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Measuring the Efficiency and the Effect of Corporate Governance on the Biotechnology and Medical Equipment Industries in Taiwan

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ABSTRACT: This study adopts data envelopment analysis with Tobit regression analysis to measure the efficiency and investigate the influence of corporate governance on the efficiency of the biotechnology and medical equipment industries in Taiwan. The empirical results show that while inside equity influences the efficiency of profitability in the pharmaceutical industry, both inside and outside equity influence the efficiency of profitability in the medical equipment industry. Moreover, both inside and outside equity influence the efficiency of marketability in the pharmaceutical and medical equipment industry. The proportion of shares held by foreign institutions is significantly positively correlated with the efficiency of profitability and negatively correlated with the efficiency of marketability, implying that the short-term profit goal of the foreign institutional investors is to sell their holdings. Besides, the number of board members and transparency of information are significantly positively correlated with both the efficiency of profitability and the efficiency of marketability.

Keywords: Data Envelopment Analysis; Biotechnology Industry; Corporate Governance; Transparency
JEL Classifications: D21; D24; G30; P27

1. Introduction

Applications of biotechnology are found in a wide variety of areas, ranging from pharmaceuticals and healthcare to agriculture, food, energy, chemicals, biological resources, and environmental protection, and hence biotechnology has already became a part of human life[1]. Over the past twenty

[1] The characteristics of biotechnology are that it consumes less power, has low pollution, has high added value, has broad applications, and is based on reusable energy. Thus the Taiwan government viewed biotechnology as an important developmental industry when promoting the next-generation of mainstream industries in 1982.

years, the government has already invested huge resources in biotechnology and established related R&D organizations. Although the global financial crisis sent the world economy into a rapid downturn in the second half of 2008, the biotechnology industry is still in its growth phase, and the size of the industry is continually expanding. Taiwan can, based on its experiences of developing its electronics industry, enhance its competitive ability by investing manpower and other resources in the biotechnology industry. The U.S. Congress judges Taiwan to be one of the great countries in the biotechnology field. As humans live longer and the quality of life improves, human beings are becoming increasingly dependent upon biotechnology products and it is anticipated that biotechnology in Taiwan will bring tremendous business opportunities in the future.

The most common business performance analysis is based on financial measures and includes various accounting ratios. Each single performance measure that is based upon only one factor may be unsatisfactory in characterizing performance, and thus merely using financial ratios cannot provide complete information regarding the overall efficiency. The analytical results of data envelopment analysis (DEA) are thus based on single synthetic ratios that judge the efficiency of companies in providing companies with suggestions for improvement and dealing with measures of company efficiency by means of multiple inputs and multiple outputs. It is for this reason that this study employs DEA as an alternative approach. In recent years, many scholars have used a two-stage production process to measure company performance; however, these two-stage methods have different definitions. This article specifically distinguishes between two-stage analysis and two-stage DEA[2]. This study adopts DEA together with Tobit regression analysis to establish the DEA-T model and divides efficiency into profitability, marketability and overall efficiency. To the knowledge of the authors, there have been no studies that have considered combining these three kinds of efficiency with a DEA-T model to form PDEA-T MDEA-T and ODEA-T models.[3] Linda and Sharmistha (2002), Chen et al. (2005), Akihiro and Shoko (2008) and Kim et al. (2009) evaluate the efficiency of the biotechnological industry in Canada, Taiwan, Japan and the United States. Although these studies provide useful information, they do not examine the profitability, marketability and overall efficiency, and thus a more sophisticated and scientific measure is needed to understand how the efficiency of the biotechnological industry can be measured using PDEA-T, MDEA-T and ODEA-T models. The present study is an attempt to create such a measure.

