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POST PANDEMIC DIGITAL TRANSFORMATION AND COMPARATIVE ANALYSIS OF ICT FIRMS IN THE STOCK EXCHANGE OF THAILAND USING TOPSIS TECHNIQUE

Abstract:

Thailand's information and communications technology (ICT) sector is experiencing rapid growth according to several factors including increase in technology adoption and government initiatives. This study aims to propose a multi-criteria decision-making (MCDM) model to measure and to compare the financial performance of eighteen ICT firms listed firms in Stock Exchange of Thailand. These firms are examined and assessed using eight financial ratios including liquidity, profitability, leverage, operating and market value ratios collected from Thompson Reuters for three-year time period between 2021 and 2023 in order to obtain a financial performance score using Technique for Order Preference by Similarity to Ideal Solution Methods (TOPSIS). This study also examines whether the firms can keep their ranking position throughout the three years. This could provide investors an additional piece of information in making investment decisions.

Keywords:

Multi-Criteria Decision Making (MCDM), TOPSIS, ICT Sector, Thailand

JEL Classification: M15, L66, C60

I. INTRODUCTION

The COVID-19 pandemic has significantly accelerated the trend of digital connectivity, influencing the growth of the Information Technology (IT) market in the near future. The rapid growth of technology has considerably enhanced convenience in everyday life and provided businesses with opportunities to advance cost-effectively. This has contributed to the development of a stable and modern economy. Post-COVID-19, technology trends are increasingly driven by AI and sustainability that is changed from the Internet of Things (IoT), which connects the world to humans, to leveraging large-scale data to enable organizations to engage better with consumers in the future. This approach, known as the Internet of Behavior (IoB), is an extension of IoT, focusing on collecting data to drive behavioral change. This surge in digital adoption is expected to have a lasting impact on the IT market, driving further investments in cloud computing, cybersecurity, and other digital solutions. According to Gartner, Inc., worldwide IT spending is projected to reach \$5.26 trillion in 2024, reflecting a 7.5% increase from 2023. This updated forecast indicates a slight reduction from the previous quarter's prediction of 8% growth. Despite the adjustment, the overall spending forecast has increased from \$5.06 trillion, underscoring strong global demand for IT services and solutions.

(<https://www.gartner.com/en/newsroom/press-releases/2024-07-16-gartner-forecasts-worldwide-it-spending-to-grow-7-point-5-percent-in-2024>)

The Thai ICT (Information and Communications Technology) market is set to experience substantial growth over the next five years, with an expected CAGR (Compound Annual Growth Rate) of 7.5%. This growth is driven by increased spending on hardware and software services as businesses and consumers invest more in technology solutions. Global leaders such as IBM, Huawei Technologies, Cisco Systems, Dell Technologies, and Amazon play a significant role in this market. Their dominance reflects the demand for advanced ICT infrastructure and services in Thailand. (Source: <https://www.mordorintelligence.com/industry-reports/thailand-ict-market>)

The rapid expansion of the ICT sector indicates a strong appetite for digital transformation, cloud computing, cybersecurity, and other technology-driven solutions within the country. Therefore, investors and firms in the ICT sector are expected to greatly benefit from this initiative, making it a potential investment opportunity.

II. LITERATURE REVIEW

I. Financial Performance Evaluation

Evaluating the financial performance of a company is important for both current and potential investors. Performance evaluation of companies is generally done within financial analyses. Financial ratios derived from the data in income statements and balance sheets are considered as crucial measurement tools in determining performance and financial assets of companies. Financial ratio analysis can help

investors in making investment decisions and predicting firm's future performance (Bulgurcu, 2013; Feng & Wang, 2000; Yadav et al, 2016).

Profitability Ratio

These ratios are used not only to evaluate the financial viability of a firm but are essential in comparing one firm to others in the same industry (Yu, 2013).

- **Return on Asset (ROA)**

The return on assets (ROA) shows the percentage of how profitable a company's assets are in generating revenue. ROA is often used as a proxy from firm performance.

- **Return on Equity (ROE)**

The return on equity (ROE) is a measure of the profitability of a firm in relation to equity. ROE is a measure of how well a company uses investments to generate earnings growth. ROE can also be often used as a proxy from firm performance.

Liquidity Ratio

These measure the amount of liquidity (cash and easily converted assets) that a company must cover debts.

- **Current Ratio**

Current ration indicates a company's ability to pay off short-term liabilities with current assets

- **Quick Ratio**

The quick ratio is an indicator of a company's short-term liquidity position and measures a company's ability to meet its short-term obligations with its most liquid assets.

Efficiency Ratio

The efficiency ratios measure the ability of a company to utilize its assets to generate income and manage its liabilities effectively in the current period or in the short term.

