Testing a Simple Financial Alternative to TOPSIS for Financial Performance Measurement

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ABSTRACT

This study investigates performance rankings and return profile of portfolios based on performance scores produced by TOPSIS selection and earnings, and tests an alternative single-criterion ROE decision model to measure performance. Results show that portfolios based on simple profitability ratios perform at least as well as portfolios based on multi-criteria TOPSIS model. The relationship between TOPSIS performance rankings and return rankings is not significant. Of the selection models examined, only portfolios based on ROE tend to provide long term value for investors.

Keywords: *Multi-criteria decision, TOPSIS, ROE, financial performance.*

Jel Classification: *D70, G11, L25.*

Finansal Performans Ölçümünde TOPSIS'e Basit Bir Finansal Alternatifin Test Edilmesi

ÖZET

Bu çalışma TOPSIS seçilimi performans skorlarına ve kazanca dayalı portföylerin getiri profillerini ve performans sıralamalarını inceleyerek performans ölçümü için TOPSIS'e alternatif tek kriterli bir karar modelini test etmektedir. Sonuçlar basit karlılık oranlarına dayalı oluşturulan portföylerin en az TOPSIS modeline göre oluşturulan portföyler kadar iyi performans gösterdiğine işaret etmektedir. TOPSIS performans sıralaması ile getiri sıralaması arasında anlamlı bir ilişki bulunmamıştır. İncelenen seçilim modelleri içinde yalnızca özsermaye karlılığına dayalı portföyler yatırımcılar için uzun vadeli değer sağlamaktadır.

Anahtar Kelimeler: *Çok kriterli karar verme, TOPSIS, ROE, finansal performans.*

JEL Sınıflandırması: *D70, G11, L25.*

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1. INTRODUCTION

Multi-criteria decision models, among them TOPSIS (Technique for Order Preference by Similarity to Ideal Solutions) developed by Hwang and Yoon (1981), are widely applied in the measurement of financial performance in Taiwan and Turkey. Studies typically attempt to capture top performing companies within certain industries, with the aim of creating portfolios that yield superior returns. However, financial applications of these models carry several limitations which remain unaddressed by the existing research. This study intends to explore these limitations and investigate the validity of adapting TOPSIS to the financial concepts, although many of the points this study makes would also apply to other multi-criteria models.

This study identifies two main biases with the financial applications of TOPSIS: subjectivity and relevance. Subjectivity is the weights assigned to each ratio, purporting to show the relative importance of each ratio in the performance. In the classic TOPSIS model, the weights are determined by the researcher, causing subjectivity bias. The scope of subjectivity bias is not limited to financial applications, issues related to subjective weighting are acknowledged by Wang and Lee (2009) and others. Relevance bias arises from the fact that various financial ratios with different functionalities are incorporated into one single TOPSIS score with the aim of obtaining a performance indicator. These often include liquidity ratios, turnover ratios, leverage ratios and profitability ratios. However, how these ratios become relevant to investor decisions is not dwelt on in the prior research. Hwang and Yoon (1981) stipulate that only characteristics considered by decision makers should be included in the model. A consequential issue arising from the relevance dimension is how to interpret the TOPSIS performance score obtained in such manner. TOPSIS blurs the distinction between ratios; one ratio might be useful for investors while another could be useful for creditors and others for policy-makers. Since ratios incorporated into model have different interpretations, what the final score would represent is unclear. It does not represent returns, since returns are computed from share prices, nor any of the ratios used to obtain the score. Producing one single score out of all ratio inputs, TOPSIS makes it hard to determine what this performance score stands for and to whom this score is useful. In the face of these issues, the typical research pattern is manifested such that author ranks companies from highest to lowest TOPSIS score and avoids commenting on performance, only interpreting the ranking of companies in the list. Making an industry-specific list of companies and ordering them from top to bottom scorer does not make economic sense. Two other issues can be identified with this approach. First, it limits the research to one industry, since score comparison must be made within-industry observations. Ratios used to calculate TOPSIS score for one industry might not have the same relevance for others. In practice, however, ratios tend to be uniformly applied across different industries without much regard for their relevance. Second, constructing portfolios based on top performing companies from the same industry does not appear a rational investment strategy since these companies are likely to have similar betas. This investment strategy, then, does not account for the risk factor. An efficient portfolio maximises return at the minimum risk level according to modern portfolio theory (Markowitz, 1952). Although this strategy attempts to maximise return, it does not attempt to minimise risk.

To investigate performance of TOPSIS model, this study employs portfolios constructed from the performance rankings of companies based on ROE (return on equity)

and two other profitability ratios. The TOPSIS procedure followed is similar to prior studies, with the exception of weight calculations. Weights are employed in two ways to alleviate subjectivity bias associated with the model: weights calculated from the normalised decision matrix and equally weighted ratios. Results indicate major inconsistencies between rankings of companies and their market returns. Top ranked companies by TOPSIS scores are often found as underperformers and vice versa. On the other hand, portfolios constructed from top-ranked companies outperform portfolios constructed from bottom-ranked companies in the five periods out of six. Portfolios constructed based on profitability rankings show the same performance, top-ranked portfolios outperforming bottom-ranked portfolios in the exact five periods out of six. However, only rankings based on ROE are significantly correlated with actual returns. This result is consistent with the relevance hypothesis put forward in this study.

This study makes mainly two contributions to the literature. First, it elaborates on the limitations of TOPSIS model with regard to its financial applications. Second, it provides the first test of relevance bias associated with the model and shows that multi-criteria TOPSIS model does not perform better than single-criteria profitability models. The findings would be useful for investors and researchers interested in the financial decision-making alike.