Corporate governance has been eagerly discussed in recent years. This study will focus on ownership structure, board size and information transparency.[4] First, Sheifer and Vishny (1986) points out that the company's largest shareholder shall be the largest monitor. Some studies point out that the higher percentage of internal ownership refers to stock returns other than investment opportunities[5]. Therefore, the proportion of management ownership is positively correlated with performance, implying that the proportion of shares held by the board members and management is consistent with the convergence of interest and the signaling hypothesis[6]. Second, Zelenyuk and Zheka (2006) and Sueyoshi et al. (2010) point out that foreign institutional ownership can enhance business

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[2] Two-stage analysis refers to data envelopment analysis combined with other analytical methods, such as Wang and Huang (2007) and Mok et al. (2007) using data envelopment analysis and Tobit regression analysis to evaluate efficiency. Two-stage DEA is proposed by Seiford and Zhu (1999) and Luo (2003) Ho and Zhu (2003) and Sten and Joaquina (2004) who separate two different types of production to evaluate individual efficiency.

[3] The PDEA-T, MDEA-T and ODEA-T models are based on the DEA-T model where the emphasis is on the efficiency of profitability, the efficiency of marketability and overall efficiency, respectively.

[4] John and Kedia (2003) indicate that the ownership structure may be divided into internal and external shareholdings. Internal governance mechanisms consider the proportion of shares held by the boards of directors and supervisors and the management. The proportion of shares held by foreign institutional investors constistutes the external governance mechanism.

[5] Mehran (1995), Cho (1998), Ferris et al. (2003), Huang et al. (2007), and Yeh et al. (2010).

[6] Jensen and Meckling (1976) describe the convergence of interest hypothesis. When the proportion of board members and managers who hold shares us higher, the result is consistent with shareholder interests. Board members, managers and shareholders should share in profits or losses. They thus encourage Board members and managers to make decisions that are beneficial to shareholders. The manager's behavior will not deviate from the maximization of corporate value. Leland and Pyle (1977) propose signaling hypothesis based on their argument that the company that increases the proportion of its internal ownership will deliver a positive message to investors that the external value of the company is about to increase.

performance. According to the efficiency monitoring hypothesis of Pound (1988), institutional shareholders hold more equity and have professional expertise so that monitoring costs are lower, implying that the institutional ownership ratio is positively correlated with the efficiency of profitability. However, foreign institutional investors will sell shares in the market when they seek to realize short-term profit targets and will not hold the shares for long-term investment, implying that the institutional ownership ratio is negatively correlated with the efficiency of marketability. Third, Bacon (1973), Zahra and Pearce (1989), Renneboog (2000), Golden and Zajac (2001), and Crutchley et al. (2002) point out that board size and company performance are positively correlated. Finally, Patel and Dalas (2002) show that a high degree of information transparency leads to more stringent corporate governance. The information transparency should ensure immediate and accurate disclosure of all material information relating to companies and is important in corporate governance. Mitton (2002) indicates that the better quality of information disclosure is able to protect the rights of minority shareholders and to improve the company's performance, implying that high information transparency is positively correlated with the efficiency of profitability. However, the risk of investors increases due to information asymmetry when the company's information is less transparent. This higher risk accompanies higher returns, implying that low information transparency is positively correlated with the efficiency of marketability. Gompers et al. (2003) and Brown and Caylor (2009) point out that corporate governance exhibits a positive relationship with business performance. The evaluation of performance combined with corporate governance is seldom discussed in the literature for the biotechnology industry, and thus the purpose of this study is to construct indicators of profitability, marketability and overall efficiency to evaluate the efficiency of biotechnology companies listed in Taiwan, and to compare the influence of corporate governance on the efficiency of the pharmaceutical industry and medical equipment industry. If corporate governance is good, then this is reflected in the efficiency of profitability and marketability, and thus it can supply more useful information on business management to the company decision-makers.

The remainder of this paper is organized as follows. Section 2 describes the econometric model. Section 3 provides the description of the data and the empirical results. Concluding remarks and implications are presented in the final section.