- **Asset Turnover (AT)**

The efficiency ratios measure the efficiency of a company's use of its assets in generating sales revenue or sales income to the company. Companies with low profit margins tend to have high asset turnover, while those with high profit margins have low asset turnover.

Leverage Ratio

The leverage financial ratio indicates the company's dept level. There are many different leverage ratios, namely Debt to Equity, Debt to Capital, and Debt to Assets.

- **Debt to Equity Ratio (DE)**

The debt-to-equity ratio (D/E ratio) is the value of total debt and financial liabilities against shareholder's equity. Debt to Equity ratio is perhaps the most popular leverage ratio and commonly used in corporate finance.

Market Ratio

The market value ratios help to evaluate the current share price of a publicly held company's stock. These ratios are used for investment decision making to decide whether a company's shares are over-priced or underpriced.

- **Dividend Yield (DY)**

The Dividend Yield ratio shows the company's annual dividend paid divided by the share price of stock. The dividend yield is represented as a percentage.

- **Price-Earnings Ratio (P/E)**

The price-earnings ratio (P/E ratio) is the ratio for measuring the expected performance of companies to calculate by the current market price of a share, divided by the earnings per share of the stock (EPS).

II. Multiple Criteria Decision Making (MCDM)

The application of Multiple Criteria Decision Making (MCDM) methods significantly improves the robustness of financial analysis and business decisions (*Kou et.al, 2014*). MCDM provides decision makers and analysts with a wide range of methodologies, well-suited to the complexity of economical decision problems. Available methodologies and their application for economic decisions are broadly overviewed by *Zavadskas and Turskis (2011)*. Several important new concepts and trends for solving actual multiple criteria problems are considered by *Liou and Tzeng (2012)*.

Performance evaluation and ranking results enable the firms to see their weaknesses and define their financial strategies. Also, according to *Li and Sun (2008)*, ranking as a practical tool ensures the survival of the firms in the sector. Sales profits and profitability on capital, which was previously used to measure financial performance, do not today suffice to evaluate the financial indicators. MCDM methods for ranking are widely used in various area of studies (*Sotoudeh-Anvari,2022*); in Finance (*Bulgurcu, 2012; Kou et.al, 2014, Abdel-Basset et al., 2020*), automotive (*Ecer 2021*) and renewable energy (*Lee & Chang, 2018*), for example.

Entropy weight method

The term entropy was proposed by *Shannon (1948, cited in Lin 1991)* which is based on estimate the data quantity and calculates objective weight of the information. It is called entropy weight method. It is an average amount of information. The entropy technique was introduced as a concept of information theory. Entropy means the average amount of information. Entropy weight method is commonly used to measures value dispersion in decision-making (*Olson, 2004; Zou et al., 2006*). The main use of informational entropy is to measure message uncertainty. If the entropy value is high, then uncertainty will be greater. However, when there are too many zero values in the measured values, the effectiveness of entropy weight method is questionable (*Zhu et al., 2020*).

TOPSIS

TOPSIS (Technique for Order Performance by Similarity to Ideal Solution) method for solving Multiple Criteria Decision Making (MCDM) problems based on the concept that the chosen solution should have the shortest Euclidian distance from the Positive Ideal Solution (PIS) and the farthest from the Negative Ideal Solution (NIS). The method is widely used with over 331,000 citations in google scholar (*cited in 10 September 2024*) according to its rational and simple to understand. The ideal solution should have a rank of one (the highest rank), while the worst alternative should have the lowest rank, and each alternative would have some intermediate ranking between the ideal solution extremes. Regardless of absolute accuracy of rankings, comparison of number of different alternatives under the same set of selection criteria allows accurate weighting of relative suitability and hence optimal selection.

TOPSIS has been widely used in various areas (*Deng et al., 2000; Behzadian et al, 2012; Hsu, 2013, Vafaei et al.,2018; Palczewski & Sałabun, 2019*) such as purchase decisions (*Jolai et al., 2011*), manufacturing decision making (*Mathew et al., 2020*), financial performance analysis (*Ban et al.,2020; Bulgurcu, 2012; Wang 2014, Yalcin et al.,2012*). In this research, the entropy technique is applied to determine the criteria weights which are used for TOPSIS method.

III. DATA COLLECTION AND RESEARCH METHODOLOGY

Data Source

Three years panel data (2021-2023) of ICT listed companies in Thailand Stock Exchange were collected from DataStream Internation (*Refinitiv Eikon & DataStream*) and Stock Exchange of Thailand.

Financial Ratio

In the study, five main criteria were identified: Profitability, Liquidity, Efficiency, Leverage, and Market Value. Eight financial ratios, as shown in Table 1, are taken as criteria in evaluating firm financial performance.

