A research on the evaluation of business performance of Taiwan's printed circuit board industry

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ABSTRACT: *The main purpose of this research is to provide a reference for the performance evaluation of the investing public and managers through effective evaluation methods. Due to the industrial characteristics of the electronics industry itself, the development of many types of products has reached a mature stage, that is, the market competition is increasingly fierce, under the market competition, the fundamental way to survive is in the formulation of competitive strategy, and the development of competitive strategy, first need to understand the relative business performance of their own enterprises in the industry.*

This study discusses the performance evaluation of Taiwan's printed circuit board (PCB) industry by using data envelopment method, attempts to evaluate the performance of Taiwan's printed circuit board industry from the perspective of financial indicators, and provides reference for relevant managers' business performance evaluation.

This study mainly explores the impact of six financial indicators, including current assets, number of employees, inventory, operating income, operating gross profit, and net profit after tax, on performance. We can use the results of linear regression analysis to see how financial indicators affect the printed circuit board industry. This study uses the available financial information of the printed circuit board industry to analyze the relationship between input and output variables, and the results of this analysis can also provide some recommendations for managers and investors.

KEY WORD: *performance measurement, data envelopment analysis, financial indicators, printed circuit board*

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I.   INTRODUCTION AND LITERATURE REVIEW

In 2020, the global circuit board production value (including the output value of board manufacturers engaged in late-stage SMT) is expected to reach about 69.7 billion US dollars; Compared with 2019, the increase was 9.4%, and there was a large gap between the output value and growth rate estimated at the beginning of the year, and the main reasons for the gap were as follows: the working life resumed for a short time, the demand far exceeded expectations, the demand for some products soared due to post-epidemic life, 5G business opportunities were not affected by the epidemic, iPhone 12 was postponed to the market, the downstream mentality was conservative, and the inventory level was improved[12].

In terms of Asian performance, the output value of circuit boards in Taiwan in 2020 was about NT$696.3 billion, which should reach US$23.6 billion in US dollars based on the original order amount. Compared with 2019, it increased by about 10.2%, reaching a new high.

Printed circuit board can be used in electronic products, so it is called the mother of industry, its prosperity and decline is closely related to the development of the electronics industry, affected by the high inventory of computers and mobile phones caused by the global overall economic recession, coupled with the prosperity of the electronics industry in previous years, so that many small factories jumped into this industry with low technical threshold.

In order to reduce production costs, PCB manufacturers must raise funds to expand production, the pursuit of economic scale, and the domestic developed capital market has become the best financing channel for manufacturers, since 1997, domestic PCB manufacturers have been listed on the OTC, has now become the largest group of listed electronic stocks. After entering the capital market, the source of funds is relatively easy, and after the large expansion of factories or expansion, domestic PCB companies are more cost-competitive than foreign competitors.

1.1 Research motivation

In the current information age, the global industry has evolved from the early traditional industry to the development direction of science and technology, but also brought Taiwan to the world economic stage, and

created an enviable economic miracle, to the current industrial structure of Taiwan, the electronics industry in the case of high technology, high productivity and high development, its role and status has been the mainstream of future economic development, as far as the electronic industry system is concerned, the content is quite complex and important, of which the printed circuit board (PCB) industry is an important part of the electronics industry, It is closely related to the overall global economic environment and the rise and fall of the electronics industry.

However, for enterprises, the past prosperity has been yesterday, under the impact of the recession, the operation of the enterprise must be more conscientious, the performance of the enterprise is bound to be eliminated under this wave of recession, only in a more efficient way of operation, can get through this recession. Therefore, it is an indispensable tool for enterprises to have an assessment that can be used as a reference for enterprises in advance.

