Business Performance Evaluation Model for the Taiwan Electronic Industry based on Factor Analysis and AHP Method

W. Wen

Abstract—In this paper, we develop a performance evaluation model to assess business performance in the Taiwan electronic industry. In order to select better performance indices, we adopt literature review, expert's questionnaire, and factor analysis-principal component analysis. Through two-stage expert meeting and questionnaires, we collect, discuss, and evaluate all the indictors. 16 out of 28 indices are selected. The 16 indictors are further divided into two levels and 4 categories depended on Analytic Hierarchy Process method and principal component analysis. Based on the result of factor analysis, there are four factors (i.e., categories) named as (1) Profitability Ability-return on assets, return on stockholders' equity, return on investment, and net profit margin, (2) Efficiency Ability- average collection period, accounts receivable turnover, inventory turnover, working capital, and (3) Liquidity- current ratio, quick ratio, and cash ratio. Additionally, the non-financial 5 indices are included as the fourth factor. Consequently, there are four factors with 16 indices to process the AHP method to determine the weight of each index for measuring business performance. Finally, the result of business performance evaluation is presented and some suggestions are given to middle or top managers for conducting business.

Index Terms—Factor analysis; Principal component analysis; Analytic hierarchy process.

I. INTRODUCTION

Accurate business performance evaluation is a key to success for enterprises. In the competitive environment of the 21st century, a company requires substantial financial and non-financial structure, rapid response, efficient management, and high quality of products and services. In the past, manual self-annual reports on financial statements such as income statement and balance sheet would be done and used to examine a company's performance. But, manual and separate data may not be effective in the fast changing information era. Meanwhile, without considering other competitors in the same industry, a company will lead to self-satisfaction. Therefore, this paper employs basic statistics, principal component analysis, and analytic hierarchy process method to build a business performance evaluation model for middle or top managers to conduct their

company. Once the model is created, we will build a business performance evaluation decision support system for providing optimal suggestions to the managers for conducting their company for facing the rapid changing global environment.

As we know that business performance can be measured by using financial and non-financial factors. Based on literature review, we have studied many financial and non-financial indices related to business performance. By studying financial performance indices, Sohn et al. [11] proposed a structural equation model (SEM) to examine the relationship between technology evaluation factors and the financial performance. It can be used for not only for the effective management of the technology credit funds for small and medium enterprises (SME) but also for evaluating financial performance of SMEs based on the technology evaluation of companies. Their results showed that the operation ability of manager has the highest direct effect on the finance performance index (FPI) and the level of technology has the highest indirect effect on the FPI. Knowledge and experience of manager as well as marketing of technology have positive effect on the FPI. Ocal et al. [10] used factor analysis to select the financial indicators for evaluating financial trend of Turkish construction industry. They collected 5 years of data starting from 1997 to 2001 for 28 Istanbul Stock Exchange traded construction companies. In the factor analysis, there were 25 ratios adopted. According to the values of the correlation matrix, 9 ratios had a weak correction with the others and could be removed. The results of factor analysis showed that 5 factors would be extracted (i.e., eigenvalues are larger than 1). They are named as liquidity factor, capital structure and profitability factor, activity efficiency factor, profit margin and growth factor, and assets structure factor. Their results showed that the companies focused on competition performance and financial performance. The paper also strengths to increase market share, sales growth rate, maintaining steady, and sufficient upstream materials and supplies, and enhance the ability to obtain critical technology and patents. Gursoy and Swanger [3] adopted structural equation modeling to examine the impacts of the internal strategic factors. Their model consists of seven exogenous constructs (sales, R7D distribution, customer service, marketing, IT, human resources, and accounting) and one endogenous construct (financial performance). Their data came from a self-administered questionnaire by mailing to 2339 industry experts. 328 out of 2339 were responded and analyzed. The result shows that four of the seven hypotheses are supported.

The four critical success factors that have a significant impact on company financial performance are sales, R&D and distribution, IT, and human resources. Lin et al. [7] applied a structural equation model to supply chain quality management and organization performance. The questionnaire data from both Taiwan and Hong Kong's supply chain firms were collected. Both data show that there have direct effects on the relationship between: QM practices and supplier participation, supplier participation and organization performance, QM practices and supplier selection, supplier participation and supplier selection. Moreover, the relationship between supplier selection and organizational performance has indirect influences. QM practice and organizational performance have also indirect effects. Maiga [8] examined the relationship between enterprise benchmarking and enterprise performance. He found three elements in the benchmarking, which affected the enterprise performance positively, including prior experience with benchmarking, the commitment of the organization to benchmarking, and internal preliminary competence analysis. Hoque [4] surveyed and discussed the impact on performance of two factors, strategy and environmental uncertainty, from 52 samples of manufacturing. His result shows that management's strategy choice is positively related to performance remarkably. But there is no evidence to prove the relationship between environmental uncertainty and performance. For financial analysis, a better financial company should have 4 abilities: liquidity/debt paying ability, financial structure (stability), activity/efficiency ability, and profitability [2, 9, 10, 11]. Other many performance related papers have been published [1,5,6].

