the major contributor. As for the results in 2010, O1 (net operating revenue, 46.4%) is the major contributor for the efficient DMUs and O3 (current net income, 36.0%) is the major contributor for the inefficient DMUs. In addition, among the inputs, I1 (marketing expenses) generally contributes the least to different groups both in 2009 and in 2010, except for the inefficient DMUs in 2010, when I4 (total number of employees) contributes the least. Therefore, for the inefficient DMUs, the contributions of the outputs O2 (operating profits), O3 (current net income), and the input I3 (total assets) are more important than other items in 2009 as well as in 2010.

Table 9. Inputs'/outputs' room for improvement and their contribution in calculating DMUs' efficiency scores in 2009

Unit name	Room for improvement by BCC model (%)								Contribution in calculating BCC efficiency scores (%)							
	O1[a]	O2[a]	O3[a]	O4[a]	I1[a]	I2[a]	I3[a]	I4[a]	O1	O2	O3	O4	I1	I2	I3	I4
D3	0	0	0	0	0	0	0	0	0	0	100	0	0	0.3	0	99.7
D9	0	0	0	0	0	0	0	0	8.1	0	87.1	4.8	0	0	100	0
D19	0	0	0	0	0	0	0	0	0	0	100	0	0	0	0	100
D21	0	0	0	0	0	0	0	0	0	0	0	100	0	0	100	0
D22	0	0	0	0	0	0	0	0	0	0	55.9	44.1	11.9	0	88.1	0
D34	0	0	0	0	0	0	0	0	0	100	0	0	0	0.1	3.3	96.6
D35	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	100
D37	0	0	0	0	0	0	0	0	97.9	2.1	0	0	0	24.2	59.3	16.5
D38	0	0	0	0	0	0	0	0	73.4	26.6	0	0	6.6	0	93.4	0
D46	0	0	0	0	0	0	0	0	100	0	0	0	0	78.7	0	21.3
D47	0	0	0	0	0	0	0	0	91.3	0	0	8.7	52.4	11.3	11.7	24.6
D48	0	0	0	0	0	0	0	0	100	0	0	0	0	0	100	0
D49	0	0	0	0	0	0	0	0	14.7	0	85.3	0	0	10.8	89.2	0
D7	0	0	0	0	0	0	0	0	100	0	0	0	17.9	0	41.1	41
D2	6.9	35.4	64.9	116.4	0	-69.2	-44.2	-53.2	100	0	0	0	89.1	2.7	2.6	5.6
D30	54.4	17.5	14.4	26.8	0	0	-23.5	0	0	0	100	0	0	75.6	0	24.4
D32	0	0	0	0	0	0	0	0	17.3	0	82.7	0	0	0	100	0
D6	18.3	109.9	18.3	96.9	-42.1	0	-46.1	0	3	0	97	0	0	0.5	0	99.5

Table 9. Inputs'/outputs' room for improvement and their contribution in calculating DMUs' efficiency scores in 2009 (continued)