Taiwan's printed circuit board industry because of the global competitive advantage, industry-related upstream, midstream, downstream complete and good integration, coupled with Taiwan's information hardware products, such as monitors, motherboards, scanners, mice, keyboards, power supplies and other products output ranked first in the world, so in recent years Taiwan's printed circuit board production and sales have shown substantial growth; In addition, the government's encouragement and promotion of the industry, the maturity of the technology of domestic players, and the expansion of production scale year by year, all these phenomena have made the average growth rate of Taiwan's printed circuit boards in recent years reach more than double digits, far exceeding the average growth rate of global printed circuit boards, and playing a very important role in the overall domestic economy[1][2].

In addition, in recent years, high-tech industries with technology as the main production factor have driven the development of the global economy, which is also the niche for Taiwan's future industrial survival. For these reasons, the motivation for this study to explore PCB performance is provided. Therefore, in this study, printed circuit board products listed in the OTC electronics industry in Taiwan will be used as a sample for evaluating performance.

1.2 Purpose of the study

The main purpose of this research is to provide a reference for the performance evaluation of the investing public and managers through effective evaluation methods. In addition, for the company, the performance is related to the survival of the future. Therefore, it can not only provide operators with an understanding of their current situation, but also provide a warning to those whose business performance is inefficient.

Due to the industrial characteristics of the electronics industry itself, the development of many types of products has reached a mature stage, that is, the market competition is increasingly fierce, under the market competition, the fundamental way to survive is in the formulation of competitive strategy, and the development of competitive strategy, first need to understand the relative business performance of their own enterprises in the industry. Second, economies of scale can be used to reduce costs, improve competitiveness and market share, so the electronics industry is expected to see a wave of mergers in the future, and the quality of business performance can provide a reference indicator for the merged and merged companies.

In addition, by using the data envelopment method to evaluate performance, it provides future research on related issues.

The purpose of this study can be summarized as follows:

1. Establish and evaluate the financial indicators and business performance evaluation of PCB companies.
2. Provide reference for relevant managers' business performance evaluation.

1.1 Literature Discussion
1.1.1 Development of Taiwan's printed circuit board industry

Taiwan printed circuit board industry since the Taiwan 58 years of development has been 30 years, early Taiwan printed circuit board industry to cheap labor and other basic elements of the advantage, in recent years Taiwan has established the image of a large printed circuit board production country in the world, the main reason is that in addition to our manufacturers have the world's first-class technical level, there is still a considerable local domestic demand market, rapid delivery and price incentives. Taiwan has a fairly complete upstream and downstream peripheral industry support, so that whether it is copper foil, glass fiber cloth or substrate prices, Taiwan is far lower than the United States and Japan, and has an absolute advantage in market competition.

Taiwan's printed circuit board industry has shown high growth in recent years, mainly due to the vigorous development of the global electronic information industry, which has led to a significant increase in the demand for printed circuit boards from system manufacturers and peripheral component manufacturers. Coupled with the competition for the price reduction of computer finished products in recent years, the information manufacturers have to try to reduce the cost of manufacturing, and under the strong demand of a large number of low prices, they no longer make all of them, but choose Taiwanese manufacturers with strong foundry ability and high mobility as their cooperation objects.

2.2 Business performance evaluation

Business performance evaluation is one of the important parts of the organization's operation, and understanding the significance of business performance, the purpose of business performance evaluation and the method of business performance evaluation will be more helpful for the evaluation work.

1. Definition of business performance

Business performance is one of the goals that organizations strive for, and usually includes two levels of meaning: "efficiency" and "effectiveness".

"Efficiency": measured by the ratio of outputs to inputs, mainly focusing on internal operational processes and placing more emphasis on technical improvement.[3]

"Performance": refers to the degree to which a system's output achieves a predetermined goal, so the effectiveness of a system is affected by the content and degree of the predetermined target.

When discussing business performance evaluation, the most important issues are "fairness" and "objectivity". Therefore, in order for the performance evaluation process to proceed smoothly, it is necessary to consider the issues of "long-term and short-term performance", "single and multiple indicators", "financial and non-financial indicators", "controllable and uncontrollable factors" and "quantitative and non-quantitative factors".