Table 1: Financial Ratio

Financial Ratio		Definition
Profitability Ratio	ROA	Return on Asset = Net Income / Total Assets
	ROE	Return on Equity = Net Income / Shareholder's equity
Liquidity Ratio	CR	Current Ratio = Current Assets / Current Liabilities
	QR	Quick Ratio = (Current Assets-Inventories) / Current Liabilities
Operation Ratio	AT	Asset Turnover =Net Operating Revenue / Total Assets
Leverage Ratio	DE	Debt to Equity Ratio =Total Liabilities / Shareholder's Equity

Market Ratio	DY	Dividend yield ratio = Dividend per Share/Share Price
	PE	Price-to-Earnings Ratio = Share Price / Earnings Per Share

Mathematically the application of the entropy TOPSIS method involves the following steps.

Step 1: Construct the Decision Matrix and determine the normalized decision matrix. In this paper, we use vector normalization as it is the most suitable normalization technique for TOPSIS method [12].

$$\bar{X}_{ij} = \frac{X_{ij}}{\sqrt{\sum_{j=1}^n X_{ij}^2}} \quad \dots$$

(1)
where $i=1, 2, \dots, 18$ and $j=1, 2, \dots, 8$

Step 2: Obtain an entropy weight

$$w_{ij} = \frac{1 - e_j}{\sum_{j=1}^n (1 - e_j)} \quad \dots (2)$$

where $i=1, 2, \dots, 18$ and $j=1, 2, \dots, 8$

$$e_j = -\frac{1}{\ln(m)} \sum_{i=1}^m P_{ij} \ln(P_{ij}) \quad \dots (3)$$

$$P_{ij} = \frac{X_{ij}}{\sum_{i=1}^m X_{ij}} \quad \dots (4)$$

The calculated entropy weights are shown in *Table 2*. The three highest-weighted sub-criteria for 2021 and 2022 are the Return on Equity (ROE), Return on Asset (ROA), and Current Ratio (CR) respectively. However, in 2023, the highest-weighted sub-criteria has changed to Dividend yield ratio (DY) followed by Return on Asset (ROA) and Asset Turnover (AT).

Table 2: entropy weight of the evaluation criteria

Year	ROA	ROE	CR	QR	AT	DE	DY	PE
2021	0.1326	0.1366	0.1271	0.1268	0.1234	0.1032	0.1245	0.1257
2022	0.1313	0.1444	0.1288	0.1254	0.123	0.0982	0.1257	0.1232
2023	0.1456	0.1213	0.0861	0.0793	0.1417	0.1398	0.1464	0.1398

Step 3: Construct the weighted normalized decision matrix

$$\{r_{ij} = w_{ij} \overline{X_{ij}}\} \quad \dots (5)$$

Step 4: Determine the PIS (v^+) and the NIS (v^-)

$$V^+ = \{r_1^+, r_2^+, \dots, r_n^+\} = \{(\max(r_{ij}) | j \in I), (\min(r_{ij}) | j \in I)\} \quad \dots (6)$$

$$V^- = \{r_1^-, r_2^-, \dots, r_n^-\} = \{(\max(r_{ij}) | j \in I), (\min(r_{ij}) | j \in I)\} \quad \dots (7)$$

Step 5: Compute the Euclidean distance of each alternative Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS)

$$d_i^+ = \sqrt{\sum_{j=1}^n (r_{ij} - r_j^+)^2} \quad \dots (8)$$

$$d_i^- = \sqrt{\sum_{j=1}^n (r_{ij} - r_j^-)^2} \quad \dots (9)$$

Step 6: Determine the ranking performance order of the alternative

$$C_i = \frac{d_i^-}{(d_i^- + d_i^+)} \quad \dots (10)$$

Table 3: Weighted normalized decision matrix, Year 2021

Company	ROA	ROE	CR	QR	AT	DE	DY	PE
ADVANC	0.0296	0.0484	0.0052	0.0048	0.0117	0.0161	0.0256	0.0222
AIT	0.0302	0.0249	0.0280	0.0237	0.0260	0.0042	0.0321	0.0139
DITTO	0.0648	0.0403	0.0515	0.0509	0.0248	0.0018	0.0000	0.0755
FORTH	0.0380	0.0681	0.0135	0.0091	0.0237	0.0174	0.0128	0.0241
HUMAN	0.0316	0.0173	0.0363	0.0375	0.0111	0.0014	0.0104	0.0449
ICN	0.0431	0.0352	0.0459	0.0428	0.0337	0.0035	0.0301	0.0126
ILINK	0.0193	0.0160	0.0149	0.0135	0.0128	0.0091	0.0151	0.0150
INET	0.0150	0.0111	0.0062	0.0064	0.0049	0.0172	0.0000	0.0126
INTUCH	0.0565	0.0386	0.0348	0.0370	0.0016	0.0009	0.0265	0.0210
JAS	0.0078	-0.0508	0.0050	0.0047	0.0047	0.0969	0.0604	0.0000
JMART	0.0314	0.0332	0.0295	0.0272	0.0078	0.0051	0.0070	0.0634
MFEC	0.0171	0.0186	0.0053	0.0131	0.0215	0.0087	0.0312	0.0156