2. Methodology

2.1 Data Envelopment Analysis (DEA)

This research attempts to use a two-stage DEA model proposed by Seiford and Zhu (1999) in combination with a modified CCR model developed by Cooper et al. (2000) to analyze the correlation between the profitability and marketability of 20 biotech-related firms listed on the Taiwan Stock Exchange and in the Over-the-Counter market in Taiwan. The output-oriented (CCR) DEA model is employed to measure efficiency in profitability and marketability (Charnes et al., 1978):

$$Max\ \varphi_0^{\mathrm{t}} + \alpha\left(\sum_{i=1}^{n} s_i^- + \sum_{j=1}^{s} s_j^+\right) \quad \mathrm{t}=1,2 \qquad \text{s.t.} \quad \sum_{k=1}^{m} \gamma_k x_{ik} + s_i^- = x_{io} \quad \mathrm{i}=1,2,...,\mathrm{n};$$

$$\sum_{k=1}^{m} \gamma_k y_{jk} - s_i^+ = \varphi_0^t y_{jo} \quad \mathrm{j}=1,2,...,\mathrm{s}; \qquad \gamma_k, s_i^+, s_i^- \geq 0 \qquad (1)$$

where x_{ik} and y_{jk} are the amount of the i-th input consumed and the amount of the j-th output produced by the k-th DMU, respectively. In Stage 1 (t =1), we have 40 DMUs (n = 20), 4 inputs, namely, employees, machinery and equipment costs (ME cost), research and development costs (RD cost) and total assets (i =4), as well as 2 outputs, namely, operating revenue and net income (j =2). In Stage 2 (t = 2), we have 20 DMUs, 2 inputs, namely, operating revenue and net income, and 2 outputs, namely, earnings per share (EPS) and market value. Let φ_0^{1*} and φ_0^{2*} be the optimal values for the Stage 1 and Stage 2 models, respectively. If φ_0^{1*} and all input/output slacks are zero, then a biotechnology industry company is said to be CCR-efficient in terms of profitability. If φ_0^{2*} and all input/output slacks are zero, then a biotechnology industry company is said to be CCR-efficient in terms of marketability.

2.2 Tobit model

The Tobit model is an econometric, biometric model proposed by Tobin (1958) to describe the relationship between a non-negative dependent variable y_i and an independent variable x_i. The model supposes that there is a latent (i.e., unobservable) variable y_i^*. This variable linearly depends on x_i via a parameter (vector) β which determines the relationship between the independent variable x_i and the latent variable y_i^* (just as in a linear model). In addition, there is a normally distributed error term u_i used to capture random influences on this relationship. The observable variable y_i is defined as being equal to the latent variable whenever the latent variable is above zero and equal to zero otherwise.

$$y_i = \begin{cases} y_i^* & \text{if } y_i^* > 0 \\ 0 & \text{if } y_i^* \le 0 \end{cases} \tag{2}$$

where y_i^*, $y_i^* = \beta x_i + u_i$ $u_i \sim N(0, \sigma^2)$, is a latent variable.

2.3 DEA-T model

We analyze the biotechnology industry companies using the DEA-T model. In the first stage, the inputs and outputs are employees (hereafter, EM), machinery and equipment costs (hereafter, MEC), operating expenses (hereafter, OE), total assets (hereafter, TA), and operating revenue (hereafter, OR) and net income (hereafter, NI). In the second stage, the inputs and outputs are operating revenue, net income and earnings per share (EPS) and market value (hereafter, MV). Furthermore, the third stage uses first stage inputs and second stage outputs to measure overall efficiency. However, each single performance measure based upon these eight factors may lead to unsatisfactory performance characterization. It is obviously difficult to tell which company has a better overall performance without having information on preferences over the one financial characteristic in order to obtain an overall performance index.

We employ DEA as an alternative approach to reconcile these eight measures via a two-stage transformation process described in Figure 1. In the Tobit model we consider the proportion of shares held by the board members, the proportion of shares held by management, the proportion of shares held by foreign institutional investors, as well as the board size and transparency of information. The performance in the first-stage may be viewed as the profitability efficiency which has to do with the company's ability to generate the revenue and profit in terms of its current labor, assets and capital stock. The performance in the second stage may be viewed as the efficiency of marketability. The efficiency of marketability refers to the company's performance in the stock market based on the revenue and profit generated. The traditional DEA methodology is modified and new DEA analytical methods are developed to provide improved performance measures which better reflect the way that businesses really stack up and compete in an information age.

