

Measuring Performance Using Data Envelopment Analysis and Balanced Scorecard for Taiwan Medical Equipment Industry

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Abstract

Nowadays, the rapid changes of industrial environment led to fierce competition among enterprises, evaluating performances have become crucial in maintaining competitive advantage. Researchers have developed different ways of evaluating performance over the past, but there are some errors in which using single method in analyzing performances will occur. Therefore, in this research we adopt application of innovative methods that will combine Data Envelopment Analysis (DEA) and the Balanced Scorecard (BSC) to complement the shortcomings arising under a single method. The study is provided with performance of scientific assessment methods and we hope to find out the effective way to solve company operating problems.

The government introduced six new rising industries in the past few years, giving them development subsidies and the budget spent on subsidy are increasing over the years. With population rapidly aging and people healthcare concept gradually mellow, the biotechnology becomes future star industry. In this study we choose the 26 medical equipment listed companies to be our research sample, using Balanced Scorecard (BSC) and Data Envelopment Analysis (DEA) to find the key successful factor (KSF) of the industry. Through this study, we can know Taiwan medical equipment industry operating status and we will give some suggestion to increase whole industry performance. This study intends to use DEA performance assessment tools and based on four BSC perspectives to analyze the data under the medical equipment industry in Taiwan, in the result of paper we know that over 64% medical equipment companies, they operation is relative efficient, it means the whole industry is in keep growth up status. The study also provides much better contribution that we strengthen the DEA application to judge inefficient resource.

Key Words: Balanced Scorecard (BSC), Data Envelopment Analysis (DEA), Performance Evaluation, Key Successful Factor (KSF)

1. Introduction

Background and Motivation

According to Ministry of Economic Affairs (2009), they classify Biotechnology industry into three categories, including three major areas respectively (1) pharmaceutical industry (2) medical equipment industry and (3) emerging biotech industry. In 2011 years, Taiwan biotechnology industry total sales revenue achieved NTD 2403 billion and medical equipment industry individual occupy NTD 993 billion then we can know that the medical equipment industry plays a very important role in biotechnology industry. Taiwan Institute of Industrial Economics Database (2012) show that global economy was suffered from European debt crisis, economy of America recovery slowly, but the medical equipment industry was suffered very small effected. The Ministry of Economic Affairs data (2012) show that the medical equipment industry is keep 13.18% growth rate and output value was NTD 109.77 billion in 2012 Q2. The whole medical equipment industry is still in growing stage.

Although the Economy and Trends in Industrial Research Center (2011) estimates that medical equipment industry will have stable growing rate, however, due to market saturation, the growth rate slowed down and foreign manufacturer enter Taiwan market make the industry more competitive. According to Espicom (2012) implicate that our market scope rank is 25 in the world, because we are in aging society and people health care knowledge maturity that make people increasing purchase relative products. Kaplan and Norton (1996), the inventors of the Balanced Scorecard, proposed that “measurement per se had created the focus”. When what is to be measured is determined, the determinants identify the actual indicators. This the reason why to select inputs or outputs for the DEA is the subject of never ending debate. Our research is dedicate to analysis the listed company operating performance in medical equipment industry, through the Balance Scorecard (BSC) four dimensions and Data Envelopment Analysis(DEA), Finally we can understand our medical equipment industry global competitiveness. In this study we wish to establish the standard model which can assess manufacturer efficiency and through this method enhance their competitive capability.

In the recent years, We have some common measuring performance method respectively, BSC (Peng *et al.*, 2006; Wang *et al.*,2006; Li *et al.*,2008; Xue *et al.*,2008; Yeh *et al.*,2009) and Data Envelopment Analysis (Hsieng *et al.*,2007; Chen *et al.*,2008; Hong *et al.*,2009; Lu *et al.*,2010); However, these two methods independence application have their own shortage. Data Envelopment Analysis is for the quantitative assessment method, and the Balanced Score Card focuses on the analysis of qualitative indicators. Therefore, Richard (2006) suggest that if we can base on BSC four dimensions indicator to measure performance with DEA, then we can solve the problem of using independent method contradiction.

2. Literature Review

2.1 Medical Equipment Industry Development Status

Medical equipment industry is people's livelihood necessary industry which is

integrate the technology across biomedical technology, materials, machinery and electronics. With the economic development and the improvement of living standards, we face the aging society and chronic population increasing, it makes health care equipment product necessary increase and Medical equipment industry has shown a trend of high growth. Furthermore Medical industry symbolizes the country's level of economic prosperity, and health and quality of life of all citizens' attainment.