MSC	0.0215	0.0144	0.0289	0.0256	0.0504	0.0032	0.0378	0.0132
PT	0.0222	0.0196	0.0070	0.0104	0.0320	0.0065	0.0714	0.0131
SVOA	0.0117	0.0097	0.0143	0.0117	0.0332	0.0069	0.0146	0.0141
SYMC	0.0145	0.0071	0.0118	0.0119	0.0036	0.0037	0.0067	0.0247
SYNEX	0.0286	0.0319	0.0191	0.0134	0.0886	0.0115	0.0134	0.0377
THCOM	0.0066	0.0018	0.0783	0.0834	0.0053	0.0023	0.0160	0.0000

Table 4: Weighted normalized decision matrix, Year 2022

Company	ROA	ROE	CR	QR	AT	DE	DY	PE
ADVANC	0.0313	0.0458	0.0055	0.0050	0.0131	0.0117	0.0286	0.0176
AIT	0.0329	0.0235	0.0365	0.0320	0.0269	0.0028	0.0363	0.0120
DITTO	0.0573	0.0273	0.0617	0.0650	0.0215	0.0017	0.0002	0.0981
FORTH	0.0391	0.0601	0.0139	0.0093	0.0235	0.0099	0.0102	0.0290
HUMAN	0.0227	0.0100	0.0398	0.0437	0.0098	0.0007	0.0086	0.0536
ICN	0.0406	0.0245	0.0458	0.0480	0.0310	0.0035	0.0434	0.0189
ILINK	0.0215	0.0160	0.0213	0.0200	0.0150	0.0043	0.0397	0.0077
INET	0.0206	0.0132	0.0049	0.0048	0.0048	0.0145	0.0059	0.0154
INTUCH	0.0623	0.0403	0.0144	0.0157	0.0000	0.0008	0.0266	0.0187
JAS	0.0059	-0.0868	0.0041	0.0043	0.0053	0.0941	0.0000	0.0000
JMART	0.0215	0.0146	0.0322	0.0275	0.0070	0.0032	0.0258	0.0155
MFEC	0.0140	0.0172	0.0205	0.0138	0.0220	0.0082	0.0365	0.0111
MSC	0.0233	0.0178	0.0247	0.0190	0.0581	0.0048	0.0293	0.0092
PT	0.0342	0.0371	0.0204	0.0070	0.0349	0.0088	0.0710	0.0108
SVOA	0.0098	0.0082	0.0185	0.0125	0.0291	0.0060	0.0170	0.0116
SYMC	0.0168	0.0083	0.0119	0.0122	0.0106	0.0033	0.0093	0.0148
SYNEX	0.0250	0.0272	0.0209	0.0157	0.0825	0.0119	0.0324	0.0127
THCOM	0.0062	0.0005	0.0625	0.0688	0.0054	0.0022	0.0158	0.0318

Table 5: Weighted normalized decision matrix, Year 2023

Company	ROA	ROE	CR	QR	AT	DE	DY	PE
ADVANC	0.0233	0.0166	0.0004	0.0003	0.0141	0.0733	0.0263	0.0287
AIT	0.0223	0.0065	0.0034	0.0026	0.0296	0.0113	0.0534	0.0160
DITTO	0.0366	0.0109	0.0055	0.0048	0.0220	0.0067	0.0002	0.0785
FORTH	0.0227	0.0138	0.0012	0.0006	0.0255	0.0437	0.0168	0.0398
HUMAN	0.0203	0.0053	0.0057	0.0056	0.0099	0.0027	0.0126	0.0424
ICN	0.0279	0.0127	0.0033	0.0032	0.0322	0.0259	0.0496	0.0129
ILINK	0.0184	0.0069	0.0017	0.0013	0.0167	0.0197	0.0210	0.0096

INET	0.0158	0.0048	0.0003	0.0003	0.0050	0.0733	0.0185	0.0116
INTUCH	0.0760	0.0174	0.0854	0.0788	0.0000	0.0000	0.0490	0.0085
JAS	0.0888	0.1136	0.0044	0.0040	0.0152	0.0079	0.0000	0.0177
JMART	0.0076	-0.0012	0.0013	0.0010	0.0073	0.0164	0.0475	0.0000
MFEC	0.0252	0.0150	0.0018	0.0010	0.0290	0.0345	0.0447	0.0048
MSC	0.0193	0.0067	0.0029	0.0019	0.0671	0.0128	0.0336	0.0162
PT	0.0345	0.0187	0.0019	0.0008	0.0507	0.0333	0.0496	0.0123
SVOA	0.0074	0.0022	0.0014	0.0010	0.0422	0.0298	0.0238	0.0172
SYMC	0.0179	0.0057	0.0023	0.0022	0.0142	0.0088	0.0089	0.0175
SYNEX	0.0128	0.0076	0.0028	0.0019	0.0816	0.0455	0.0497	0.0218
THCOM	0.0093	0.0021	0.0087	0.0085	0.0066	0.0072	0.0280	0.0891