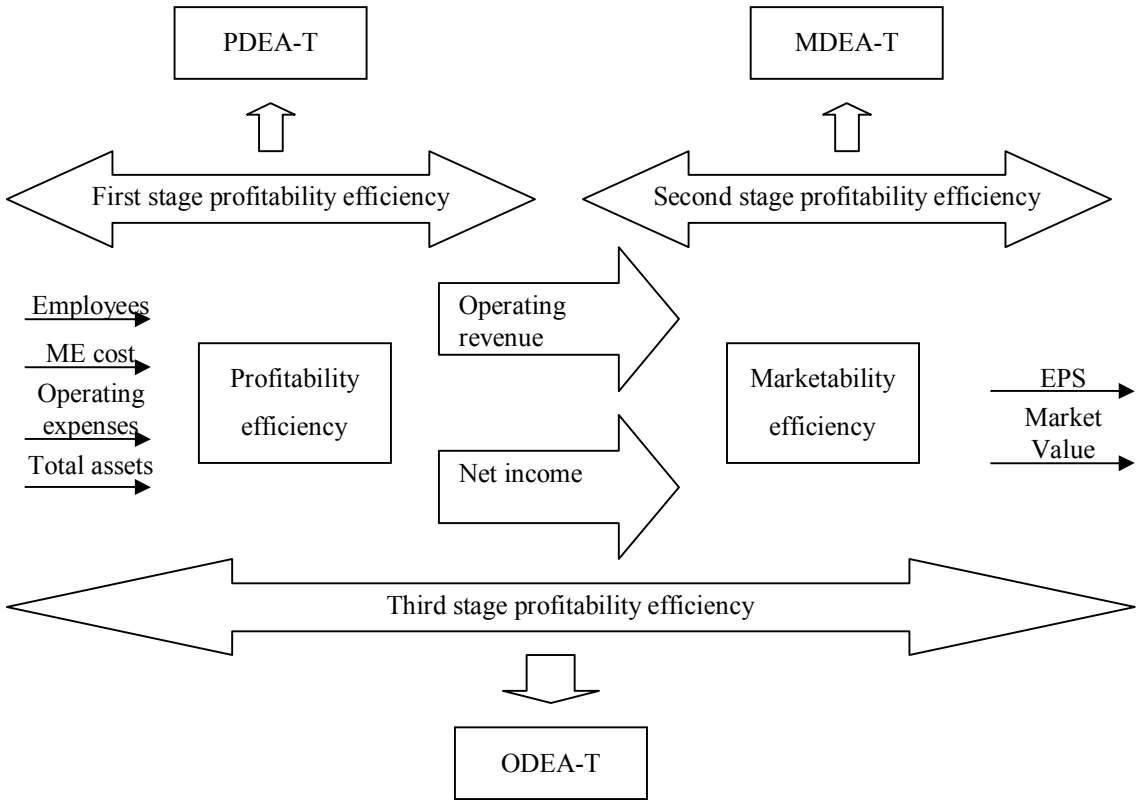
3. Empirical Results

3.1 Data, Summary Statistics and Correlation

This study selects 20 biotech-related firms listed on the Taiwan Stock Exchange and traded in the OTC market in Taiwan from 2005 to 2008. The annual data are obtained from the Taiwan Economic Journal (TEJ) database[7]. Panel A in Table 1 shows the summary statistics for the employees, machinery and equipment costs, operating expenses, total assets, operating revenue, net income, earnings per share and market value. Taiwan's biotechnology industry has very different categories, and hence this study is divided into two categories: the pharmaceutical industry and the medical equipment industry.

[7] The pharmaceutical industry companies selected are Yung Zip Chemical, SCI Pharmtech, Synmosa Biopharma, Standard Chem. & Pharm., Yung Shin Pharmaceutical, China Chemical & Pharmaceutical, Sinphar Pharmaceutical, Chi Sheng Chemical, Orient Europharma, and Chia Jei Technology Business. The medical equipment industry companies include Health & Life, Microlife, Rossmax International, Apex Biotechnology, Pihsiang Machinery Mfg., Johnson Health Tech., Pacific Hospital Supply, St. Shine Optical, Bioteque and United Orthopedic.