Based on Industrial Economics & Knowledge Center (2012) data implicate that we have more 700 relative companies in our medical equipment industry. The main scope is small and medium enterprise and employee under 300 people. Manufacturer are OEM/ODM based, the main operation is production. Compare with 2011, our sales revenue achieved NTD 760 billion, the growth rate is 11.5%. The main reason is Europe and America market economic growth slowed and our product price is more elasticity further emerging market demand for medical equipment product is emerge. In addition to our manufacture provide location based product, we also innovate our marketing and place strategy to occupy emerging market. Therefore, we enhance whole production value.

Taiwan medical equipment industry structure is unlike to global medical equipment industry structure. Compare with global medical equipment industry structure, they provide hospital product and our main product is home health care product like sphygmomanometer, thermometer, and scooters. Our manufacturer technical production is mature and we also help foreign manufacture produce. Now our medical equipment manufacture is in the leader position in the global market.

According to Frost & Sullivan survey (2012), they classify medical equipment industry into medical devices industry, medical imaging industry and patient monitoring industry, combine cardiovascular surgery, orthopedics, respiratory surgery, ophthalmology, neurology, urology which product they provide in equipment and disposable equipment used in various subject. IEK (2012) indicated that we have more than 700 companies total employee number are 34,200 and we based on financial report we can know the average profit rate is 34% ; research development expensive take 3.3% on sales revenue .Compare with 2011, the medical equipment industry sales revenue is NTD 760 billion and the growth rate is 11.4%. Blood glucose monitoring products and contact lenses products have become Taiwan's top two export items and it also become the medical equipment industry growth energy.

IEK also forecast 2013 total revenue of Taiwan's medical equipment industry will reach NTD 814 billion, according to this growth rate, estimated in 2015 will reach NTD 927 billion.

(NTD billion)

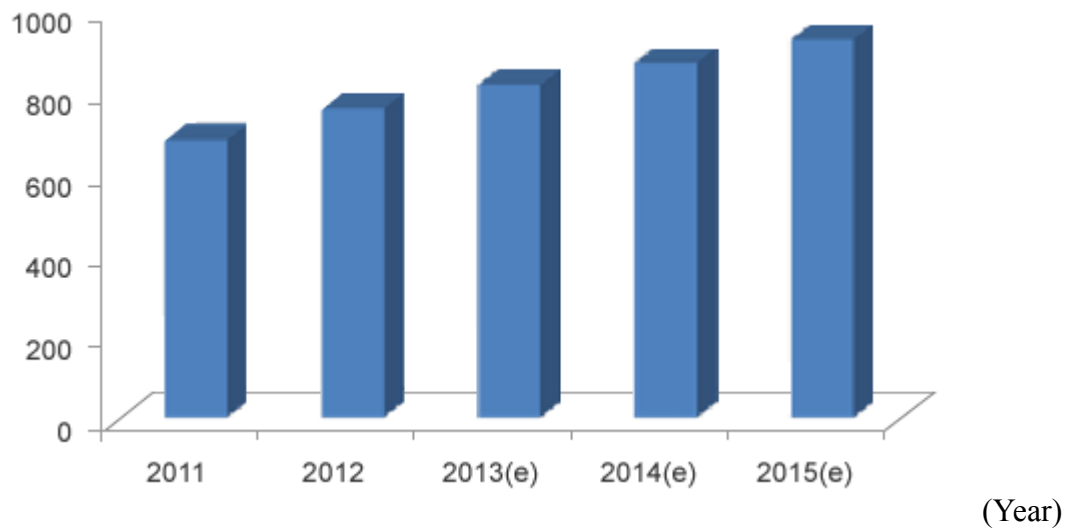
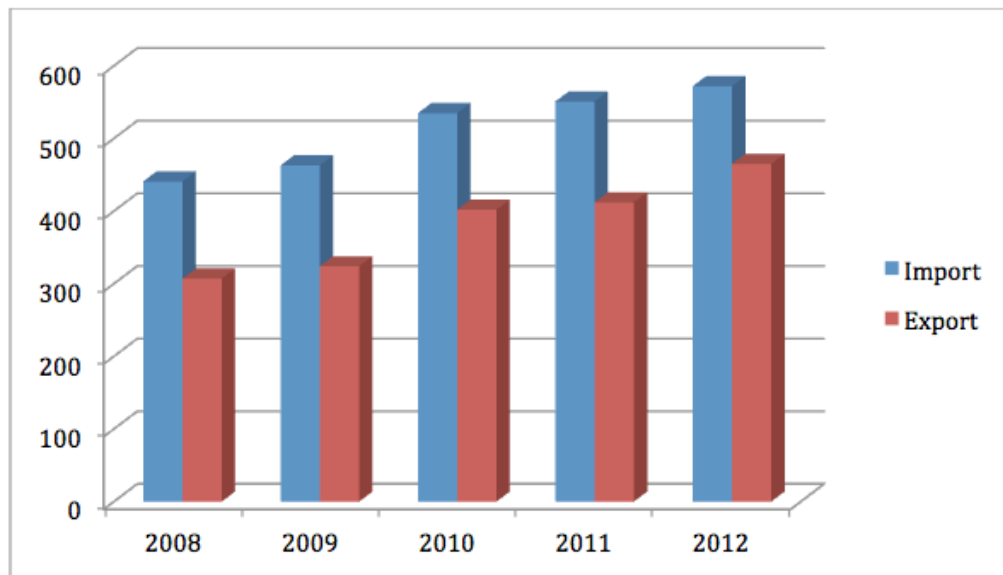


