Vol. 7 No.2 (2010) p49-56 Journal of Management Science & Statistical Decision

Using Data Envelopment Analysis to Measurement Patent Performance of Medical Instruments Industry

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Abstract: This study analyzes 6,626 patents related to the medical instruments industry, and develops a subsequent patent analysis and performance assessment by means of DEA analysis. From the upper or lower ranking and comparing by DEA models this study found that the mix analysis could provide the results deeply with patents performance of DMUs in medical industries and worth to debate that would be difficult to see in traditional patent analysis. Finally, important elements that influence the performance of DMUs can also be found after sensitivity analysis. This study shows that less input may promote efficient performance while output is equal, but for traditional patent that would be different status with citation rate and R&D capacity. For medical industries' top companies, they would be more considerate the different character of each correlative variable which have impact for three above input at least for comparison with the others by average efficient score.

Keywords: Patent Analysis, DEA models, Medical Industries

1. Introduction

In the past, patent research in the biomedical industries focused mostly on medicine, bio-technology, the regulations of authorisation, medical care and flexibility of medication prices (Messerlin, 2005, Opderbeck, 2005; Tellekson et al., 2005), while medical instrument research and the related exploration of patent performance assessment were relatively ignored. Moreover, with new technologies the development of medical instruments has increased at a rapid pace, and thus this is an area that deserves much greater attention.

Many researchers have recognised the positive influence of patent development on company profits (Cockburn and Griliches, 1988; Ernst, 2003; Megna and Klock, 1993). Even then, these studies mainly focus on high-tech industries (Abraham and Moitra, 2001; Hung and Yang, 2003; Levitas et al., 2006), such as nano-technology, semiconductors, bio-chemistry (Blackman, 2004; Wartburg and Teichert, 2008), and biotechnology industry (Katila, 2000) or sectors such as the motor industry (Barrett, 2005). Although, some researches showed the good performance assessment on other industries, such as high-tech industries, bank, hotel, even university (Barth and Staat, 2005; Chen et. al, 2005; Chen and Yen, 2005; Sigala and Mylonakis, 2005; Agasisti and Bianco, 2006), but not consider patents factors To date, the medical instrument industry and its related patents performance have been relatively neglected. For this reason, Wu and

Cheng suggested that the medical instrument companies should set up a technological interaction platform to promote the performance of this industry and to keep updating each other with the latest information to enhance their competitive capacities.

Because of the variety of medical instrument patents and the common clinical application of these patents, this study aims to find and assess the performance of the most influential impact factors through the analysis of past patent research. This study utilises the database of the United States Patent and Trademark Office (USPTO) – an internationally recognised source for patents – to collect data for the analysis. This study starts with the use of the keywords in the USPTO patent database index which start with the letter 'M' (USPTO, 2006); then, the search modifies the keyword search, which results in five key areas for the patent analysis that will be used as the input and output factors of the DEA models. Based on the USPTO database (USPTO, 2006), the key words are Medical Equipment, Surgical Equipment, Medical Administration, Health Administration and Medicated Devices. The data consists of 6,626 patents.

Although the latest medical instrument techniques are frequently published in medical journals, some techniques are not published for commercial reasons, and thus this study also uses patent analysis to classify the collected data to make it more complete. The data collected cover from 1971/01/01 to 2008/05/30.

The major purposes of this paper are:

(1) Undertaking a comprehensive patent analysis of technologies for the global medical industry, and providing more information on the status and influences of future patent developments.

(2) Collecting and arranging the specific factors of important patents for medical industries to process the correlative performance of patents analysis and to provide the references directions of R&D and patents application for relative industries in the future.

(3) Assessing the efficiency of patent technology for in the medical industry and finding the key factors that affect the patent development.

2. Literature Review

2.1 Patent Definition

The WIPO defines a patent as "an exclusive right granted for an invention, which is a product or a process that provides, in general, a new way of doing something, or offers a new technical solution to a problem." Ernst (1995) noted that invention is good for the productivity and competitive capacity of a company or a country. From an economic viewpoint, innovation or invention helps to raise productivity, lower cost, improve competitive capacity and profit, so that more resources can be invested in pursuing innovation and invention, which thereby creates a positive loop (Hsu et al., 2006). However, patenting strategies should be centered around developing comprehensive patent combinations, which means holding closely-related patents of certain key technologies rather than simply aiming to build a large amount of unrelated patents (Sternitzke et al., 2007).

2.2 The Trends of Patent Analysis

As proposed by Vermeulen (2003), patenting strategies can be investigated in terms of four aspects: marketing profit, profit source, bargain power and industrial control. Stern et al. (2000) point out that patent analysis can be used to evaluate the importance of innovation, and it can also be used to show differences in quality and value on the basis of the features of patent rights (Narin et al., 1987; 1993).