Figure 1. DEA-T model



This study examines the DEA model's validity by looking at the correlation between two variables in Panel B in Table 1. The pharmaceutical industry's investment in machinery and equipment is higher than that in the medical equipment industry because the pharmaceutical industry mainly performs experiments in R&D. Thus, the output of the pharmaceutical industry is highly uncertain, and in other words it is not certain that there will be much output when inputs include a large amount of R&D resources. Besides, due to the products in the pharmaceutical industry having a direct relationship with the human body, there are a series of controls and observations enforced by the bureau of public health. Newly-developed medications must go through a series of animal and clinical experiments over a period of two or three years, so that seven years is often needed to commercialize a product. The average output value of the medical equipment industry is higher than that of the pharmaceutical industry, because the pharmaceutical industry needs to be integrated with related industries, such as the photoelectronics, nanometer and electric machinery industries. The medical equipment industry focuses on the export market because of the long period of R&D, high cost, high technological threshold, and complicated technology. The output value is about eighty percent in the medical equipment industry. In both the pharmaceutical industry and medical equipment industry, at both the first stage and second stage the inputs and outputs are significantly positively correlated[8].

[8]The DEA model does not establish the production function in advance but the selected variables must conform to the assumption of isotonicity. When any input increases, it will not cause the outputs to be reduced.

Table 1. Summary Statistics and Correlation

Panel A: Summary Statistics

Industry	**Pharmaceutical Industry**				**Medical Equipment Industry**			
Items	Max	Min	Average	SD	Max	Min	Average	SD
EM	1220	80	524.33	400.36	6984	236	1281	1650
MEC	2200646	24790	512305	538145	1450276	11204	311503	335629
OE	1566811	54463	542302	457226	5415079	72586	727507	1233429
TA	6742238	507715	2651763	2171770	11030320	643004	2543536	2620673
OR	3948758	264184	1682797	1279153	12051444	402357	2421130	3072411
NI	606389	-22224	137970	163946	1718654	-92449	257237	346189
EPS	4.63	-0.48	1.4	1.2	11.16	-2.55	2.82	3.35
MV	8119	413	2280	2104	37069	267	4694	6679

Panel B: Correlation

Items	EM	MEC	OE	TA	OR	NI	EPS	MV
EM	1	0.6745	0.9216	0.8914	0.9563	0.6127	0.3774	0.6984
MEC	0.5969	1	0.8093	0.8574	0.7674	0.4058	0.3721	0.5556
OE	0.8693	0.6758	1	0.9482	0.9781	0.4463	0.2352	0.5875
TA	0.9271	0.7367	0.9095	1	0.9632	0.583	0.3504	0.7311
OR	0.8728	0.5926	0.9606	0.9136	1	0.5958	0.3452	0.7063
NI	0.5847	0.8138	0.7848	0.6986	0.6998	1	0.8151	0.9237
EPS	0.0241	0.2153	0.2431	0.0527	0.2893	0.4935	1	0.6282
MV	0.7748	0.8841	0.8918	0.8927	0.8199	0.8935	0.256	1

Notes 1 EM, MEC, OE, TA, OR, NI, EPS and MV denote employees, machinery and equipment costs, operating expenses, total assets, operating revenue, net income earnings per share and market value.
2 The upper and lower triangular matrices represent the medical equipment industry and pharmaceutical industry in Panel B.

3.2 Technical Efficiency

Panel A in Table 2 shows profitability and marketability efficiency according to the type of company. The company with high profitability efficiency (marketability efficiency) represents the company with higher profits (stock value)[9]. For DMU-PI3, the average profitability efficiency is lower than the average marketability efficiency; however, for DMU-PI9, the average profitability efficiency is higher than the average marketability efficiency, indicating that DMU-PI3 and DMU-PI9 present the opposite situations. Moreover, DMU-MEI2 and DMU-MEI10 also present the opposite situation in the medical equipment industry. The opposite situation attributes a different rank to industry characteristics and the efficiency of marketability is easily affected by the news.