	Room for improvement by BCC model (%)								Contribution in calculating BCC efficiency scores (%)							
Unit name	O1 [a]	O2 [a]	O3 [a]	O4 [a]	I1 [a]	I2 [a]	I3 [a]	I4 [a]	O1	O2	O3	O4	I1	I2	I3	I4
D20	0	0	0	0	0	0	0	0	21.7	0	0	78.3	0	0	100	0
D28	0	0	0	0	0	0	0	0	32.7	0	0	67.3	3.3	13.7	83	0
D23	28.2	40.5	27.3	7.7	-24.5	-92.2	0	-79.9	0	0	0	100	0	0	100	0
D33	0	0	0	0	0	0	0	0	0	0	0	100	13.5	1.8	9.6	75.1
D36	1.1	30.4	1.1	53.3	-20	-88.1	0	-52.9	7.6	0	92.4	0	0	0	100	0
D31	32.4	58	56	32.4	0	-88.2	0	-72.4	34.8	0	0	65.2	15.1	0	84.9	0
D24	16.2	16.2	16.2	25.9	0	0	0	-67.5	2.3	62.4	35.3	0	40	25.6	34.4	0
D45	14.7	14.7	14.7	121.8	0	-57.9	0	-46.2	23.7	34.1	42.2	0	6.7	0	93.3	0
D16	62.5	15.3	15.2	15.2	0	-72	0	-38.6	0	0	48.1	51.9	6	0	94	0
D50	0	0	0	0	0	0	0	0	4.1	95.9	0	0	27.7	29.2	3.6	39.5
D13	0	0	0	0	0	0	0	0	2.1	0	69.5	28.4	0	57.6	42.4	0
D17	26.4	20.8	22.2	54.5	-2.5	0	0	0	0	100	0	0	0	40.9	6.2	52.9
D39	57.2	63.8	94.4	44.2	0	0	0	0	0	0	0	100	32.9	21.9	31.3	13.9
D18	51.5	51.5	52.6	137.5	0	-7	0	-68	29.9	70.1	0	0	4.4	0	95.6	0
D41	0	0	0	0	0	0	0	0	22.5	77.5	0	0	9.4	54.2	36.4	0
D44	46.5	109	115.7	46.5	-1	0	0	0	22.3	0	0	77.7	0	4.9	52.1	43
D14	68.5	30.2	30.2	30.2	0	0	0	-43.2	0	14.7	51.8	33.5	49.6	20.6	29.7	0
D15	40.9	7.5	8.9	41.7	-13.5	-37.3	0	-35.9	0	100	0	0	0	0	100	0
D40	0	0	0	0	0	0	0	0	0	0	100	0	0	0	97.7	2.3
D5	72.6	86	110.3	72.6	0	0	0	-18.4	45.6	0	0	54.4	32.1	11.4	56.5	0
D27	73.2	74.9	113	73.2	0	-42.4	0	-5.9	22.3	0	0	77.7	8.8	0	91.2	0
D11	59.4	59.4	112.6	99	-8.3	0	0	0	19.6	80.4	0	0	0	8.5	21.9	69.6
D4	110	110	155.9	117.9	0	0	0	-35.3	16.9	83.1	0	0	19.6	34.8	45.5	0
D43	0	0	0	0	0	0	0	0	0	0	99.9	0	79.9	20.1	0	0
D10	110.6	74.8	116.8	74.8	0	0	0	0	0	89.9	0	10.1	27.2	21.7	2	49.1
D25	239.1	23.2	59.1	67.3	0	0	0	0	0	100	0	0	0.8	25.2	12.3	61.7
D42	58.4	16.1	31.4	16.1	0	0	0	-16	0	97.3	0	2.7	48.4	43.2	8.3	0
D26	62.8	36.8	27.2	174,252,755.1	-51.4	-19.6	-27	0	0	0	100	0	0	0	0	100
D12	91.7	29.4	29.4	33.5	-40	0	0	-27.3	0	99.6	0.4	0	0	81.8	18.2	0
D8	125.4	125.4	125.9	160.9	-28.1	0	0	0	13.7	86.3	0	0	0	18	23.2	58.8
D1	204.8	204.8	4913.9	244.4	0	0	0	-26	53.5	46.5	0	0	25	33.1	42	0
D29	205.1	138.6	109.2	109.2	0	0	0	0	0	0	55.8	44.2	10.3	37.4	41.2	11.2
Average of all DMUs	38.8	32.0	129.1	39.2 [b]	-3.7	-11.3	-2.3	-14.0	23.6	27.3	28.1	21.0	12.8	16.2	46.9	24.1
Average of efficient DMUs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	34.2	13.1	33.9	18.8	9.7	13.1	50.4	26.8
Average of inefficient DMUs	71.8	59.3	239.1	73.8 [b]	-6.9	-21.3	-4.4	-26.4	14.6	39.4	23.1	22.9	15.4	18.8	43.9	21.8

Notes: [a] O1 refers to the net operating revenues; O2 refers to the operating profits; O3 refers to the current net income; O4 refers to the cash flow from operating activities; I1 refers to the marketing expenses; I2 refers to the R&D expenses; I3 refers to the total assets; I4 refers to the total number of employees.
[b] D26 is not included in this average.