The positive ideal solutions (PIS) were generated by selecting the maximum value for the benefit criterion or the minimum value for the cost criterion. Similarly, the negative ideal solutions (NIS) were generated by selecting the minimum value for the benefit criterion or the maximum value for the cost criterion. Both PIS and NIS for the years 2021-2023 are presented in *Table 6*. The Euclidean distances from each alternative to the Positive Ideal Solution (PIS) and Negative Ideal Solution (NIS), denoted as d^+ and d^- respectively, were calculated and the scores were then derived, and the companies were ranked as shown in *Table 7- Table 9*.

Table 6: Distance from Positive Ideal Solution (d^+), Distance from Negative Ideal Solution (d^-), and Ranking

	Year 2021				Year 2022				Year 2023			
	d^+	d^-	C_i	Rank	d^+	d^-	C_i	Rank	d^+	d^-	C_i	Rank
ADVANC	0.6308	0.5111	0.4476	12	0.6077	0.5493	0.4748	13	0.7446	0.3207	0.3011	17
AIT	0.5957	0.5516	0.4808	9	0.5543	0.6032	0.5211	5	0.6844	0.4345	0.3883	8
DITTO	0.4727	0.6600	0.5827	1	0.5739	0.5846	0.5046	10	0.6625	0.4672	0.4136	3
FORTH	0.5977	0.5495	0.4790	10	0.6063	0.5509	0.4761	12	0.7171	0.3783	0.3454	12
HUMAN	0.5846	0.5633	0.4907	8	0.6703	0.4709	0.4126	17	0.7011	0.4070	0.3673	10
ICN	0.5378	0.6082	0.5307	2	0.5722	0.5862	0.5060	8	0.6892	0.4270	0.3825	9
ILINK	0.6572	0.4766	0.4203	15	0.8159	0.0730	0.0821	18	0.7314	0.3497	0.3235	15
INET	0.7002	0.4109	0.3699	17	0.6031	0.5544	0.4790	11	0.7797	0.2223	0.2218	18
INTUCH	0.5606	0.5872	0.5116	4	0.6144	0.5419	0.4687	14	0.5251	0.6177	0.5405	1
JAS	0.771	0.2544	0.2481	18	0.5725	0.5859	0.5058	9	0.5958	0.5498	0.4799	2
JMART	0.5788	0.5693	0.4959	5	0.5459	0.6108	0.5281	3	0.7374	0.3368	0.3135	16
MFEC	0.6447	0.4935	0.4336	13	0.6354	0.517	0.4486	15	0.7098	0.3916	0.3556	11
MSC	0.5836	0.5643	0.4916	7	0.6511	0.4971	0.4330	16	0.6752	0.4488	0.3993	6
PT	0.6001	0.5468	0.4768	11	0.5476	0.6093	0.5267	4	0.6749	0.4491	0.3996	5
SVOA	0.6534	0.4819	0.4245	14	0.5618	0.5961	0.5148	6	0.7248	0.3632	0.3338	13
SYMC	0.6728	0.4543	0.4031	16	0.4185	0.7042	0.6273	1	0.7286	0.3556	0.3280	14

SYNEX	0.5551	0.5924	0.5163	3	0.563	0.595	0.5138	7	0.6769	0.4462	0.3973	7
THCOM	0.5833	0.5647	0.4919	6	0.5057	0.6444	0.5603	2	0.6676	0.4600	0.4079	4