Panel B in Table 2 represents the profitability efficiency and marketability efficiency for each year. The profitability efficiency of the pharmaceutical and medical equipment industry in 2005 has the best performance and then exhibits a decreasing trend year by year; however, the marketability efficiency exhibits steady growth from 2005 to 2007, but in 2008 due to the global financial crisis neither industry is able to have outstanding performance. The average profitability efficiency value of 70.84% (72.52%) that is implied under the established standards of output means that about 29.16% (27.48%) of the contribution of factor inputs does not produce anything in the pharmaceutical

[9] When the efficiency value is equal to 1 it indicates that this is a relatively effective unit. Conversely, if it is less than 1, it represents a relatively ineffective unit. In this study, the value of the CCR model is that it measures the overall situation.

(medical equipment) industry. This study further constructs Figure 2 by means of average PE and ME, which reveals different levels of efficiency by separating the two-stage efficiency of the biotechnology companies. It has more identity and substance than the single-stage DEA approach, which clearly shows the two-stage efficiency and competitive ability.

Table 2. Profitability and Marketability Efficiency

Panel A: Each Company

Pharmaceutical Industry							Medical Equipment Industry						
DMU	PE	R	ME	R	OE	R	DMU	PE	R	ME	R	OE	R
PI1	0.5728	8	0.8448	4	0.5334	10	MEI1	0.9138	2	0.7989	8	0.5631	7
PI2	0.9348	2	0.9401	1	0.7543	4	MEI2	0.8968	3	0.4842	10	0.5155	9
PI3	0.4475	10	0.8642	3	0.6865	7	MEI3	0.6655	9	0.8515	6	0.5664	6
PI4	0.7383	5	0.6576	7	0.7094	5	MEI4	0.9331	1	0.8325	7	0.9124	2
PI5	0.6562	6	0.8345	5	0.8212	3	MEI5	0.833	6	0.8716	5	0.8734	4
PI6	0.5891	7	0.6166	9	0.5699	8	MEI6	0.8377	5	0.6123	9	0.5380	8
PI7	0.5246	9	0.6142	10	0.5405	9	MEI7	0.8209	7	0.9285	4	0.8797	3
PI8	0.7608	4	0.69	6	0.6925	6	MEI8	0.8601	4	0.9486	2	0.9431	1
PI9	1	1	0.629	8	1.0000	1	MEI9	0.7351	8	0.939	3	0.7389	5
PI10	0.8605	3	0.9191	2	0.9230	2	MEI10	0.5932	10	0.9846	1	0.5022	10

Panel B: Each Year

Year	PE	ME	OE	Year	PE	ME	OE
2005	0.7354	0.7867	0.6832	2005	0.817	0.822	0.8390
2006	0.7232	0.7184	0.6504	2006	0.8507	0.8177	0.7848
2007	0.6973	0.7937	0.8344	2007	0.8429	0.8606	0.7622
2008	0.6779	0.7453	0.6634	2008	0.7252	0.8004	0.5090
Average	0.7085	0.761	0.7079	Average	0.7252	0.8004	0.7238

Note: R, PE, ME and OE denote the rank, profitability efficiency, marketability efficiency and overall efficiency.

This paper shows that each DMU has a different expression in profitability and marketability by means of the analytical results. The DMU must take into account both advantages and disadvantages when we select favorable strategies to promote competitive ability. Thus this study selects 20 observations for the pharmaceutical industry and medical equipment industry to analyze the efficiency of profitability and efficiency of marketability. We classify the 20 observations into four categories according to the median of the two-stage efficiency. We provide some suggestions for this in Table 3.