Ernst et al. (2000) notes how patents influence the gross profit of a company and can thus determine the organization of the firm's R&D section. Moreover, according to the report by Cohen et al. (2002), patents have a spillover effect on R&D activities in a company. Ernst (2003) employs patent activities, technology share and share of patents granted to monitor rivals, the management of human resources and R&D in an enterprise. Karki and Krishnan (1997) adopt patent citations to survey the latest technology, competitive technology and the links between technologies. As a result, patent information could provide useful references for the decision-makers in medical companies in every phase of running the business and need to assess the performance of patent development in medical industries.

3. Methodology

3.1 Patent Analysis and Performance Assessment

With regard to data collection, this study searches the patent information for the period from January 1, 1971 to May 30, 2008, contained in the USPTO patent databases via five key words: Medical Equipment, Surgical Equipment, Medical Administration, Health Administration and Medicated Devices.

3.2 Data

This study uses the PatentGuider 2.0 software tool, which provides strong and convenient analysis with regard to the USPTO patent database. For instance, it compares patent data collected from databases in the USA, Japan, Europe, China and Taiwan, and each of the databases from these countries provides different patent information with different features. According Golany and Roll (1989), there are a total of twenty-one DMUs which have at least twenty patents to be selected, more than two times the total number of input and output factors, conforming to the rule of experience (see table 1).

4. Results of DEA and Patent Analysis

4.1 Patent Analysis

For medical companies, this paper selects two variables, R&D Capacity and Citation Rate, to consider the traditional patent analysis (see table 2).

From traditional patent analysis it can be seen that the top company, with R&D 100% capacity, has a low citation rate of 0.208. Comparing with table 2, BA has the lower citation, but its number of patent is highest, and that could be the reason for its high R&D capacity. For Ste, it has the second highest R&D capacity based on its number of citations, but not number of patents. Comparing the top two companies, we also find that the company with the higher patent count and lower citation rate has the highest independent technology.

4.2 DEA Models Analysis

The results of the DEA models analysis (see table 3) are found six inefficient DMUs in the CCR model and three inefficient DMUs in the BCC model. We could see that the efficient DMUs in the BCC model are better than CCR model while we allow the return to scale (RTS). All the inefficient DUMs in CCR model are to be improved their performance even reaching to be efficiency. Under DEA crossing analysis with CCR model, the cross efficiency analysis results also indicate that the most of efficient DMUs are ranked better place beside EST and HRS. For the inefficient DMUs have the same results, most of inefficient DMUs are ranked the lower place beside AMD, BI and TRUC. Comparing with the RTS, the inefficient DMUs who have the better ranking in crossing analysis model, they have the same status of increasing RTS. Also efficient DMUs who have constant of RTS, even they appear the efficient results in CCR model, their ranking are lower. We also see the same results in BCC model, while we allow the RTS, the efficient analysis of DMUs are showed the approximate status. But another interesting thing is the top 4 efficient DMUs (BA, MC, Upj and GE) regardless of CCR or BCC model, to display the same situation. Otherwise, the top 4 efficient DMUs who have the constant to RTS are ranked at better place in CCR and BCC model.

Anyway, from the topper or lower ranking we could observe the interesting results. For comparison with these models, we indicate the mix analysis results deeply with patents performance of DMUs in medical industries and found something worth to debate that would be difficult to see in traditional patent analysis. That is this paper one of main contributions. For next section, we are going to discuss the impact of factors with all DMUs.

5.Conclusion

For traditional patent analysis, as we said before that many papers are focus on many factors and to talk about the influence of patent development. But lack of past researches has spot on what variables are specific for each important company who are in medical industries. For numbers views, that would be right, absolute quantity seems to fit the traditional patent analysis. On the surface view, it maybe right, for example, the R&D capacity is measured with patent counts, citation, and citation rate is used to evaluate the worth of patent. But we are still not enough evidence to know how the others factors impact those companies' performance for the amplitude of vibration by patents development.

Anyway, from the topper or lower ranking and comparing by DEA models we could observe the interesting results that the mix analysis could provide the results deeply with patents performance of DMUs in medical industries and found something worth to debate that would be difficult to see in traditional patent analysis. If we put the best performance for their data with some companies that show the good ranking, and indicates some improvement space with their operation of current data. For crossing analysis, we also see the same status while we allow the return to scale that some companies' ranking and could be seen some improving aspect with the performance of their factors on hand actually.

Finally, important elements that influence the performance of DMUs can also be found after sensitivity analysis. We not only see the third contribution that less input maybe promoted the efficient performance while output is equal, but for traditional patent that would be different status with citation rate and R&D capacity.