Table 10. Inputs'/outputs' room for improvement and their contribution in calculating DMUs' efficiency scores in 2010

Unit name	Room for improvement by BCC model (%)								Contribution in calculating BCC efficiency scores (%)							
	O1[a]	O2[a]	O3[a]	O4[a]	I1[a]	I2[a]	I3[a]	I4[a]	O1	O2	O3	O4	I1	I2	I3	I4
D2	0	0	0	0	0	0	0	0	90.4	0	0	9.6	0	0	100	0
D3	0	0	0	0	0	0	0	0	64	0	36	0	0	0	90.6	9.4
D5	0	0	0	0	0	0	0	0	100	0	0	0	75.1	10.7	4.8	9.4
D6	0	0	0	0	0	0	0	0	0	31.2	68.8	0	40.2	0	0	59.8
D7	0	0	0	0	0	0	0	0	92.8	0	7.2	0	15.3	0	42.3	42.4
D9	0	0	0	0	0	0	0	0	46.6	53.4	0	0	64.6	23.2	3.3	8.9
D19	0	0	0	0	0	0	0	0	100	0	0	0	0	0	0	100
D21	0	0	0	0	0	0	0	0	12.3	0	0	87.7	0.1	99.9	0	0
D22	0	0	0	0	0	0	0	0	0	0	0	100	15.6	0	84.3	0
D30	0	0	0	0	0	0	0	0	2.2	97.8	0	0	0	32.7	0	67.3
D34	0	0	0	0	0	0	0	0	49.2	0	50.8	0	0	0	100	0
D35	0	0	0	0	0	0	0	0	68.7	0	31.3	0	0	0	0	100
D37	0	0	0	0	0	0	0	0	100	0	0	0	0	2.5	41	56.4
D38	0	0	0	0	0	0	0	0	80.7	0	19.3	0	0	0	53.1	46.9
D39	0	0	0	0	0	0	0	0	26.3	73.7	0	0	13.4	14.1	0	72.4
D46	0	0	0	0	0	0	0	0	100	0	0	0	4.9	0	55	40.2
D47	0	0	0	0	0	0	0	0	100	0	0	0	0	51	27.2	21.9
D48	0	0	0	0	0	0	0	0	100	0	0	0	0	25	0	75
D28	0	0	0	0	0	0	0	0	0	88	12	0	38.3	61.7	0	0
D49	0	0	0	0	0	0	0	0	89.6	0	10.4	0	0	40.2	0	59.8
D44	53	53	53	1587.8	0	0	0	0	59.6	36	4.4	0	26.9	8.2	44.7	20.2
D23	0	0	0	0	0	0	0	0	11.1	0	76	12.9	0	0	100	0
D50	0	0	0	0	0	0	0	0	0	0	100	0	0	0	35.3	64.7
D17	23.1	23.2	11.6	44.7	0	0	0	-10.8	0	0	100	0	5.3	22.4	72.3	0
D11	0	0	0	0	0	0	0	0	0	78.1	21.9	0	0	18.4	81.6	0
D45	0	0	0	0	0	0	0	0	8.1	0	0	91.9	1.7	0	98.3	0
D31	52	73.8	52	68.9	0	-66.6	0	-70.2	40.2	0	59.8	0	15.8	0	84.2	0
D41	0	0	0	0	0	0	0	0	20.7	79.3	0	0	0	35.3	64.7	0
D18	32.8	32.8	56	33.6	0	0	0	-60.7	26	74	0	0	5.3	11	83.7	0
D8	0	0	0	0	0	0	0	0	0	0	0	100	1	0	49.6	49.4
D14	21.2	24.7	11.3	21.9	0	0	0	-60.6	0	0	100	0	3.6	36.6	59.7	0
D24	27.1	32.5	27.1	27.1	0	0	0	-57.7	4.6	0	77.8	17.5	35.2	19.6	45.2	0
D33	40.5	32	32	111.2	0	0	0	-13.8	0	71.4	28.6	0	32.2	46.1	21.7	0