Figure 2.1 Taiwan medical equipment industry forecast sales from 2011 to 2015
Source: IEK (2013)

Even if our market scope is not bigger than America, but Taiwan population structure is orient to aging society besides domestic market demand increasing and people health care knowledge is maturity take the medical equipment product consume growth up. The data based on Republic of China customs database. The figure 2.1 show that Taiwan medical equipment industry imports is NTD 572 billion and export is NTD 465 billion, while imports amounted to grow up 3.6% in 2011 and export value growth of 12.9% compared to 2011. Therefore Taiwan medical equipment industry is in growing status and the industry is provided with very strong export competitive strength. Taiwan's dependence on imported medical supplies products to maintain roughly about 4:6, the main structure of the domestic manufacturers as well as hospitals which need high-end medical products with medical supplies and related products mainly rely on imports to provide.

(NTD billion)



(Year)

Figure2.2 Republic of China Customs import and export statistics

2.2 Performance Evaluation

Peter Drucker (1990) is the first researcher who proposed performance evaluation and consider that performance evaluation is used to measure organization and employee performance. Performance evaluation is applying scientific method and establishing standards procedures to evaluate performance. The performance definition, means efficient use of resources to provide cost-effective services or products and it combine efficiency, effectiveness and satisfaction. We can defined Performance as broad that is activity (or a group) results (Spronk and Vermeulen, 2003). Efficiency emphasis on economic efficiency, response efficiency and production efficiency; Effectiveness focus on the output quality; Satisfaction refers to employee working feeling and emotional respond. In brief to said, efficiency is do the things right; effectiveness is do the right things right .However, Ho and Zhu (2004) apply the return on assets (ROA) concept to define performance as company operation efficiency multiply company operation effectiveness, furthermore develop data envelopment analysis (DEA) model to measure Taiwan Commercial Bank performance. We have a lot of performance evaluation method like following : (1)Multiple Statistic Analysis(Huang, 1986; Chen, 1991; Fielding *et al.*, 1985); (2) DEA(Chen & Yeh, 1998; Feroz *et al.*, 2003; Ho & Tan, 2004; Seiford & Zhu, 1999; Zhu, Ho & Lin, 2005; Wang *et al.*, 2010); (3) Analysis Hierarchy Process (Ho & Tan, 2004; Ho & Oh, 2010); (4) Fuzzy Set Theory (Ho & Tan, 2004); (5) Grey Relation Analysis(Feng & Wang, 2000; Ho, 2006; Wang, Ho, Feng & Yang, 2006); Balanced Scorecard (Kaplan, 1998; Maisel, 1992, Norreklit, 2000); Financial Statement Analysis(Feroz *et al.*, 2003, Pantalone & Platt, 1987; Espahbodi, 1991). Using performance measure way mostly is various types of inputs and a single output, or need a default type of a function, or need through a subjective judgment. However, Data envelopment analysis method used

without pre-production function, and mathematical programming models to measure by the relative efficiency of the assessment unit correspond objective mental, DEA can also provide advice and direction to improve the management. But using single method still have their own shortage, DEA focus on fiancé aspect neglect others aspect Therefore, this study we combine DEA and BSC four aspect to assess operation performance.