The measurement of business performance can help whether the strategy adopted by the company and whether the organizational structure achieves the set goals.

Grosskof and Valdmanis (1999) [8] proposes three conceptual ranges of performance for firm performance:

(1) Financial performance: refers to the achievement of the economic goals of the enterprise, generally more commonly used indicators such as operating growth rate, return on assets, return on capital and profit margin.

(2) Business performance: financial indicators plus operational performance as business performance, such as product share, product quality, added value rate and other non-financial indicators.

(3) Organizational effectiveness: For the broadest range of business performance, it includes the scope of the above two, but also includes performance purchase target performance such as employee morale.

2. Business performance evaluation methods

Cederblom (1982) [4] When coaching consulting services related to global manufacturing and performance management, it was found that most companies will rank the indicators of change performance evaluation last, because the average person usually thinks that performance evaluation is just a routine year-end appraisal as the basis for the payment of performance bonuses, but often ignores the function of performance indicators to guide the direction of employees' efforts and motivate, if not set properly, it will cause misallocation of resources, resulting in a significant impact on the competitive advantage of the enterprise.

However, although there is no perfect performance evaluation system, it has gradually matured with the evolution of the times. For example, Sherman and Gold (1985) argue that the performance appraisal system may be flawed, but it will still provide important benefits to employers and should not be abolished. [11] Therefore, since 1975, many scholars have been working to develop various effective performance measurement components.

3. Performance evaluation indicators

In any kind of performance analysis, the focus is on the trade-off, classification and evaluation of inputs and outputs. Therefore, again, the most important step in DEA is the selection of input factors and output factors. Because the performance evaluation of the DEA method is based on the input and output data values of each research object, the establishment of appropriate input and output variables as measurement factors is an important key to DEA performance evaluation research.

This study analyzes the performance indicators cited in the literature on performance evaluation of high-tech industries, and distinguishes the performance evaluation variables used in each study into input and output parts.

1.2 Research Objectives

The purpose of this study can be summarized as follows:

1. Establish and evaluate the financial indicators and business performance evaluation of PCB companies.
2. Provide reference for relevant managers' business performance evaluation.

1.3 Research Methodology and Data Analysis

DEA model:

The researcher uses a basic linear programming approach to evaluate the performance of printed circuit board manufacturers. The solution to the problem can be solved by using the CCR mode in DEA. Charnes (1978) introduced DEA by stating that the use of the CCR model can evaluate the DMU (Decision Making Unit; DMU) overall efficiency of decision-making units [11].

When using DEA, the function ratio is allowed to be in the range of input and output weights. Example: Two input variables (X1 and X2) and two output variables (Y1 and Y2) were selected from this study. Its efficiency

$$= \frac{U_1 Y_1 + U_2 Y_2}{V_1 X_1 + V_2 X_2}$$

Equalize the sum of the weights to 1. The combined score of the weights of inputs and outputs will then be less than 1, so DEA can be expressed as follows:

Max

$$\frac{\sum_{r-1}^{s} U_r Y_{r0}}{\sum_{i=1}^{m} V_i X_{i0}}$$

Subject to

$$\frac{\sum_{r=1}^{s} U_r Y_{rj}}{\sum_{i=1}^{m} V_i X_{ij}}$$

$$\leqq 1 \quad j = 1, \dots \dots n$$
$$Ur , Vi > 0 \; ; r = 1, \dots, s \; ; I = 1, \dots m$$

We then developed three programs that effectively applied DEA theory. And illustrate it with examples:

Step 1: Identify DEA variables

To distinguish the input and output variables of the DEA model, the three input variables (V1, V2, V3) are current assets, number of employees, inventory, and three output variables (U1, U2, U3) are operating income, operating gross profit and net profit after tax.

Step 2: Establish the DEA model

All factors can form a DEA model, which then interacts with the Pearson correlation coefficient double-tailed test to obtain better factors. The results, shown in Table 3.2, show that input and output factors are correlated.