D32	79.6	31.7	31.7	31.7	0	0	0	-13.6	0	21	55.1	23.8	29.4	24.8	45.8	0
D4	54	47.1	58.8	48.7	0	0	0	-43.6	0	100	0	0	34	51.5	14.6	0
D16	43.1	30	20.5	20.5	-42	0	0	0	0	0	16.9	83.1	0	1.8	93.3	4.8
D15	0	0	0	0	0	0	0	0	11.1	39.9	25.3	23.7	0	0	100	0
D13	4.2	4.2	13	4.4	-87.6	-25.5	-0.3	-26	16.3	83.7	0	0	19.1	51.5	8.1	21.3
D20	45.3	93.2	45.3	103.4	-18.5	0	0	-44.3	9.4	0	90.6	0	0	41.6	58.4	0
D27	98	98	136.5	118.2	0	0	0	-28.8	11.4	88.6	0	0	27.2	17.6	55.2	0
D42	137.2	21.8	52.3	58	0	0	0	-31.5	0	100	0	0	50.4	27.3	22.3	0
D12	0	0	0	0	0	0	0	0	1.4	0	46.8	51.8	0	20.6	79.4	0
D43	0	0	0	0	0	0	0	0	69.9	0	30.1	0	0	0	100	0
D25	305.2	28.1	36.3	27.6	-16.9	0	0	0	0	0	0	100	0	0.6	58.4	41
D26	11.6	11.2	11.2	94.9	-93	-23.6	-41.7	-10.2	0	42.5	57.5	0	26.4	45.8	12	15.8
D10	253.2	66.4	77.2	35.2	0	0	0	0	0	0	0	100	12.2	3.9	37.8	46
D1	142	187.1	142	142	0	0	0	-8	8.4	0	20.9	70.7	8.3	14.7	77	0
D29	194.3	166.6	107.7	107.7	0	0	0	0	0	0	76.3	23.7	30.5	38	29.9	1.6
D36	269	423.3	269	271.8	0	-76.3	0	-60.4	32.9	0	67.1	0	21.6	0	78.4	0
D40	455.8	276.2	145.3	61.3	0	0	0	0	0	0	0	100	4.4	13.7	40.5	41.3
Average of all DMUs	46.8	35.1	27.8	60.4	-5.2	-3.8	-0.8	-10.8	31.1	23.2	25.8	19.9	13.2	18.2	47.1	21.5
Average of efficient DMUs	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	46.4	18.7	18.5	16.5	9.3	15.0	45.2	30.5
Average of inefficient DMUs	111.5	83.7	66.2	143.8	-12.3	-9.1	-2.0	-25.7	9.9	29.4	36.0	24.7	18.5	22.7	49.7	9.1

Notes: [a] O1 refers to the net operating revenues; O2 refers to the operating profits; O3 refers to the current net income; O4 refers to the cash flow from operating activities; I1 refers to the marketing expenses; I2 refers to the R&D expenses; I3 refers to the total assets; I4 refers to the total number of employees.

4.4.3 Operating efficiency and marketing management strategy

Operating efficiency and strategy matrix: With reference to Table 8, DMUs' rank progression or regression in pure technical efficiency and scale efficiency over the period 2009–2010, this paper incorporates the concept of a management matrix to build a four-quadrant operating efficiency and strategy matrix, as illustrated in Figure 1. DMUs that progress both in pure technical efficiency and scale efficiency or maintain both efficiencies of 1 or are ranked the same are located in Quadrant 1; those that progress in pure technical efficiency but regress in scale efficiency are located in Quadrant 2; those that regress in both pure technical efficiency and scale efficiency are located in Quadrant 3; those that regress in pure technical efficiency but progress in scale efficiency are located in Quadrant 4. According to the efficiency features of different quadrants, suggestions of operating strategy are also described in Figure 1. The results show that most of the DMUs belong to Quadrant 1; they represent 56% of all the DMUs. This means that most of the DMUs have good operating strategies from the viewpoint of technology and the scale of the firms. However, there are still 44% of DMUs located in Quadrants 2, 3 and 4; they need to adjust their current operating strategies to meet the market's and clients' demands.

Quadrant 2 1. Efficiency features: DMUs progressing in pure technical efficiency & regressing in scale efficiency. 2. Suggested strategy: continuing to maintain DMUs' R&D and products policy and trying to enhance operating scale efficiency by merging or separating firms' business. A total of 8 DMUs in this quadrant (6 Big & 2 Small): D49, D23, D45, D8, D18, D10, D4, D1.	**Quadrant 1** [a] 1. Efficiency features: DMUs progressing both in pure technical efficiency & scale efficiency. 2. Suggested strategy: continuing to maintain DMUs' R&D and products policy and operating scale. A total of 28 DMUs in this quadrant (15 Big & 13 Small): D3, D9, D19, D21, D22, D34, D35, D37, D38, D46, D47, D48, D7, D28, D50, D41, D43, D2, D15, D30, D6, D12, D17, D39, D26, D14, D11, D5.
Quadrant 3 1. Efficiency features: DMUs regressing both in pure technical efficiency & scale efficiency. 2. Suggested strategy: adjusting DMUs' R&D and products policy to technology-oriented and trying to enhance operating scale efficiency by merging or separating firms' business. A total of 6 DMUs in this quadrant (2 Big & 4 Small): D13, D32, D16, D20, D40, D31.	**Quadrant 4** 1. Efficiency features: DMUs regressing in pure technical efficiency & progressing in scale efficiency. 2. Suggested strategy: adjusting DMUs' R&D and products policy to technology-oriented and continuing to maintain DMUs' operating scale. A total of 8 DMUs in this quadrant (2 Big & 6 Small): D33, D42, D24, D25, D44, D36, D27, D29.