II. METHODS

According to literature review, we collected and filtered 28 indices in common use for evaluating business performance. Among the 28 indices, 18 indices are financial indices and 10 indices are non-financial indices. The main participants, who filled in the questionnaire, are 34 experts from electronic companies, from academics, and from accounting department. Through two-stage expert meeting and questionnaires, we collect, discuss and evaluate all the 28 indictors. The survey adopts a 5-point Likert scale (1=Not important at all, 5=very important).

In order to choose critical indicators, we utilize 3 approaches to reduce the indices from 28 to 18. First, based on total number of "Important" and "Very Important," shown in questionnaires for financial indices, the index of which total number is less than or equal to 27 is deleted and for non-financial indices, the index of which total number is less than or equal to 28 is deleted (see Table 1). After counting the total number of "Important" and "Very Important," 10 out of 28 indices are removed. Therefore, times interest earned, debt-to-equity, total asset turnover, fixed asset turnover, gross profit margin, productivity, number of patents, upstream materials and supplies, downstream tactical alliances are erased.

Table 1 Financial and non-financial indices-total number of important and very important

NO \ Indictor	Important	Very Important	Total
1 current ratio	24	6	30
2 quick ratio	21	9	30
3 cash ratio	20	13	33
4 working capital	18	13	31
5 Permanent capital to fixed assets	22	6	28
6 Debt ratio	16	16	32
7 Times interest earned	9	10	19
8 Debt-to-equity	19	8	27
9 Inventory turnover	14	14	28
10 Total asset turnover	15	5	20
11 Accounts receivable turnover	14	16	30
12 Fixed asset turnover	11	5	16
13 Average collection period	16	13	29
14 Return on assets	19	10	29
15 Return on stockholders' equity	14	16	30
16 Return on investment	20	10	30
17 Net profit margin	16	15	31
18 Gross profit margin	13	13	26
19 Product competitiveness	13	20	33
20 Market share	19	11	30
21 Productivity	20	8	28
22 Product quality level	13	18	31
23 Number of patents	14	25	25
24 R&D expenditure ratio	18	26	26
25 Ability to obtain critical technology	11	33	33
26 Capability to improve manufacturing processes	19	29	29
27 Upstream materials and supplies	19	27	27
28 Downstream tactical alliances	17	27	27

Second, the study also examines communalities of the 18 indices as criteria to select index. We divided the 18 indices into two groups-financial indices and non-financial indices. The financial group has 13 indices and the non-financial group has 5 indices. For the financial group, in line with the principal component -the values of communalities, we deleted the indicators, permanent capital to fixed assets and debt ratio of which extraction values of communalities are lower than 0.2 (see Table 2). Thus, 11 out of 13 indices are remained as shown in Table 3. For the non-financial group, none of index's communalities is lower than 0.2. Thus, all 5 non-financial indices are kept (see Table 4).

Table 2 Communalities for the 18 indices including financial and non-financial indices

Communalities

	Initial	Extraction
current ratio	1.000	.283
quick ratio	1.000	.506
cash ratio	1.000	.324
working capital	1.000	.365
permanent capital to fixed	1.000	.167
debt ratio	1.000	.198
inventory turnover	1.000	.571
accounts receivable turnover	1.000	.635
average collection period	1.000	.365
return on assets	1.000	.297
return on stockholder's equity	1.000	.545
return on investment	1.000	.590
net profit margin	1.000	.566
product competitiveness	1.000	.336
market share	1.000	.377
product quality level	1.000	.299
ability to obtain critical technology	1.000	.302
capability to improve manufacturing processes	1.000	.480

Extraction Method: Principal Component Analysis.

Table 3 Communalities for the 11 financial indices

Communalities

	Initial	Extraction
current ratio	1.000	.861
quick ratio	1.000	.628
cash ratio	1.000	.655
working capital	1.000	.634
inventory turnover	1.000	.799
accounts receivable turnover	1.000	.848
average collection period	1.000	.778
return on assets	1.000	.830
return on stockholder's equity	1.000	.698
return on investment	1.000	.641
net profit margin	1.000	.568

Extraction Method: Principal Component Analysis.