3. Research Methodology

3.1 DEA and BSC approach

In this study we apply the Balance Scorecard (BSC) concept and through Data Envelopment Analysis (DEA) to measure medical equipment industry performance. Our research adopts the four major aspects of the balanced scorecard, including the financial, customer, internal process, learning and innovation aspects. In each process, we used the DEA software to discover the relative efficiency scores and results of each decision making unit (DMUs) then calculated total efficiency. In data collection we will use the Market Observation Post System (MOPS), and through their provide data to explore 26 medical equipment list companies.

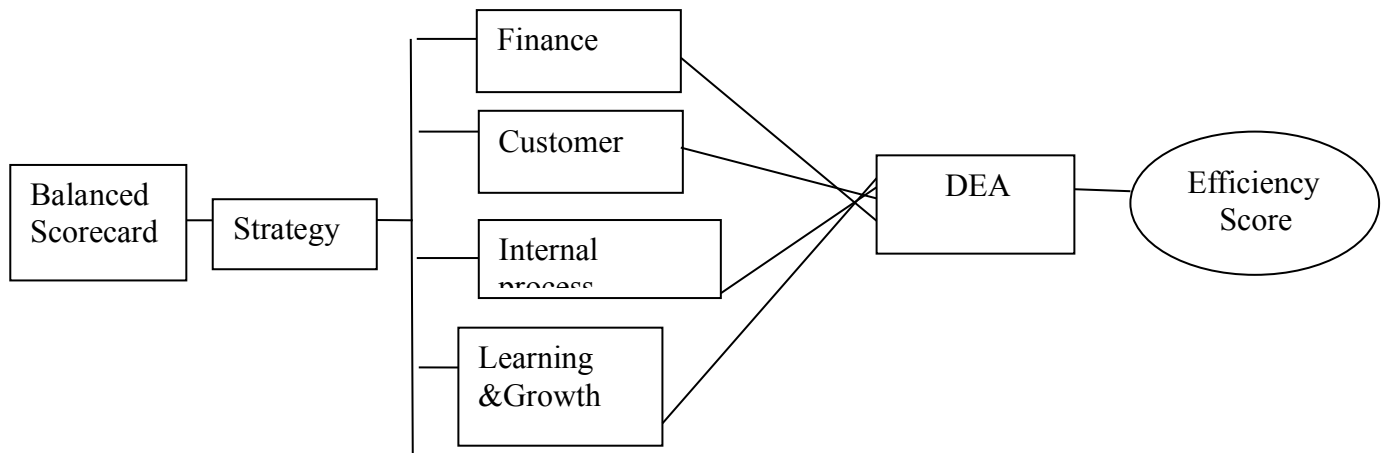


Figure 3.1 Research framework

3.2 Input Item and Output Item Selection

When we select input item and output item we should reference expert suggests, relative research paper discuss or using factor analysis method. In this study we apply indicator is based on Niven (1999), Chan (2004), Hsu (2005), Tan (2006), Wang (2006), Chen (2006), Chen *et al.*, (2010) ; Although medical equipment industry is capital intensive so they need to focus on medical equipment development and innovation so that we put research development expense to be our input indicator.

Financial Perspective

Kaplan & Norton (1996) indicated that if we using financial perspective, we can assess the implementation of a company's strategy and profit make better, which relate to the ability to reap profits, operational revenues, capital returns, profit growth, and cash flow. Different financial objectives depend on different lifecycle phases. They classify three different and three kinds of phase.

In the growth phase, Firms require minimum expenditures, due process, and employee abilities to develop new markets, new customers, and new products; during the maintaining phase they emphasize traditional financial measures; and companies are absorbed on cash flow and capital returns during the harvest phase. Our study select operation revenue and total assets financial indicator to measure our performance.

1. Operation Revenue: By inspecting a company's operating, or "regular," revenue an investor can often gain meaningful insights into the health of a business, especially because waning companies often sell underperforming stores and/or assets, making the income statement look more attractive than it might otherwise be. Operating revenue is not the same as operating profit, operating revenue is more commonly used general in financial statement analysis.(source : <http://www.investopedia.com/>)

In this study through operating revenue we can know the medical equipment

earnings and the data collection base on each company financial report.

2. Total Assets: In Financial accounting an asset is an economic resource. Anything tangible or intangible that is capable of being owned or controlled to produce value and that is held to have positive economic value is considered an asset. Measuring the asset we can know the medical equipment operating result and the data collection base on each company financial report.