Note: [a] DMUs maintaining both pure technical efficiency & scale efficiency of 1 or in the same ranks are located in the quadrant 1.

Figure 1. Operating efficiency and strategy matrix

Analysis of firms' scale: In order to know how to adjust DMUs' operating scale to enhance their scale efficiency, this paper first compares the scales of DMUs located in Quadrants 2, 3 and 4 with those in Quadrant 1. While the paid-in capital or the total revenue are often used to define the scale of the firm, this paper considers the total number of employees (one of the input items in this paper) as a better standard of firms' scale in order to highlight two important properties of the information services industry: First, human capital is an important input factor and, second, firms with a low number of employees can also create high turnover. Moreover, a correlation coefficient test shows that the total number of employees is positively correlated with the paid-in capital, total revenue, and total assets. Accordingly, all 50 DMUs are ranked in descending order according to total number of employees. Based on the definition provided by the Small and Medium Enterprise Administration in Taiwan, small and medium enterprises (SMEs, defined as companies with an annual turnover of less than TWD100 million or less than a hundred employees) account for more than 90% of businesses in the information services industry in 2010. However, this paper intends to identify the relative scale of firm size. Accordingly, the top 25 DMUs are roughly divided into firms of relatively large scale, and relatively small scale; thus, the proportion of relatively large scale firms and relatively small scale firms in this paper is 1:1.

The result of firms' scale listed in Table 7 shows that a total of 15 DMUs in Quadrant 1 belong to the relatively large scale, which represent 54% of the 28 DMUs in Quadrant 1; the other 13 DMUs, representing 46%, belong to the relatively small scale. Among these 13 DMUs, 10 DMUs have a market share of less than 1%, but two DMUs (D7 and D37) have a market share of 4.2% and 3.6% which are more than the average market share of the 50 DMUs. This evidence proves that firms with a low number of employees can still generate high turnover. A total of 6 DMUs in Quadrant 2 belong to relatively large scale, which represents 75% of the 8 DMUs; the other 2 DMUs, representing 25%, belong to the relatively small scale. A total of 2 DMUs in Quadrant 3 belong to the relatively large scale, which represent 33% of the 6 DMUs; the other 4 DMUs, representing 67%, belong to the relatively small scale. A total of 2 DMUs in Quadrant 4 belongs to the relatively large scale, which represents 25% of the 8 DMUs; the other 6 DMUs, representing 75%, belong to the relatively small scale.

We conclude that, in this empirical study, in Quadrants 1 and 2 the proportion of relatively large scale firms is important; this phenomenon is contradicted in Quadrants 3 and 4. Furthermore, the difference in the proportion of relatively small scale and relatively large scale firms is even more pronounced in Quadrants 2 and 4. The proposed operating efficiency and strategy matrix reveals that in Quadrant 2, there are three times more large scale firms than small scale firms; in Quadrants 3 and 4, there are twice and three times more small scale firms than large scale firms, respectively. This shows that relatively small scale firms are constrained by financial support, scale, human resources and the overall environment, and are more likely to encounter bottlenecks in R&D and product innovation. As a consequence, their product and technology development cannot compete with that of large firms. Small firms are advised to invest in the future and strengthen their R&D and technology.