Figure 1: TOPSIS Ranking, Year 2021 – 2023

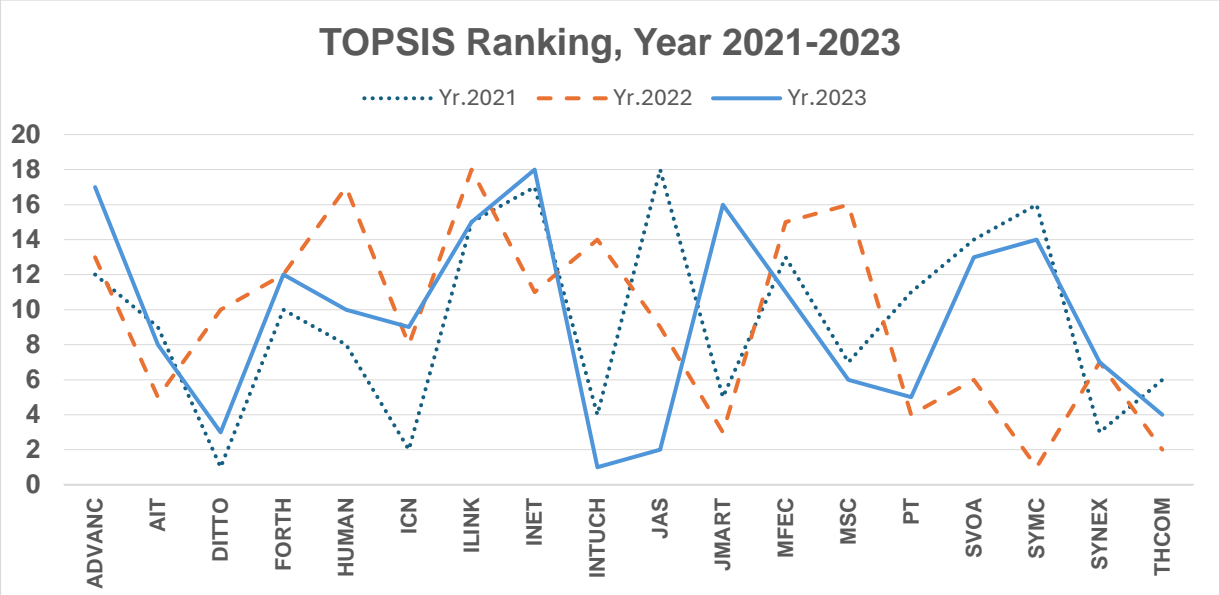


Table 7: The results of entropy-based TOPSIS model for financial performance evaluation, Year 2021

Year 2021	Profitability Ratio		Liquidity Ratio		Operation	Leverage	Market Ratio		TOPSIS
Company	ROA	ROE	CR	QR	AT	DE	DY	PE	
ADVANC	8	2	17	17	11	4	8	7	12
AIT	7	8	8	8	6	11	4	12	9
DITTO	1	3	2	2	8	16	17	1	16
FORTH	4	1	12	15	7	2	12	5	1
HUMAN	5	11	4	5	12	17	14	3	3
ICN	3	5	3	3	5	14	6	16	6
ILINK	12	12	10	9	10	5	9	10	10
INET	14	14	15	16	14	3	17	15	8
INTUCH	2	4	4	4	18	18	7	8	2
JAS	17	18	18	18	16	1	2	17	15
JMART	6	6	6	6	13	10	15	2	17
MFEC	13	10	16	10	9	7	5	9	4
MSC	11	13	7	7	2	12	3	13	18
PT	10	9	14	14	4	9	1	14	5
SVOA	16	15	11	12	3	8	11	11	13
SYMC	15	16	13	13	17	13	16	6	7
SYNEX	9	7	9	11	1	6	13	4	11
THCOM	18	17	1	1	14	15	9	17	14

Table 8: The results of entropy-based TOPSIS model for financial performance evaluation, Year 2022

Year 2022	Profitability Ratio		Liquidity Ratio		Operation	Leverage	Market Ratio		TOPSIS
Company	ROA	ROE	CR	QR	AT	DE	DY	PE	
ADVANC	7	2	16	16	11	3	8	7	13
AIT	6	8	5	5	6	12	5	11	5
DITTO	2	5	2	2	9	16	17	1	1
FORTH	4	1	14	14	7	4	13	4	10
HUMAN	10	14	4	4	13	18	15	2	7
ICN	3	7	3	3	4	13	2	6	2
ILINK	11	11	8	7	10	10	3	17	12
INET	13	13	17	17	17	2	16	9	17
INTUCH	1	3	13	9	18	17	9	5	8
JAS	18	18	18	18	15	1	18	18	18
JMART	12	12	6	6	14	11	10	8	11
MFEC	15	10	9	11	8	7	4	14	14
MSC	9	9	7	8	2	9	7	16	9
PT	5	4	11	15	3	6	1	15	3
SVOA	16	16	12	12	4	8	11	13	15
SYMC	14	15	15	13	12	14	14	10	16
SYNEX	8	6	9	10	1	5	6	12	4
THCOM	17	17	1	1	16	15	12	3	6

Table 9: The results of entropy-based TOPSIS model for financial performance evaluation, Year 2023

Year 2023	Profitability Ratio		Liquidity Ratio		Operation	Leverage	Market Ratio		TOPSIS
Company	ROA	ROE	CR	QR	AT	DE	DY	PE	
ADVANC	7	4	17	17	12	1	10	5	17
AIT	9	11	5	6	6	12	1	11	8
DITTO	3	8	6	5	9	16	17	2	14
FORTH	8	6	16	16	8	3	14	4	3
HUMAN	10	15	4	4	14	17	15	3	7
ICN	5	7	8	8	5	8	3	12	4
ILINK	12	9	11	9	10	9	12	15	12
INET	14	13	18	18	17	1	13	14	10
INTUCH	2	3	1	1	18	18	5	16	9
JAS	1	1	3	3	11	14	18	7	15
JMART	17	18	15	13	15	10	6	18	18
MFEC	6	5	10	14	7	5	7	17	1
MSC	11	10	7	7	2	11	8	10	2
PT	4	2	9	15	3	6	4	13	16
SVOA	18	16	13	11	4	7	11	8	11
SYMC	13	13	14	10	13	13	16	9	6
SYNEX	15	12	11	12	1	3	2	6	5
THCOM	16	17	2	2	16	15	9	1	13