Customer Perspective

Kaplan & Norton (1996) identifies target customers and segments markets to build relationships with customers, which reflect the execution of strategic business units (SBUs). The outcome indicators include increasing customer satisfaction, customer retention, the customer base, profit rates, and market shares. Our study is choosing marketing expense and employee to measure the performance.

1. Marketing Expensive: Marketing expenses are calculated in the equation to determine business profit. When calculating business profit, marketing expense is subtracted from business profit. The profit on a particular business is always a function of the amount of units the business sells, times the margin made on each unit, less the marketing expense involved, less the direct overhead. Marketing expenses include things such as advertising, promotions and public relations efforts. (source: Ivy Liu, Demand Media. <http://smallbusiness.chron.com/>)
Tong (1997) and Chen (2010) *et.al* also propose that marketing expense will enhance the company image. Therefore company using marketing expensive to struggle the customer order become the part of competitive strategy.
2. Employee Number : Company from develop new product after selling, all of process need employee that can achieve. Therefore, this study must put employee to be our indicator.
3. Market Share: The percentage of an industry or market's total sales that is earned by a particular company over a specified time period. Market share is calculated by taking the company's sales over the period and dividing it by the total sales of the industry over the same period. This metric is used to give a general idea of the size of a company to its market and its competitors. Kaplan and Norton (1996) and Hsu (2005) also used market share to be BSC Indicator
(source: [http : //www.investopedia.com](http://www.investopedia.com))

Internal Process Perspective

Kaplan and Norton (1996) and Niven (1999) consider that different between traditional performance method is Balance scored card providing with innovation process, Thus company need to continue to innovate their product to increase their revenue ,so we choose research development expense to be this aspect indicator. Research development expense: R&D expense (short for research and development expense) is essentially the amount of money that a company spends to develop new

products and services each year.

Learning and Growth Perspective

According to Kaplan & Norton (1996) and Niven (1999) also discussed a learning and growth perspective, Company need to define their core competence , technologies, employee skill and innovating information technology, then company through learning to make routine operations more efficient. We can base on employee productivity to know the company if have better performance in Learning and Growth. Employee productivity is a performance measure method, the purpose is to find out employees and manufacturing production relative and investigate the resource whether using good or worse.

Table 3.3 Input and output select

	Measure Indicator
Input item	Total Assets 、Marketing Expense 、Employee number 、Research Development Expense
Output item	Operating Revenue Market Share Employee Productivity

4. Empirical Results

The Performance of Taiwan Medical Equipment Companies

In chapter four we apply the DEA Frontier software to discover the DMUs score, our research is based on BCC output oriented .The results provide the efficiency scores for all companies, based on each company's combination of inputs and outputs, compared to those of the others in the sample. Efficient DMUs all receive scores equal to one in the DEA analysis (Thomas, Barr, Cron, and Slocum, Jr. 1998) .As we can see the table4.2 that 17 companies(Health &Life, Microlife, Rossmax International, Radiant Innovation, Actherm, Apex Medical, Avita, Dr.Chip Biotechnology, Polylite Taiwan, Diva Laboratories, Genesis Genetics Asia, Info-Tek, EBM Technologies, Fuburg Industrial, Sunmax Biotechnology) get the 100% score take over 68% in the relatively to other companies is efficient ;. Bioptik Technology, Taidoc, Pihsiang Machinery, Pacific Hospital Supply, Medigen Biotechnology, Mldex Optical, United Orthopedic, Bioteque and Bionet are in the distinctly inefficient unit. In 4.2 chapter we will discuss each inefficient company and give the suggestion to them. According to Michael Norman and Barry Stocker (1991) proposed that efficiency analysis can main classify into four categories as follow: Robustly efficient unit, Marginally efficient unit, Marginally inefficient unit and Distinctly inefficient unit.

4.2 The Result of Difference Variance

According to DEA balance variance result we can know that relative inefficient company's potential improvement whether or not companies need to put more resource or reduce the resource and based on BSC four dimensions. For example Taidoc company needs to reduce 06.16% Assets and reduce 44.57% R&D Expense that can make resource efficient and Taidoc company also need to add Sales Revenue 3.64%, Market Share 3.64%, Employee Productivity 52.22% that can make the company operation relative more efficient.