Table 4 Communalities for the 5 non-financial indices

Communalities

	Initial	Extraction
product competitiveness	1.000	.567
market share	1.000	.610
product quality level	1.000	.786
ability to obtain critical technology	1.000	.484
capability to improve manufacturing processes	1.000	.435

Extraction Method: Principal Component Analysis.

III. TECHNICAL INDICES AND ANALYSIS RESULTS

3.1 Financial and non-financial indices

Financial analysis can help managers identify major strength and weakness of a business. It is frequently used to evaluate business performance. There are 4 popularly financial abilities: liquidity/debt paying ability, financial structure/stability ability, activity/efficiency ability, and profitability. In the following, we list the equation for each financial index and its frequency appeared in business performance related papers in the past few years.

Liquidity/debt paying ability means that businesses are able to pay short term debt paying. It includes current ratio, quick ratio, and cash ratio. The equations of these ratios are giving as follows:

Index	Frequency
current ratio $= (\dfrac{current\,assets}{current\,liabilities})$	4
Quick ratio $= (\dfrac{current\,assets - inventory}{current\,liabilities})$	3
Cash ratio $= (\dfrac{cash\,equivalents + marketable\,securities}{current\,liabilities})$	1

Financial structure/stability represents the ability to pay total current liabilities or long term debt. It indicates the company's risk exposure in meeting debt services charges. There are four common uses of indices as follows:

Index	Frequency
Permanent capital to fixed assets $= (\dfrac{permanent\,capital}{fixed\,assets})$	1
Debt ratio $= (\dfrac{total\ \ debt}{total\ \ assets})$	4
Times interest earned $= (\dfrac{earnings\,before\,interest\,and\,taxes(EBT)}{interest\,charges})$	1
Debt-to-equity $= (\dfrac{total\,debt}{shareholders\,equity})$	0

Activity /efficiency ability assesses how efficiently a firm is using resources. It commonly consists of inventory turnover, total asset turnover, accounts receivable turnover, fixed asset turnover, fixed asset turnover, average collection period, and working capital.

Index	Frequency
Inventory turnover $= (\dfrac{\text{cost of goods sold}}{\text{average inventory}})$	**2**
Total asset turnover $= (\dfrac{\text{net sales}}{\text{average total assets}})$	**3**
Accounts receivable turnover $= (\dfrac{\text{net sales}}{\text{average gross receivable}})$	1
Fixed asset turnover $= (\dfrac{\text{net sales}}{\text{average fixed assets}})$	1
Average collection period $= (\dfrac{\text{accounts receivable}}{\text{credit sales/365}})$	1
working capital $= (\text{current assets} - \text{current liabilities})$	1

Profitability measures a firm's ability to generate profit or operation profit on sales, assets, and owners' investment. It contains five indices, return on assets, return on stockholders' equity, return on investment, net profit margin, and gross profit margin as shown below:

Index	Frequency
Return on assets $= (\dfrac{\text{profit}}{\text{total assets}})$	4
Return on stockholders' equity $= (\dfrac{\text{earnings after taxes(EAT)}}{\text{stockholders' equity}})$	3
Return on investment $= (\dfrac{\text{earnings after taxes(EAT)}}{\text{total assets}})$	3
Net profit margin $= (\dfrac{\text{earnings after taxes (EAT)}}{\text{sales}})$	1
Gross profit margin $= (\dfrac{\text{sales - cost of sales}}{\text{sales}})$	1

For non-financial dimension, there are five critical indices including marketability of technology, competition performance, manufacturing capability, innovation capability, and supply-chain relationships. Product competitiveness is mainly composed of product competitiveness and competition performance is composed of market share. With respect to manufacturing capability, it can be classified into two parts: productivity and product quality level. Innovation capability can be divided into four parts: number of patents, R&D expenditure ratio, ability to obtain critical technology, and capability to improve manufacturing processes. Supply-chain relationships consist of upstream materials and supplies, and downstream tactical alliances.