This is the result of data collection and analysis from thirty-two printed circuit board manufacturers, including three input variables (V1, V2, V3) and three output variables (U1, U2, U3). The input and output variables are explained as follows:

U1 = Operating income
U2 = operating margin
U3 = net benefit after tax
V1 = current assets,
V2 = Number of employees
V3 = Inventory

1.3.1 Data Analysis

1. Results and analysis

The efficiency of Taiwan's printed circuit board industry from 2019to 2022 was studied using the DEA model. In addition, linear regression analysis is used to study input variables that have a great impact on output. The following are the results of this study.

2. Results of DEA mode

Enter the input and output of 33 printed circuit board manufacturers in Lindo, calculate the efficiency value for each manufacturer, and list the efficiency value of 33 manufacturers in Table 1

Table 1 Comparison of CCR Efficiency Values (DEA)

Vendor number	DEA（CCR Score rating）			
	2019	2020	2021	2022
1	1	1	0.843	0.726
2	0.995	1	0.840	0.817
3	0.878	1	1	0.943

4	1	1	1	0.926
5	0.814	1	1	1
6	1	1	1	1
7	0.826	0.843	0.633	0.314
8	1	0.725	0.815	0.745
9	0.474	0.847	0.545	0.764
10	1	1	1	1
11	0.778	0.914	0.924	0.914
12	0.932	0.940	0.820	0.556
13	0.612	0.642	0.501	0.545
14	0.715	0.814	0.688	0.786
15	0.657	0.732	0.632	0.613
16	1	1	0.722	0.744
17	0.888	0.854	0.789	0.726
18	1	0.854	0.845	0.975
19	0.884	1	0.945	0.756
20	0.958	1	0.886	1
21	1	1	1	1
22	0.936	1	0.751	0.821
23	1	0.854	0.749	0.623
24	0.777	0.826	0.978	0.701
25	1	1	1	1
26	0.622	0.888	0.854	0.831
27	1	1	1	1
28	1	0.999	1	1
29	1	1	0.778	0.718
30	0.632	0.824	0.874	0.854
31	0.387	0.854	0.462	0.573
32	0.605	0.712	0.701	1
33	0.935	1	0.778	0.825

1.4 Results of regression analysis

Our research uses linear regression analysis to analyze the financial position of current assets, headcount and inventories on the printed circuit board industry. The results of our analysis are shown in Tables 2 to 4.

H1: Financial indicators (current assets, number of employees, inventory) are significantly correlated with operating income.

H1A: Current assets are significantly correlated with operating income.

H1B: The number of employees is significantly correlated with operating income.

H1C: Inventory is significantly correlated with operating income.

Table 2 Simple model for linear regression analysis of printed circuit board industry revenue (N=128)

	Normalization coefficient (Bata distribution)	t	Significant (P value)	Standard error
liquid asset	0.496	10.381	0.000*	0.082
Number of employees	0.338	8.938	0.000*	0.126
stocks	0.227	7.208	0.000*	0.258
R	0.974			
R-squared	0.950			
The adjusted R squared	0.948			
F verification	777.637			

* Statistical level is 95% confidence interval

* P-value less than 0.05 is significantly correlated

* (Independent variables: current assets, number of employees, inventory; Dependent variable: operating income)

These data obtained by linear regression analysis are used to predict the relationship between the operating income of the printed circuit board industry and financial indicators (current assets, number of employees, inventory), and the results are shown in Table 3, the R2 in the regression coefficient is 0.950, while the adjusted R-squared value is 0.79, and the P value is less than 0.05 is significantly correlated.

The standardized coefficients in Table V are 0.496 for current assets, 0.338 for employees and 0.227 for inventory, and show current assets (t=10.381, P=0.000<0.05), employees (t=8.938, P=0.000<0.05), inventory (t=7.208, P=0.000). <0.05), the P value is less than 0.05, showing that current assets, number of employees, inventory and operating income are significantly correlated.