Figure 2. Average efficiency

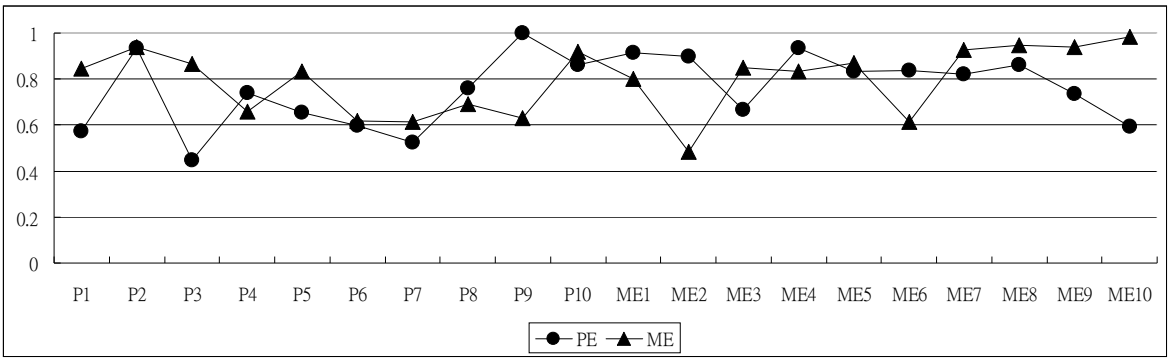


Table 3. Matrix of management decisions			
Items		**Profitability Efficiency**	
		High	**Low**
Marketability Efficiency	High	P2, P10, ME8	P1, P3, P5, ME5, ME7, ME9, ME10
	Low	P4, P8, P9, ME1, ME2, ME4, ME6	P6, P7, ME3

For the first group, that of higher profitability efficiency and marketability efficiency, the three DMUs (P2, P10 and ME8) are leaders in the biotechnology industry with their great profitability and marketability. These companies should adjust their business strategies to maintain their competitive advantage, and continue to input resources into R&D activity. The second group, made up of companies with higher efficiency of profitability and lower efficiency of marketability, consists of seven DMUs (P4, P8, P9, ME1, ME2, ME4 and ME6) which are followers in the biotechnology industry with outstanding management ability and low profitability. They should strengthen their marketing strategies by means of great business management ability to establish strategic alliances and promote marketability. The third group, or those companies with higher marketability efficiency and lower profitability efficiency, include seven DMUs (P1, P3, P5, ME5, ME7, ME9 and ME10), all of which are potential companies in the biotechnology industry with lower profitability and higher marketability. They should enhance their internal business management by means of education of training, and take advantage of studies by directors as well as invite consultants to promote the business management ability of the companies. The final group, those with lower marketability efficiency and profitability efficiency, consist of a further three DMUs (P6, P7 and ME3) that are companies in biotechnology industry with lower marketability and profitability that is lagging behind. They should strengthen their R&D and business strategies by integrating resources, strategic alliances and M&A activity to enhance their ability to compete in the market.

3.3 Tobit Regression

Table 4 lists the proxies for corporate governance that are correlated with operational efficiency and profitability effectiveness[10]. This study divides the impact of ownership structure on efficiency into three parts which are PSHB, PSHM and PSHF. First, the empirical results show that PSHB is not significantly correlated with overall efficiency. Because the overall efficiency does not distinguish the impact of corporate governance on business performance, we further analyze the overall efficiency to discriminate between profitability and marketability efficiency. The PSHB is significantly positively correlated with profitability and marketability (profitability) efficiency in the pharmaceutical (medical equipment) industry.[11] However, PSHB is significantly negatively correlated with marketability efficiency in the medical equipment industry, implying that board members will protect their ownership interests and reject measures that benefit the company's investment plans.[12] Second, PSHM is significantly positively correlated with overall efficiency and profitability efficiency in the pharmaceutical industry. We find that the impact of PSHM on the overall efficiency is derived mainly from the efficiency of profitability. Third, PSHF is not significantly correlated with overall efficiency. PSHF is significantly negatively correlated with the efficiency of marketability in the pharmaceutical industry, implying the existence of short-term profit goals on the part of the foreign institutional investors to sell their holdings in the pharmaceutical industry. The PSHF is significantly positively correlated with the profitability of efficiency in the medical equipment industry, indicating satisfaction

[10] This study selects efficiency value as the dependent variable and selects the proportion of shares held by the management, the proportion of shares held by the board members, the number of board members, the proportion of shares held by foreign institutional investors and the ratio of liabilities as the independent variable using Tobit regression. The ratio of liabilities is the control variable.

[11] The positive correlation result supports the convergence-of-interest hypothesis of Jensen and Meckling (1976).

[12] Demsetz (1983) and Jensen and Ruback (1983) also point out that the entrenchment hypothesis explains this situation.

with Pound's (1988) efficiency monitoring hypothesis.[13] Consequently, we find that the ownership structure of corporate governance has an important impact on efficiency.

