Measuring Operation Efficiency for Universal Top 10 TFT-LCDs by Improved DEA from 2007 to 2009

Zon-Yau Lee [1], Chu-Fen Hu [2]

[1]Graduate Institute of Project Management Kainan Univerisity, Taiwan

[2]Graduate Institute of Project Management Kainan University, Taiwan

Abstract. The panel industry has been impacted profoundly by global recession from 2007 to 2009. Currently the major players of TFT-LCD (Thin Film Transistor-Liquid Crystal Display) cluster in South Korea, Taiwan and Japan, and contribute 80% sales in global market. For example, Taiwanese display panel industry created 7% of overall gross domestic product (GDP) and reached 9,283 billion TWD in 2009. At this stage, it seems that TFT-LCD monitor has become the mainstream of ICT industry products. In view of the rapid growth of global demand, TFT-LCD manufacturers face tremendous competition. In this context, how to configure the best resource allocation and create more profit tend to be the major issue. In this study, the TFT-LCD firms in China, Korea and Japan is analyzed. Based on the trend analysis by Industrial Technology Research Institute in Taiwan, public database and information, financial statements and annual reports of these firms, we use improved Data Envelopment Analysis (DEA) in association with Window Analysis to measure their dynamic operating performance in China, Korea and Japan from 2005 to 2009. The research results show, in terms of A & P efficiency, Samsung is the highest firm in 2009 an followed by 2007, 2008, Toshiba, and maximum outlier group created in 2007, followed by Innolux in 2007 and Toshiba in 2008. With respect to co-optition strategy, Japan centers on technology and manufacturing cooperation. China stresses on marketing channels and own brand strategy. Korea uses low-priced products and OEM partner collaboration.

Keywords: Thin Film Transistor-Liquid Crystal Display (TFT-LCD), Improved Data Envelopment Analysis (DEA), Operation Efficiency, Window Analysis

1. Introduction

After 13 years, Taiwan has become the second largest TFT-LCD production country, since they involved in 1993. Taiwan ever reached top one against Korea, but back to number two after global recession in 2008. TFT-LCD industry was defined as one of 'Two Trillion, Twin Stars' industries by Taiwan government in 2006. The total asset investment accumulation of Taiwan's TFT-LCD industry has reached NT$ 1.4 trillion, the investment on production equipment also is over NT$ 1 trillion, of which 85% exported. There is a debate in relation to such a massive expenditure and low investment return (Chung, 2008).

Based on the survey done by IEK (Industrial Economics and Knowledge Center), ITRI (Industrial Technology Research Institute), it indicated that Taiwan's LCD Panel production reached 42 million pieces with the value of US 17 billion. Until the end of 2008, the main stream product (32 inch to 42 inch) LCD TV panel was 57% of total sales (Tsao, 2006, Chung, 2006). In 2010, the capital investment of Taiwan's TFT-LCD panel industry reached NT$ 5,873 million. However, compared to Taiwan, South Korea is expected to continue on a larger scale capital expenditure to invest NT$ 6,443 million during the 8.5 generation production expansion and enlarge the gap between Taiwan in terms of capital investment (Liu, 2010).

At present the world's most active countries on TFT-LCD development include Japan, Korea and Taiwan. Even China is also trying to catch up with major players through great potential. It is expected that the next growth of TFT-LCD will be driven LCD TV business opportunity, which leads to another intense competition. Taiwanese companies have to invest sufficiently and utilize resources effectively to compete with other international companies (Change et al 2007). This study aims to measure the global TFT-LCD operation efficiency and positioning analysis through inputs and outputs analysis, to understand if global TFT-LCD firms reach optimal resource configuration.

The purposes of this study are: (a) analysis and comparison of global TFT-LCD manufacturers in terms of current situation, capacity and trends; (b) analysis and comparison of the global TFT-LCD makers' business performance from 2005-2009 by financial statements; (c) use of improved DEA methods to

evaluate global TFT-LCD manufacturers' relative efficiency; (d) use of window analysis to measure the global TFT-LCD manufacturers' operational efficiency; (e) discuss of industrial policies in Taiwan.