Strategy analysis from the perspective of market share and main products: Table 7 summarizes some of the characteristics of DMUs which are related to core products and market share. The order of DMUs in this table follows that in Table 8. The quadrant to which each DMU belongs is also indicated in the table. The average total market share of efficient DMUs and the average market share of each efficient DMU (that is, the DMUs with a BCC average score ranked 1 in Table 7) over the period 2009–2010 are: 66.2% (65.80% in 2009 and 66.57% in 2010) and 3.7% (which equals 66.2% divided by 18 efficient DMUs); those of inefficient DMUs are: 33.8% (34.2% in 2009 and 33.43% in 2010) and 1.1% (which equals 33.8% divided by 32 inefficient DMUs). This means that there are twice as many pure technical efficient DMUs than inefficient DMUs in the information services market. Moreover, on average, each pure technical efficient DMU is almost three times more competitive in the market than those that are inefficient. Table 7 shows that most of the DMUs located in Quadrant 1 have a proportion of core products superior to 70%. Their core products concentrate on software services or digital contents, such as online games and gaming software, e-commerce, peripheral and system integration, and network services.

In terms of market share, the efficient DMUs do not always play an important role or belong to relatively large firms. It is noted that there are 7 out of the 18 efficient DMUs that belong to relatively small firms. Moreover, DMUs which concentrate most of their financial and human resources on one single core product and on their proper industry can more easily obtain better efficiency than their competitors. In other words, the business strategy for products or services specialization should emphasize each firm's key product; the emphasis of the development strategy for products or services diversification should be on the heterogeneity of products or services. Sometimes, the former is more suitable than the latter for industries in a rapidly changing and highly competitive market like the information services industry. The empirical results confirm that most inefficient firms tend to adopt a business strategy that involves products or services diversification. Therefore, this paper concludes that a business strategy of products or services diversification may not always result in better operating efficiency for firms in the information services industry.

These observations can encourage DMUs that belong to small firms and are located in Quadrants 2, 3 and 4 to make progress if they can determine optimal learning models and formulate effective marketing and operating strategies.

5. Conclusions

This paper successfully uses the CCR and BCC models of the DEA to perform an operating efficiency evaluation of 50 information services firms selected from TSE, OTC, and ROTC listed companies in Taiwan over the period 2009–2010. It explores the reasons for inefficient overall operating performance and whether the factors are due to pure technical inefficiency or scale inefficiency, in order to make suggestions for operating directions and management strategies for further improvement. The analysis results of overall technical efficiency, pure technical efficiency and scale efficiency indicate the efficient and inefficient DMUs in 2009 and 2010. Compared to 2009, 5 more DMUs become overall technical efficient in 2010; 6 more DMUs become pure technical efficient and 2 more DMUs become scale efficient in 2010. The average efficiency scores of the inefficient DMUs declined slightly in 2010.

An analysis of DMUs' reference DMUs and their number helps to conclude that firms in the information services industry should be advised to concentrate their resources and efforts on one single product related to online/PC games services. From the viewpoint of market share, it is easier to consider the efficient DMUs with small scales of market share as learning role models than the efficient DMUs with large scales. A slack variable analysis is conducted to understand the space and scope for improvement. The results show that in 2009 and 2010, on average, the pure technical inefficient DMUs are should be advised to increase their current net income by about 2.4 times in 2009 and increase their cash flow from operating activities by about 1.4 times in 2010. Among the input items, firms should be advised to reduce the number of employees by 26.4% in 2009 and by 25.7% in 2010. An analysis of the contribution in calculating efficiency scores clarifies that for the inefficient DMUs, the contributions of operating profits, current net income, and total assets are much more important than other items both in 2009 and in 2010. For the efficient DMUs, the net operating revenue and the current net income are the major contributors in 2009; in 2010, only the net operating revenue is the major contributor.

Finally, this paper uses the DMUs' rank progression or regression in pure technical efficiency and scale efficiency over the period 2009–2010 to build a four-quadrant operating efficiency and strategy matrix. This proposed matrix combined with an analysis of DMUs' market share and core products show that DMUs which concentrate most of their financial and human resources on one single core product and on their proper industry can relatively more easily obtain better efficiency than their competitors. The empirical results also indicate that most inefficient firms tend to diversification of products or services as their business strategy. This strategy may not always bring better operating efficiency for firms in the rapidly changing and highly competitive information services industry; sometimes a business strategy of products or services specialization is more suitable. Inefficient DMUs may make progress if they can identify optimal learning models and formulate effective marketing and operating strategies. As a result, they can more effectively adjust their business management strategies and enforce their place in the global information industry market.

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