Dimension	Index
Marketability of technology	Product competitiveness
Competition performance	Market share
Manufacturing capability	Productivity
	Product quality level
Innovation capability	Number of patents
	R&D expenditure ratio
	Ability to obtain critical technology
	Capability to improve manufacturing processes
Supply-chain relationships	Upstream materials and supplies
	Downstream tactical alliances

3.2 Analysis results

In order to know whether the indices are suitable for processing factor analysis, Kaiser-Meyer-Olkin and Bartlett's test of sphericity test are examined. When we tested the 18 indices, Table 5 shows the KMO value for the 18 indices is 0.617>0.5, which means that factor analysis is mediocre. Although the value of the Bartlett's test of sphericity, 0.0 <0.05, shows that the data are the multivariate normal and acceptable for factor analysis. However, when we only considered financial indices and deleted the extraction

of which value is less than 0.2, there remain 11 financial indices. Then, while we tested 11 financial indices after deleting permanent capital to fixed assets and debt ratio, the KMO value was increased to 0.765>0.5(see Table 6). The value means that conducting factor analysis is good enough. Moreover, the value of Chronbach's alpha provides a measure of internal consistency. The closer the alpha is to 1, the greater the internal consistency of the items being assessed. The value of Chronbach's alpha is 0.896 and demonstrates excellent internal consistency. Apparently there is no any alpha value of variable which would increase if the variable is deleted from Table 7. Finally, in Table 8, we select three factors with eigenvalues larger than 0.98 and their accumulate percentage of variance is 72.174. Table 9 shows the component matrix before rotation. Owing to the values of components 2 and 3 with low values, Table 9 needs to be done a rotation. Table 10 illustrates the rotated component matrix. According to Table 2.10, three factors are named as (1) Profitability Ability-return on assets, return on stockholders' equity, return on investment, and net profit margin, (2) Efficiency Ability-average collection period, accounts receivable turnover, inventory turnover, working capital, and (3) Liquidity-current ratio, quick ratio, and cash ratio. Additionally, the non-financial 5 indices are included as the fourth factor. Its KMO value for the 5 non-financial indices is 0.759>0.5, which means that factor analysis is also good enough. Furthermore, the value of the Bartlett's test of sphericity, 0.0 <0.05, shows that the data are the multivariate normal and acceptable for factor analysis (see Tables 11 and 12). Consequently, there are four factors with 16 indices to process the AHP method to determine the weight of each index.

Table 5 KMO and Bartlett's Test for the 18 indices

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.617
Bartlett's Test of Sphericit	Approx. Chi-Square	366.893
	df	153
	Sig.	.000

Table 6 KMO and Bartlett's test for the 11 financial indices after deleted permanent capital to fixed assets and debt ratio

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.765
Bartlett's Test of Sphericity	Approx. Chi-Square	200.054
	df	55
	Sig.	.000

Table 7 Item-Total Statistics

Item-Total Statistics

	cale Mean i tem Deleted	cale Varianc Item Delete	Corrected Item-Total Correlation	Cronbach's Alpha if tem Deleted
current ratio	42.5588	23.527	.490	.894
quick ratio	42.5000	21.591	.684	.883
cash ratio	42.2647	23.291	.540	.891
working capital	42.3235	22.832	.532	.892
inventory turnover	42.4118	20.553	.712	.881
accounts receivable tu	42.2647	20.988	.783	.877
average collection per	42.4118	21.765	.566	.891
return on assets	42.4706	22.863	.498	.894
return on stockholder'	42.2647	21.534	.688	.883
return on investment	42.4412	21.830	.718	.881
net profit margin	42.2647	21.958	.669	.884

Table 8 Total variance explained for the 11 financial indices

Total Variance Explained

Comp	Initial Eigenvalues			ion Sums of Squared Lo			on Sums of Squared Lo		
	Total	of Varia	mulative	Total	of Varia	mulative	Total	of Varia	mulative
1	5.466	49.691	49.691	5.466	49.691	49.691	3.144	28.581	28.581
2	1.487	13.521	63.212	1.487	13.521	63.212	3.001	27.283	55.864
3	.986	8.962	72.174	.986	8.962	72.174	1.794	16.311	72.174
4	.735	6.682	78.857						
5	.646	5.869	84.726						
6	.515	4.686	89.411						
7	.370	3.362	92.773						
8	.265	2.411	95.184						
9	.242	2.202	97.386						
10	.182	1.656	99.041						
11	.105	.959	00.000						

Extraction Method: Principal Component Analysis.

Table 9 Component matrix for the 11 financial indices

Component Matrix[a]

	Component		
	1	2	3
accounts receivable turno	.844	-.225	-.291
inventory turnover	.788	-.170	-.386
return on investment	.781	.150	-.095
quick ratio	.759	-.051	.222
return on stockholder's ed	.749	.371	.012
net profit margin	.744	.115	.025
average collection period	.638	.555	-.250
cash ratio	.630	-.479	-.170
working capital	.616	-.481	.151
return on assets	.564	.582	.415
current ratio	.575	-.352	.638

Extraction Method: Principal Component Analysis.
a. 3 components extracted.