The board size is significantly positively correlated with with overall efficiency, profitability efficiency and marketability (marketability) efficiency in the pharmaceutical (medical equipment) industry. The finding that board size and company performance are positively correlated is consistent with Bacon (1973), Zahra and Pearce (1989), Renneboog (2000), Golden and Zajac (2001), and Crutchley et al. (2002).

The high transparency of information (TIG) is significantly positively correlated with the efficiency of profitability in the pharmaceutical industry. The low transparency of information is significantly positively correlated with the efficiency of marketability in the pharmaceutical and medical equipment industry. The stock is highly risky when there is poor information disclosure by the companies, implying that a dollar of profit earned by a company will be reflected in the stock market as being more or less than one dollar. Investors cannot understand the real value of their companies, and thus only bad information transparency has a significant impact on market efficiency.

Table 4. DEA-T Model

Industry	**Pharmaceutical Industry**			**Medical Equipment Industry**		
Model	PDEA-T	MDEA-T	ODEA-T	PDEA-T	MDEA-T	ODEA-T
Constant	-3.8751**	-0.6424	-7.3121***	9.9580***	2.2653	14.2649***
PSHB	0.0218**	0.0183***	-0.0398	0.0131***	-0.0091**	0.0033
PSHM	0.0169**	-0.0087	0.0279**	-0.0138	-0.0018	0.0125
PSHF	-0.0329	-0.0369**	0.019	0.0044*	-0.0027	-0.046
BZ	0.1193***	0.0601**	0.1234***	-0.03	0.0528**	0.034
TIG	0.1741**	0.006	0.1223	-0.0395	0.0952	0.046
TIB	-0.0995	0.3528***	0.1218	0.0404	0.1075**	0.1633
LC	0.0651	0.1785	-0.132	0.2339**	0.1153	0.4808*
RL	-0.0039*	-0.0069***	-0.0046	-0.0085***	0.0002	-0.0187***
CA	0.1675**	0.0399	0.3342***	-0.4453***	-0.0757	-0.6629***

Notes 1. PSHB, PSHM, PSHF, BZ, , RL and CA denote the proportions of shares held by the board members, the proportions of shares held by the management, the proportion of shares held by foreign institutional investors, the board size, the ratio of liabilities, and paid-up capital.
2. LC is a dummy indicating that the company is a listed company if 1, and 0 otherwise. TIG (TIB) is a dummy indicating high (low) transparency of information if 1; and 0 otherwise.

4. Conclusions

Earlier research has usually selected financial and accounting ratios to analyze the business performance of companies, but using each ratio based only upon single factors may lead to unsatisfactory results, so that insufficient information regarding the overall efficiency is supplied. This study adopts DEA with a Tobit regression to establish the DEA-T model and to investigate the influence of corporate governance on the overall efficiency, profitability efficiency and marketability efficiency of biotechnology companies in Taiwan. This paper further classifies 20 companies into four categories according to profitability and marketability. We believe that the results of this study can provide investors and business managers with abundant information.

The four major findings of this paper are as follows. First, this study finds that the efficiency of profitability or marketability in the pharmaceutical industry is worse than that in the medical equipment industry. This paper reveals a different kind of efficiency by separating the two-stage efficiency of biotechnology companies, indicating that there is more identity and substance than in single-stage DEA. Second, we find that the ownership structure of corporate governance has an

[13] Pound (1988) proposed the efficiency monitoring hypothesis which explains the relationship between corporate performance and institutional shareholders. Institutional shareholders hold more equity and have professional expertise so that monitoring costs are lower.

important impact on the third-stage of efficiency. Third, this study shows that the impact of corporate governance on overall efficiency is derived mainly from the profitability or marketability efficiency of three DEA-T models. Finally, the proposed analytical DEA-T model is not only suited to the biotechnology industry but can also be used in other industries.

Corporate governance is again an area of interest. Better corporate governance can reduce the agency and information asymmetry between management and investment. The investment target for investors is such that better corporate governance of companies would be preferred. The findings of this study emphasize the importance of the impact of corporate governance on efficiency in the biotechnology industry, with the evidence being highlighted by many investors, politicians and even practitioners.

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