Table 4.3 The Result of Difference Variance

	Assets	Marketing Expense	Employee Number	R&D Expense	Sales Revenue	Market Share	Employee Productivity
Bioptik Technology	0%	0%	-21.14%	0%	00.74%	00.74%	18.88%
Taidoc	-6.16%	0%	0%	-44.57%	3.64%	3.64%	52.22%
Pihsiang Machinery	-71.55%	0%	0%	-07.76%	14.24%	15.48%	34.57%
Pacific Hospital Supply	0%	-30.15%	0%	0%	21.44%	21.44%	104.76%
Medigen Biotechnology	-83.52%	-23.88%	0%	-89.49%	66.61%	54.61%	23.69%
Mldex Optical	-05.04%	0%	0%	0%	67.30%	67.30%	150.35%
United Orthopedic	0%	-38.72%	0%	-58.61%	86.38%	86.38%	200.88%
Bioteque	-13.72%	-58.2%	0%	0%	100.01%	103.30%	257.21%
Bionet	-28.84%	-79.63%	0%	0%	104.83%	108.41%	141.20%

4.3 Inefficient DMUS Suggestion

In 4.2 we know that inefficient DMUs potential improvement and in 4.3 we through BSC four aspect and give each suggestion to inefficient DMUs. Bioptik Technology (99.26%), we based on customer aspect, they put too much resource into employee number make resource waste so the solution we suggest to Bioptik Technology is reduce the employee number can make operation more efficiency; Taidoc (96.49%), we based on Internal Process aspect, Taidoc put too much research development expense but didn't get very good return, in Fiancé aspect, the assets need to be reduced that can make performance better ether; Pihsiang Machinery (87.54%), we based on Fiancé aspect, they need to reduce 70% assets to make operation performance more efficiency, in output aspect and we can know that there operation revenue market share, employee productivity didn't achieve the goal; Pacific Hospital Supply (82.34%), we based on customer aspect, the company put too much marketing expense to promote products, the budget need to reduce 30% that can let resource using more efficiency; in output aspect, the operation revenue market share, employee productivity didn't achieve the goal; Medigen Biotechnology (80.85%), we based on input factor aspect: We know that Medigen Biotechnology put too much asset, marketing expensive and R&D expensive to run business but the performance is bad; Mldex Optical (59.77%), we based on Fiancé aspect, the resource of assets is the main reason that make company operation inefficiency; United Orthopedic (53.65%), we based on customer aspect, United Orthopedic emphasize the marketing they put a lot of resource but they need to reduce 38.72% budget of marketing that can make operation efficiency, in internal process aspect, United Orthopedic emphasize the

R&D they put a lot of resource but they need to reduce 58.62% budget of R&D expense that can make operation efficiency; Bioteque (50%) and Bionet (48.2%), These two companies face the same problem the resource of assets and marketing doesn't appropriate using that make operation inefficiency.

5. Conclusion

5.1 Finding and Implication

Taiwan medical equipment industry is government emphasis investment industry and called future star industry. In this study we learn from different aspect (customer, internal process, learning growth) to analysis the industry performance ,we apply BSC four aspect to choose the input indicator then using DEA to get the research result, Finally we find out over 64% medical equipment companies, they operation is relative efficient. It means the whole industry is in keep growth up status, especially the main business is Diagnostic Monitoring or Surgery belong with this secondary industry the performance is very good. Also we can based on our study provide the score to give each DMU there operation problem through finance, customer, internal process, learning and growth four aspect. From our research result we can learn from benchmark companies who get 100% score For example, Microlife Corp and Rossmax International Ltd .they put a lot of budget to do marketing and there companies development strategy is integrate the place and service then get very good return. Other inefficient companies we have already to give suggest and comment in chapter 4.

The medical equipment companies face external companies enter, the opportunity to Taiwan medical equipment companies is develop the innovation product, so in this study we can see each DMU input a lot of research development expensive to create new product make competitive advantage.

5.2 Limitations and Future Study

There are several limitations considering this research design. First, the research target we focus on 26 medical equipment listed companies but there are 700 small and medium-size enterprises in this industry. Therefore in the future study we may through issues survey to get more data then the research can be more representative. Second, our research is using classical DEA model so it can't reveal good leadership from firms and if the efficiency result is all equal to 100% we can't discriminate. Therefore, Anderson and Petersen (1993) have been already proposed super DEA to solve the problems. Third, medical equipment industry plays an important role and has huge influence in sustainable economic development ,the product they provide also consider health care but our research can't not provide the social responsibility and product using satisfaction . However BSC through it looks at social responsibility and product using satisfaction, is rather weak in this area .Therefore we need to extend the BSC learning and growth aspect through add social responsibility factor to evaluate performance and customer aspect add product using satisfaction ether, the way we can issue survey to company.

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