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Table 1. The Relative Patent Analysis Data of DMUs

DMU	Patent Counts	Independent Technology	Inventors	Activity Years	Ave. Patent Age	Citation Counts	Citation for Others
3M Innovative Properties Company (3M)	24	1	28	9	8	10	10
Abbott Laboratories (AL)	22	0.3	26	9	24	30	19
Advanced Micro Devices, Inc. (AMD)	28	0.148	39	5	5	115	17
Baxter International Inc. (BI)	43	0.204	93	15	11	49	11
Baxter Travenol Laboratories, Inc. (BTL)	20	0.333	26	8	28	12	8
Bayer Aktiengesellschaft (BA)	168	0.857	191	26	27	35	30
Canon Kabushiki Kaisha (CKK)	27	0.5	53	11	9	4	2
Eclipse Surgical Technologies, Inc. (EST)	23	0.5	21	4	11	32	16
Fuji Photo Film Co., Ltd. (FPF)	24	0.583	44	12	12	12	7
General Electric Company (GE)	48	0.071	120	23	12	28	2
Hill-Rom Services, Inc. (HRS)	53	0.712	105	9	6	59	42
Hitachi, Ltd. (Hit)	30	0.714	101	15	11	7	5
Medtronic, Inc. (Med)	24	0.571	46	11	11	7	4
Merck & Co., Inc. (MC)	69	1	37	19	30	36	36
Minnesota Mining and Manufacturing Company (MMM)	36	0.274	53	12	15	62	36
Olympus Corporation (OC)	23	1	54	5	6	2	2
Schering Corporation (SC)	26	0.472	20	10	31	36	36
Steris Corporation (Ste)	26	0.239	42	9	13	138	34
The Regents of the University of California (TRUC)	21	0.4	37	10	11	5	4
The Upjohn Company (Upj)	43	1	29	12	30	9	9
Wisconsin Alumni Research Foundation (WARF)	24	0.317	28	10	11	60	19

Table 2. R&D Capacity and Citation Rate for Medical Industries

Company	Citation Rate	R&D Capacity
3M	0.417	16
AL	1.364	27
AMD	4.107	79
BI	1.14	49
BTL	0.6	16
BA	**0.208**	**100**
CKK	0.148	16
EST	1.391	27
FPF	0.5	18
GE	0.583	41
HRS	1.113	53
Hit	0.233	18
Med	0.292	16
MC	0.522	49
MMM	1.722	52
OC	**0.087**	**12**
SC	1.385	31
Ste	**5.308**	**88**
TRUC	**0.238**	**13**
Upj	0.209	25
WARF	**2.5**	**44**

Note: R&D Capability = (Patent count*1.2 + Citation count*1.4 + Self-citations*0.9) ;Citation Rate = (Citation count/Patent count)

Table 3. The Integrated Analysis of DEA for Medical Industrial Patents

DMU	CCR			BCC			A&P Model		E-W Model		RTS
	Score	Cross Analysis	Rank	Score	Cross Analysis	Rank	Score	Rank	Score	Rank	
3M	0.7849	0.4177	13	1	0.3322	13	0.7849	11	1.0672	2	Increasing
AL	0.7124	0.3938	17	1	0.3259	15	0.7124	17	0.6504	11	Increasing
AMD	0.9381	0.5228	6	1	0.4341	5	0.9381	9	0.3888	5	Increasing
BI	0.7905	0.4955	7	1	0.4196	6	0.7905	10	0.3931	17	Increasing
BTL	0.6813	0.4259	12	1	0.3321	14	0.6813	19	0.8555	7	Increasing
BA	1	0.9500	1	1	0.7741	1	2.2821	2	0.2273	21	**Constant**
CKK	1	0.5626	5	1	0.3658	8	1.3958	7	0.8860	9	Constant
EST	1	0.4042	14	1	0.3545	10	1.0722	8	0.8336	1	Constant
FPF	0.6034	0.3847	18	0.8651	0.2993	20	0.6034	21	0.8042	10	**Increasing**
GE	1	0.5910	4	1	0.4575	4	4.1044	1	0.3806	19	**Constant**
HRS	1	0.3942	16	1	0.3638	9	1.4196	5	0.3177	20	Constant
Hit	0.6999	0.3678	20	0.8097	0.2704	21	0.6999	18	0.5042	18	**Constant**
Med	0.7750	0.4386	10	0.9300	0.3242	16	0.7750	12	0.8852	8	Increasing
MC	1	0.6372	2	1	0.5169	2	1.4004	6	0.4430	16	**Constant**
MMM	0.7469	0.4369	11	0.9704	0.3919	7	0.7469	15	0.3951	15	Increasing
OC	1	0.4614	9	1	0.3200	19	1.7673	3	1.0063	4	Constant
SC	0.7580	0.3824	19	1	0.3236	17	0.7580	14	0.5277	13	Increasing
Ste	0.6641	0.3465	21	0.8291	0.3201	18	0.6641	20	0.2982	14	**Increasing**
TRUC	0.7727	0.4876	8	1	0.3515	11	0.7727	13	1.0451	3	Increasing
Upj	1	0.6332	3	1	0.4583	3	1.4283	4	0.7826	12	**Constant**
WARF	0.7274	0.3992	15	1	0.3357	12	0.7274	16	0.5489	6	Increasing