The rankings of all listed Information and Communications Technology companies are plotted in *Figure 1*. Based on the collective financial ratio evaluation, most companies could not maintain relatively stable positions. DITTO achieved a significantly highest ranking in 2021 while SYMC ranking is highest ranking in 2022 and INTUCH ranked the highest in 2023. However, ranking in Year 2022 is not related to ranking in Year 2021 and Year 2023.

IV. RESULTS AND CONCLUSION

Table 7-9 show performance ranking of the listed companies in ICT sector using only one financial ratio as a ranking criteria (ROA, ROE, CR, QR, AT, DE, DY and PE) compared with the ranking using an entropy-based TOPSIS method. The top-ranked company using the TOPSIS method for 2021 is FORTH, similar to the result using ROA as a criteria. The top-ranked company using the TOPSIS method for 2021 is FORTH, similar to the result using ROA as a criteria. The first ranked company using TOPSIS for 2022 is DITTO, in the same way to the result using PE. For 2023, MFEC is the top-ranked but no financial ratio support as a ranking criteria. When comparing each year, it is found that no company has been able to maintain its previous ranking using the TOPSIS technique in the post Pandemic situation.

Table 10 shows the results of a Spearman's rank correlation analysis comparing the rankings of companies using the TOPSIS method with rankings based on individual financial ratios. According to the result shown in Year 2021 and Year 2023, the ranking orders generated by the TOPSIS method were significantly correlated with those based on four individual financial ratios; Return on Asset (ROA), Current Ratio (CR), Quick Ratio (QR), and

Debt-to-Equity (DE), at significant level 0.05. However, the finding shows that ranking using individual financial ratios in Year 2022 are not significantly correlated with the TOPSIS ranking. The ranking obtained from TOPSIS and those using Return on Equity alone, are significantly correlated in Year 2021, but not significantly correlated in Year 2022 and Year 2023. Therefore, multi-criteria decision-making is encouraged.

Table 10: The results of Spearman's rank correlation

	Year 2021	Year 2022	Year 2023
ROA	0.699*** <i>0.001</i>	-0.205 <i>0.414</i>	0.540* <i>0.021</i>
ROE	0.577* <i>0.012</i>	-0.257 <i>0.303</i>	0.383 <i>0.117</i>
CR	0.823** <i>0.000</i>	0.073 <i>0.773</i>	0.868** <i>0.000</i>
QR	0.773** <i>0.000</i>	0.036 <i>0.887</i>	0.725** <i>0.001</i>
AT	0.023 <i>0.224</i>	-0.031 <i>0.903</i>	0.166 <i>0.510</i>
DE	-0.639** <i>0.004</i>	-0.053 <i>0.836</i>	-0.608** <i>0.007</i>
DY	-0.101 <i>0.689</i>	-0.059 <i>0.817</i>	0.129 <i>0.610</i>
PE	0.342 <i>0.165</i>	0.055 <i>0.829</i>	0.255 <i>0.307</i>

** Correlation is significant at the 0.01 level (2-tailed).

* Correlation is significant at the 0.05 level (2-tailed).

V. REFERENCES

- Abdel-Basset, M., Ding, W., Mohamed, R., & Metawa, N. (2020). "An integrated plithogenic MCDM approach for financial performance evaluation of manufacturing industries," *Risk management*, 22, 192-218.
- Ban, A. I., Ban, O. I., Bogdan, V., Popa, D. C. S., & Tuse, D. (2020). "Performance evaluation model of Romanian manufacturing listed companies by fuzzy AHP and TOPSIS," *Technological and Economic Development of Economy*, 26(4), 808-836.
- Behzadian, M., Otaghsara, S. K., Yazdani, M., & Ignatius, J. (2012). A state-of-the-art survey of TOPSIS applications. *Expert Systems with applications*, 39(17), 13051-13069.
- Bulgurcu, B. K. (2012). "Application of TOPSIS technique for financial performance evaluation of technology firms in Istanbul stock exchange market," *Procedia-Social and Behavioral Sciences*, 62, 1033-1040.
- Bulgurcu, B. (2013). Financial performance ranking of automotive industry firms in Turkey: Evidence from entropy weighted technique. *International Journal of Economics and Financial Issues*, 3(4), 844-851.
- Chen, K. H., & Shimerda, T. A. (1981). "An empirical analysis of useful financial ratios," *Financial management*, 51-60.