H2: Financial metrics (current assets, number of employees, inventory) are significantly correlated with operating margin.

H2A: Current assets are significantly correlated with operating margin.

H2B: The number of employees is significantly correlated with operating gross profit.

H2C: Inventory is significantly correlated with operating margin.

Table 3 Simple model for linear regression analysis of printed circuit board industry operating margin (N=128)

	Normalization coefficient (Bata distribution)	t	Significant	Normalization coefficient (Bata distribution)
liquid asset	0.745	6.829	0.000*	0.034
Number of employees	0.049	0.564	0.574	0.053
stocks	0.093	1.298	0.197	0.108
R	0.858			
R-squared	0.737			
The adjusted R squared	0.731			
F verification	115.841			

The statistical level is a 95% confidence interval

P-values less than 0.05 are significantly correlated

(Independent variables: current assets, number of employees, inventory; Dependent variable: Operating margin)

Table 3 shows the relationship between financial indicators (current assets, number of employees, inventory) and operating margin, with R2 in the regression coefficient being 0.737, the adjusted R-squared value being 0.731, and the P value being less than 0.05 being significantly correlated. The standardization coefficients of current assets, number of employees and inventory were 0.745, 0.049 and 0.093, respectively, showing current assets (t=6.829, P=0.000<0.05), number of employees (t=0.564, P=0.574>0.05), inventory (t=1.298, P=0.197> 0.05), Table 4.6 shows that there is no significant correlation between headcount and inventory and operating margin.

H3: Financial metrics (current assets, number of employees, inventory) are significantly correlated with net profit after tax.

H3A: There is a significant correlation between current assets and net income after tax.
H3B: There is a significant correlation between the number of employees and net profit after tax.
H3C: Inventories are significantly correlated with net profit after tax.

Table 4 Simple model for linear regression analysis of net benefit after tax in printed circuit board industry (N=128)

	Normalization coefficient (Bata distribution)	t	Significant	Normalization coefficient (Bata distribution)
liquid asset	0.590	3.364	0.001*	0.044
Number of employees	-0.190	-1.374	0.172	0.068
stocks	0.149	1.289	0.200	0.140
R	0.565			
R-squared	0.320			
The adjusted R squared	0.303			
F verification	19.427			

The statistical level is a 95% confidence interval
P-values less than 0.05 are significantly correlated
(Independent variables: current assets, number of employees, inventory; Dependent variable: net benefit after tax)

Table 4 shows the relationship between financial indicators (current assets, number of employees, inventory) and net profit after tax, where R2 is 0.320, the adjusted R-squared value is 0.303, and the P value is less than 0.05. The standardization coefficients of current assets, number of employees and inventory were 0.590, -0.190 and 0.149, respectively, showing that there was no significant correlation between current assets (t=3.364, P=0.001<0.05), number of employees (t=-1.374, P=0.172>0.05), inventory (t=1.289, P=0.200>0.05), and Table 4.6 shows that there is no significant correlation between the number of employees, inventory and after-tax net benefit.

Conclusion

The main highlights of the research analysis are listed below.

H1: Financial indicators (current assets, number of employees, inventory) are significantly correlated with operating income.

hypothesis	opinion	outcome
H1a	Current assets are significantly correlated with operating income.	supported
H1b	The number of employees is significantly correlated with operating income.	supported
H1c	Inventory is significantly correlated with operating income.	supported

H2: Financial metrics (current assets, number of employees, inventory) are significantly correlated with operating margin.

hypothesis	opinion	outcome
H2a	Current assets are significantly correlated with operating margin.	supported
H2b	The number of employees is significantly correlated with operating gross profit.	Not supported
H2c	Inventory is significantly correlated with operating margin.	Not supported

H3: Financial metrics (current assets, number of employees, inventory) are significantly correlated with net profit after tax.

hypothesis	opinion	outcome
H3a	Current assets are significantly correlated with net profit after tax.	supported
H3b	The number of employees is significantly correlated with net profit after tax.	Not supported
H3c	Inventories are significantly correlated with net profit after tax.	Not supported

From the results, we can see that current assets are significantly correlated with operating income, the number of employees is significantly correlated with operating income, inventory is significantly correlated with operating income, current assets are significantly correlated with operating gross profit, and current assets are significantly

correlated with after-tax net profit. However, the number of employees was not significantly correlated with operating gross profit, inventory and operating gross profit, number of employees and net profit after tax, and inventory and net profit after tax.