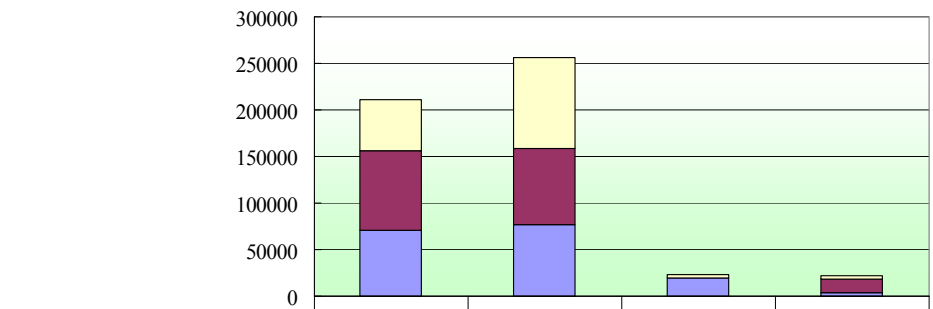
The drawback of measuring business performance purely relies on financial statements is only absolute efficiency but lack of relative benchmark. Merely measuring single indicator barely covers the entire issue, while many indicators matter how to allocate weighting. Simply considering output without factoring in input can easily bias the results. Data Envelopment Analysis (DEA) can meet above considerations and solve problems. The analysis results by DEA can undertake performance assessment in conjunction with financial statements. However, conventional DEA model is seeking relative efficiency value rather than the absolute efficiency. Therefore, using improved DEA not only can find out the best vendors with better performance, but also can make up the drawback of traditional DEA incapable of effective analysis due to too small unit numbers.

A number of existing work using DEA for efficiency analysis and performance evaluation in a wide range of issues, including a use of DEA to assess the efficiency of American 123 private power plants and 23 public sectors (Fare et al., 1985). Another application was to assess the operating efficiency of 22 public hospital and non-profit private hospitals in USA (Grosskop & Valdmanis, 1987). Smith & Mayston (1987) also adopted DEA for administrative efficiency of UK educational institutions. Rwgister (1988) evaluated the administrative efficiency of US Postal Service from 1956 to 1984 using DEA. Berg, et al. (1991) utilized DEA to evaluate the efficiency of Norway's 107 banks. Cook et al., (1992) assessed annual utilization of 31 robots' efficiency.

There are lots of papers using DEA as the main method. However, little work done for the application in TFT-LCD area. Limited by information accessibility, some only used single country TFT-LCD manufacturers (Chang et al., 2007a or merely adopted simpler approach (Chen, 2005). Therefore, this study uses innovative approach to analyze global TFT -LCD manufacturers. The data sources include Yearbook of TFT-LCD published by IEK (Industrial Economics & Research Center) of ITRI (Industrial Technology Research Institute) from 2007 to 2010, public information and financial statements.

2. The shipment comparison of TFT-LCD in 2009

Based on historical observations, the impact of financial crisis in 2008 declined the market demand. For example, the output value of Taiwan's TFT-LCD industry from the prosperity to decline. South Korea in 2009 had 30,385 million US$ production value of large-scale panel and own 49.9% market share. Taiwan had 23,134 million US$ and 38% market share, which is far behind South Korean as shown in Figure 1.



	Taiwan	Korea	Japan	China
Notebook PC (include Mini NB)	55924	97647	3370	2856
LCD Monitor	84181	81827	146	15417
LCD TV	71308	76281	19828	3225

Fig. 1: 2009 global shipments of TFT-LCD.

3. Empirical Analysis

This section covers the relative analysis of 2007-2009. The relative efficiency of CCR, reference collection, being referred number, A&P efficiency, cross-efficiency and outliers are embarked.

3.1. The CCR, A&P and Cross Efficiency from 2007 to 2009

From 2007 to 2009, the results revealed the most efficient DMUs by CCR over 3 years are: Samsung in 2009, Toshiba and Innolux in 2008, and Innolux in 2007. The higher being referred numbers, the more efficient. Innolux in 2007 is referred 20 times as the highest one, and Innolux in 2008 is referred 15 times. The details are shown in Table 1.