Deng, H., Yeh, C. H., & Willis, R. J. (2000). Inter-company comparison using modified TOPSIS with objective weights. *Computers & Operations Research*, 27(10), 963-973.

Ecer, F. (2021). "A consolidated MCDM framework for performance assessment of battery electric vehicles based on ranking strategies," *Renewable and Sustainable Energy Reviews*, 143, 110916.

Feng, C. M., & Wang, R. T. (2000). Performance evaluation for airlines including the consideration of financial ratios. *Journal of Air Transport Management*, 6(3), 133-142.

Hwang, C. L., Yoon, K., Hwang, C. L., & Yoon, K. (1981). "Methods for multiple attribute decision making," Multiple attribute decision making: methods and applications a state-of-the-art survey, 58-191.

Hsu, L. C. (2013). Investment decision making using a combined factor analysis and entropy-based topsis model. *Journal of business economics and management*, 14(3), 448-466.

Jolai, F., Yazdian, S. A., Shahanaghi, K., & Khojasteh, M. A. (2011). "Integrating fuzzy TOPSIS and multi-period goal programming for purchasing multiple products from multiple suppliers," *Journal of purchasing and Supply Management*, 17(1), 42-53.

Kou, G., Peng, Y., & Wang, G. (2014). "Evaluation of clustering algorithms for financial risk analysis using MCDM methods," *Information sciences*, 275, 1-12.

Lee, H. C., & Chang, C. T. (2018). "Comparative analysis of MCDM methods for ranking renewable energy sources in Taiwan," *Renewable and sustainable energy reviews*, 92, 883-896.

Li, H., & Sun, J. (2008). "Ranking-order case-based reasoning for financial distress prediction," *Knowledge-based systems*, 21(8), 868-878.

Lin, J. (1991). "Divergence measures based on the Shannon entropy," *IEEE Transactions on Information theory*, 37(1), 145-151.

Liou, J. J., & Tzeng, G. H. (2012). "Comments on "Multiple criteria decision making (MCDM) methods in economics: an overview," *Technological and Economic Development of Economy*, 18(4), 672-695.

Mathew, M., Chakraborty, R. K., & Ryan, M. J. (2020). A novel approach integrating AHP and TOPSIS under spherical fuzzy sets for advanced manufacturing system selection. *Engineering Applications of Artificial Intelligence*, 96, 103988.

Olson, D. L. (2004). Comparison of weights in TOPSIS models. *Mathematical and Computer Modelling*, 40(7-8), 721-727.

Palczewski, K., & Sałabun, W. (2019). "The fuzzy TOPSIS applications in the last decade," *Procedia computer science*, 159, 2294-2303.

Singh, A. J., & Schmidgall, R. S. (2002). "Analysis of financial ratios commonly used by US lodging financial executives," *Journal of Retail & Leisure Property*, 2, 201-213.

Shi-fei, D., & Zhong-zhi, S. (2005). Studies on incidence pattern recognition based on information entropy. *Journal of Information Science*, 31(6), 497-502.

Sotoudeh-Anvari, A. (2022). "The applications of MCDM methods in COVID-19 pandemic: A state of the art review," *Applied Soft Computing*, 109238.

Vafaei, N., Ribeiro, R. A., & Camarinha-Matos, L. M. (2018). Data normalisation techniques in decision making: case study with TOPSIS method. *International journal of information and decision sciences*, 10(1), 19-38.

Wang, Y. J. (2014). "The evaluation of financial performance for Taiwan container shipping companies by fuzzy TOPSIS," *Applied Soft Computing*, 22, 28-35.

Yadav, S. K., Kapoor, R., & Dhaigude, A. (2016). Financial performance ranking of oil and gas companies in India using TOPSIS method. *International Journal of Applied Business and Economic Research*, 14(6), 4463-4473.

Yalcin, N., Bayrakdaroglu, A., & Kahraman, C. (2012). "Application of fuzzy multi-criteria decision making methods for financial performance evaluation of Turkish manufacturing industries," *Expert systems with applications*, 39(1), 350-364.

Yu, M. (2013). State ownership and firm performance: Empirical evidence from Chinese listed companies. *China Journal of Accounting Research*, 6(2), 75-87.

Zavadskas, E. K., & Turskis, Z. (2011). "Multiple criteria decision making (MCDM) methods in economics: an overview," *Technological and economic development of economy*, 17(2), 397-427.

Zou, Z. H., Yi, Y., & Sun, J. N. (2006). "Entropy method for determination of weight of evaluating indicators in fuzzy synthetic evaluation for water quality assessment," *Journal of Environmental sciences*, 18(5), 1020-1023.

Zhu, Y., Tian, D., & Yan, F. (2020). "Effectiveness of entropy weight method in decision-making," *Mathematical Problems in Engineering*, 2020, 1-5.