In the verification results, we know that the higher the current assets, the number of employees and inventory, the higher the operating income. The higher the current assets, the higher the operating gross profit and net profit after tax; The more employees and inventories, the higher the operating gross profit and net profit after tax.

The two input variables of number of employees and inventory are significantly correlated with operating income, but not with operating gross profit and net profit after tax. It can be seen that the higher the number of employees and inventory, higher operating income can be created, but operating gross profit and net profit after tax are subject to deduction of related expenses and income tax, and the number of employees and inventory will cause higher expenses, so these two input variables are not significantly related to operating gross profit and net profit after tax.

Conclusions and recommendations

This study mainly explores the impact of six financial indicators, including current assets, number of employees, inventory, operating income, operating gross profit, and net profit after tax, on performance. We can use the results of linear regression analysis to see how financial indicators affect the printed circuit board industry. This study uses the available financial information of the printed circuit board industry to analyze the relationship between input and output variables, and the results of this analysis can also provide some recommendations for managers and investors.

However, environmental factors inside and outside the industry are also important points to be considered when using DEA, such as the company's internal policies and management methods, external economic environment and government policies, etc., which may affect the performance of the company. DEA can help us compare and analyze the performance of 33 printed circuit board manufacturers, and then we propose input and output variables, which are current assets, number of employees and inventory, and output variables are operating income, operating gross profit and net profit after tax. Using these six variables, the results were obtained, and the results showed that 13 manufacturers were the best performers in 2019, but 15, 9 and 9 manufacturers performed better between 2020 and 2022, respectively. As a result, we can see that in 2020, printed circuit board manufacturers performed better than other years. In 2019~2020, the Internet prevailed, resulting in a large increase in demand for network products and hot sales, coupled with the popularization of mobile phones, mobile phone boards and base platens and other communication products demand warmed up. As a result, many printed circuit board manufacturers in Taiwan bought equipment to expand production capacity at that time, competing to invest in the production of these high-end products, and judging from the grand situation in 2020, the initial investment in these products by manufacturers was indeed very profitable. However, under the influence of the sharp downturn, these manufacturers who invested heavily in advanced equipment to expand production capacity suffered from a serious oversupply of production capacity after 2021. Capacity utilization has dropped sharply, and there is a serious oversupply. In addition to the rapid expansion of production capacity, another reason is the sluggish market demand, and the rapid decline in global network market demand after the second half of 2020 has had an adverse impact on the shipment of high-rise boards in Taiwan's printed circuit board industry, resulting in poor profits.   In the future, the computer system architecture will move towards the system single-chip step will become faster and faster, when the PCB will also play the role of passive component integration, so the PCB industry must face unprecedented technical upgrading, need to spend more energy than in the past on research and development, materials and quality management, to meet the needs of high-density development, good wiring design and accurate impedance control and other PCB performance, in order to compete for a place in the market. The recommendations of this study are as follows:

1. This study only uses a single industry to test the hypothesis of this study. Follow-up research should use other high-tech industries and traditional industries to verify the impact of financial indicators on performance.
2. Follow-up research can use other analysis methods to judge the performance of the industry, such as gray correlation analysis method, second-order data envelopment method, etc. This is because the traditional single-stage data envelopment method cannot effectively express the business characteristics of the industry when conducting business efficiency assessment, and the efficiency identification ability is also insufficient compared with the two-stage data envelopment method.
3. Follow-up research can use different financial indicators to analyze the impact on industry performance.

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