Table 1: CCR efficiency, A&P efficiency, and Cross-Efficiency from 2007 to 2009

No	Year	DMU	CCR	Reference set	Numbers	A&P	Cross	Isotonicity
1	2009	AUO	0.1483	6、25	0	0.1483	0.4389	-0.6622
2	2009	CMT	0.1734	6、25	0	0.1734	0.3441	-0.4963
3	2009	CPT	0.1348	20、25	0	0.1348	0.0534	1.5262
4	2009	Hannstar	0.5127	15、20	0	0.5127	0.0935	4.4807
5	2009	Innolux	0.8175	6、15、25	0	0.8175	0.2389	2.4221
6	2009	Samsung	1	6	12	12.2646	0.2668	2.7481
7	2009	LG	0.5384	6、25	0	0.5384	7.7449	-0.9305
8	2009	Sony	0.4518	20、25	0	0.4518	3.3334	-0.8645
9	2009	Sharp	0.2032	15、20、25	0	0.2032	1.3168	-0.8457
10	2009	Toshiba	0.3662	20、25	0	0.3662	2.9586	-0.8762
11	2008	AUO	0.3109	6、15、25	0	0.3109	0.6791	-0.5423
12	2008	CMT	0.2466	6、15、25	0	0.2466	0.4853	-0.4919
13	2008	CPT	0.2907	14、15	0	0.2907	0.2451	0.1861
14	2008	Hannstar	0.9893	14	3	0.9893	0.1731	4.7151
15	2008	Innolux	1	15	15	1.4487	0.3056	2.2719
16	2008	Samsung	0.3868	15、20、25	0	0.3868	2.8823	-0.8658
17	2008	LG	0.4924	6、15、25	0	0.4924	0.7271	-0.3228
18	2008	Sony	0.4235	20、25	0	0.4235	2.9875	-0.8583
19	2008	Sharp	0.2113	20、25	0	0.2113	1.1860	-0.8219
20	2008	Toshiba	1	20	9	1.2233	1.3686	-0.2693
21	2007	AUO	0.3499	6、15、25	0	0.3499	0.6598	-0.4696
22	2007	CMT	0.228	6、15、25	0	0.228	0.4202	-0.4574
23	2007	CPT	0.2942	15、20、25	0	0.2942	0.1756	0.6750
24	2007	Hannstar	0.3791	6、15、25	0	0.3791	0.1059	2.5811
25	2007	Innolux	1	25	20	1.2599	0.1549	5.4540
26	2007	Samsung	0.3019	14、15	0	0.3019	0.7572	-0.6165
27	2007	LG	0.5058	6、15、25	0	0.5058	0.4214	0.2002
28	2007	Sony	0.1257	15	0	0.1257	0.4010	-0.6866
29	2007	Sharp	0.4646	15	0	0.4646	0.1175	2.9528
30	2007	Toshiba	0.4141	15	0	0.4141	0.0494	1.8621

In terms of discrimination ability, CCR model doesn't indicate which mode is better. The reference set is needed to judge the efficiency, and its two distinguishing assessment model are better than CCR model. A&P model is the extension of CCR model, which can increase the discrimination power, while cross-efficiency evaluation adopts stricter standard to increase the discrimination power. The A&P efficiency greater than 1 is Samsung in 2009, and followed by Innolux in 2008, Innolux in 2007, and Toshiba in 2008. The biggest isotonicity is Innolux in 2007, followed by Hannstar in 2008, Hannstar in 2009, Sharp in 2007, and Samsung in 2009 as shown in Table 1.

3.2. Discussion

It can be observed that Innolux has the best operation efficiency out of top 10. Innolux has differential business model and technical assistance by Hon Hai Group, which save lots of R & D costs. Additionally, their group innovation strategy is quite successful, which results from downstream collaboration and direct overseas orders with Hon Hai's assistance. From the viewpoint of value chain, Innolux integrate key business processes from selling products to customers directly to present the best operating performance.

4. Conclusion

TFT-LCD is widely used in TVs, notebooks, and mobile Phones, and their production requires high material costs. How to reduce manufacturing costs is thus a key task in this highly competitive global market. Since the TFT-LCD industry is highly competitive, properly utilizing resources to lead to outstanding performance is critical for keeping ahead. Performance evaluation is often viewed as a foundational tool to monitor, diagnose and improve processes, and determining resource strategies. The performance comparison can be carried out internally (self comparison over time) or externally (compare with competitors).

This paper is motivated by a need to compare relative operating performance to remain competitive. The operating performance in TFT-LCD industry significantly interacts with capacity and resource allocation, these components can influence the performance and evaluation result and reflect the appropriateness of previous decision making. Performance evaluation is critical, as addressed, but often controversial. How to establish a proper mechanism and convincing performance measurement is a big challenge. To dispel the controversy, this paper proposes a model to systematically analyze the operating performance among global TFT-LCD top firms from 2007 to 2009.

The improved DEA including Window Analysis is adopted to undertake analysis because the DEA model can solve the problem in terms of different measurement units caused by the evaluation of multiple inputs and outputs. The proposed model with improved DEA provides an overall performance measure through relative comparisons, in which we carefully link DEA theory and Window Analysis. In terms of discrimination ability, CCR model doesn't indicate which mode is better. The reference set is needed to judge the efficiency, and its two distinguishing assessment model are better than CCR model. A&P model is the extension of CCR model, which can increase the discrimination power, while cross-efficiency evaluation adopts stricter standard to increase the discrimination power. This study adopts dynamic approach to analyze each TFT-LCD firms in Taiwan, Japan and Korea individually and overall, to facilitate comparative analysis and the development of better policy decision making.

The research results show Samsung has the highest efficiency in 2009 in terms of A&P efficiency. It explains why Samsung is the top firm in TFT-LCD global competition. It also can be noticed TFT-LCD firms in different countries adopt distinctive strategies to improve operating efficiency. Through empirical data collection and analysis, we believe this research has developed a systematic research methodology express, model and organize performance evaluation in terms of the relationship between inputs and outputs. This methodology also provides consistent performance conclusions compared with reality.

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