Table 10 Rotated Component matrix for the 11 financial indices

Rotated Component Matrix[a]

	Component		
	1	2	3
return on assets	.836	-.162	.322
average collection period	.816	.281	-.179
return on stockholder's equ	.766	.295	.156
return on investment	.611	.487	.173
net profit margin	.570	.412	.272
accounts receivable turnov	.354	.828	.195
inventory turnover	.353	.818	.072
cash ratio	.031	.745	.314
current ratio	.149	.183	.898
working capital	.042	.553	.571
quick ratio	.467	.391	.507

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.
  a. Rotation converged in 7 iterations.

Table 11 KMO and Bartlett's Test for the 5 non-financial indices

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy		.759
Bartlett's Test of Sphericit	Approx. Chi-Square	58.066
	df	10
	Sig.	.000

Table 12 Total variance explained for the 5 non-financial indices

Total Variance Explained

	Initial Eigenvalues			action Sums of Squared Loadi		
Compon	Total	of Varian	umulative	Total	of Varian	umulative
1	2.883	57.658	57.658	2.883	57.658	57.658
2	.868	17.365	75.024			
3	.604	12.071	87.094			
4	.397	7.932	95.026			
5	.249	4.974	100.000			

Extraction Method: Principal Component Analysis.

IV. CONCLUSION AND FUTURE WORKS

This paper constructs a business performance evaluation model by using financial and non-financial index model. We examined more than 40 indices for evaluating business performance through literature review. 28 out of 40 indices are chosen as critical indices. Next, a two-stage expert meeting and questionnaire have been done to count the total number of "Important" and "Very Important" for each financial and non-financial index. After that, we also used the principal component -the values of communalities, to select the indictors. Consequently, 16 out of 28 indices are remained for evaluating business performance. Finally, the principal component is adopted for running factor analysis. Based on the result of factor analysis, there are four factors named as (1) Profitability Ability-return on assets, return on stockholders' equity, return on investment, and net profit margin, (2) Efficiency Ability- average collection period, accounts receivable turnover, inventory turnover, working

capital, and (3) Liquidity- current ratio, quick ratio, and cash ratio. Additionally, the non-financial 5 indices are included as the fourth factor. Consequently, there are four factors with 16 indices to process the AHP method to determine the weight of each index.

At present, an AHP method is being applied to calculate the priority, weight, of the 16 selected financial and non-financial factors for measuring business performance. Once the model is built, we will develop an artificial neural network to automatically classify the level of business performance for each company in the same industry. Hence, each business knows what business performance it is and what position the company is. Then a decision support system will be created and the DSS can provide vital suggestions to top-level managers for running the company.

REFERENCES

[1] S. Dwyer, O. C. Richard, & K. Chadwick, "Genderdiversity in management and firm performance: the influence of growth orientation and organizational culture," *Journal of Business Research*, 56, 2003, pp.1009-1019.

[2] C.H. Gibson, "Financial reporting and analysis," *South-western CENGAGE Learning*, 2009.

[3] D. Gursoy, & N. Swanger, "Performance-enhancing internal strategic factors and competencies: Impacts on financial success." *Hospitality Management*, 26, 2007, pp. 213-227.

[4] Z. Hoque, "A contingency model of the association between strategy, environmental uncertainty and performance measurement: impact on organizational performance," *International Business Review,* 13, 2004, pp.485-502.

[5] M. Lam, "Neural network techniques for financial performance prediction:integrating fundamental and technical analysis," *Decision Support systems*, 37, 2004, pp.567-581.

[6] M. J. Lebas, "Performance measurement and performance management," *Internatinal Journal of Production Economics,* 41, 1995, pp.23-35.

[7] C. Lin,, W. S. Chow, C. N. Madu,, C. H. Kuei,, & P. P. Yu, "A structural equation model of supply chain quality management and organizational performance," *Int. J. Production Economics*, 96, 2005, pp. 355-365.

[8] A. S. Maiga, & F. A. Jacobs, "The Association between benchmarking and organizational performance: an empirical investigation," *Managerial Finance*, 30, 2004, pp.13-33.

[9] J.R. McGuigan, W.J. Kretlow, R.C. Moyer, Contemporary corporate finance," *South-western CENGAGE Learning, 2009*.

[10] M. E. Qcal, E. L. Oral,, E. Erdis,, & G. Vural, "Industry financial ratios-application of factor analysis in Turkish construction industry," *Building and Environment, 42,* 2007, pp.385-392.

[11] S. Y. Sohn,, H. S. Kim,, & T. H. Moon, "Predicting the financial performance index of technology fund for SEM using structural equation model," *Expert Systems with Applications, 32*, 2007, pp.890-898.