The remainder of the study is organised as follows. Section 2 reviews existing literature. Section 3 discusses selection of an alternative performance measure. Section 4 describes data and methodology. Section 5 presents results of financial performance tests. Section 6 concludes the study.

2. LITERATURE REVIEW

Recent studies extensively use TOPSIS to measure financial performance. The application is, however, mostly limited to certain markets such as Turkey and Taiwan. Feng and Wang (2000; 2001) evaluate performance of airlines and travel companies by a TOPSIS model. Yurdakul and Ic (2003) investigate performance of five Turkish carmakers and compare TOPSIS rankings with corresponding year-end share prices. They find that TOPSIS produces largely consistent rankings with share prices and attribute inconsistent rankings to the unexpected market fluctuations in 2001 financial crisis. Ertugrul and Karakasoglu (2009) use 16 cement firms listed in Borsa Istanbul and a wide array of financial ratios to produce performance rankings. Yükçü and Atagan (2010) examine performance of hotels by TOPSIS scores obtained from four ratios. Dumanoglu and Ergül (2010) use a sample of 11 listed technology firms and conclude that TOPSIS produces consistent performance estimates. Uygurtürk and Korkmaz (2012) construct portfolios based on TOPSIS rankings to investigate whether TOPSIS could be used to make investment choices. They find that top ranked portfolio produces 2.31% average annual return and bottom ranked portfolio produces 2.26% average annual return. They conclude that portfolio selection based on TOPSIS rankings produces superior returns, nonetheless the difference in portfolio returns is negligible and small. Türkmen and Cagil (2012) use TOPSIS to examine 12 informatics firms and produce performance rankings. Temizel and Baycelebi (2015) investigate if TOPSIS scores obtained from financial ratios could be used to select companies that provide the highest returns. Their analysis shows no significant relationship between TOPSIS rankings and returns. Likewise, Orcun and Eren (2017) find no meaningful relationship between TOPSIS rankings and return rankings. They interpret this as an indicator of investor complacence towards financial ratios and firm performance during their investment decisions, which is a forced and far-fetched

argument. A similar false conclusion is made by Ozden et al. (2012), where they interpret absence of correlation between rankings and returns by pointing to investor indifference towards firm performance. Few studies in the literature, among them Ozden et al. (2012), Temizel and Baycelebi (2015), and Orcun and Eren (2017), examine the relation between TOPSIS performance rankings and real share returns and consistently find no correlation between two. In the light of these studies, it is justified to examine whether TOPSIS is a suitable model to measure financial performance and make investment decisions. A comparison of the model performance with a financial alternative would provide useful insights.

3. ROE AS A PERFORMANCE MEASURE

Valuation theory says that price of an asset is equal to the present value of its expected future cash flows. Adopting from Cohen et al. (2002:416), pricing equation can be defined as follows:

$$P_{t-1} = \sum_{t=1}^{\infty} \frac{CF_t}{(1+k)^t} + \varepsilon_{t-1}$$

In the present value equation, three factors determine the price (P_{t-1}): cash flows (CF_t), discount rate (k) and mispricing error (ε_{t-1}). The changes in the price, called return, then depend on the changes in cash flows and discount rate. Assuming correct estimations of cash flows and discount rate, the mispricing error would not exist. Since future cash flows are not known, they have to be estimated or proxied by another variable. In the return decomposition setting of Campbell (1991), stock returns can be decomposed into an expected return component and cash flow component. The cash flow component can then be proxied by the accounting return on equity (ROE). Assuming zero mispricing error, the changes in returns are due to changes in cash flows or discount rate. The relation between ROE and returns is also stated eloquently by Fama and French (2006:492). Deriving from the dividend discount model, which is a cash flow-based valuation model itself, they infer that companies with higher expected earnings relative to current book equity have higher expected returns. Two criteria correspond to the description in Fama and French (2006): ROE and EPS (earnings per share). Since ROE and EPS, with slight differences in interpretation, indicate the same performance aspect, they can be used interchangeably in many contexts.[1] Due to prevalent use of ratios and heteroscedasticity issue associated with inflated variables, as in EPS, use of ROE is more common in the literature.

ROE is also a well-known measure of operating performance. It measures efficient use of equity capital. According to DuPont analysis, ROE can be broken down into three ratios: Net profit margin, asset turnover and financial leverage. This decomposition explains that ROE incorporates efficient use of assets -represented by asset turnover-, operating efficiency -represented by net profit margin-, and risks and benefits of financial leverage. DuPont

[1] We can show that ROE and EPS are both derived from the same accounting information as follows: ROE is calculated as earnings divided by book value of equity. EPS is calculated as earnings divided by number of shares. Multiplying ROE by the book value of one share will give EPS. If we denote N number of shares and P book value of a share: $ROE = \frac{Earnings}{N * P}$, and $EPS = \frac{Earnings}{N}$, then $EPS = ROE * P$.

components have different constructs and they can separately reveal useful information about operating performance (Soliman, 2008). However, using ROE eliminates the need to include all these three ratios in the model since changes in any of these ratios will induce a proportional change in ROE. The ROE ratio can be calculated as follows:

$$ROE = \frac{Net\ Profit}{Equity} = \frac{Net\ Profit}{Sales} * \frac{Sales}{Assets} * \frac{Assets}{Equity}$$

Given the established literature summarised above, ROE, along with two other profitability ratios, will be used in this study as a simple alternative model to assess performance. The other two profitability ratios are included as additional proxies for cash flow, however ROE remains the main model for this study.

4. DATA AND METHODOLOGY

BIST Technology and Information Technology Index (XUTEK/XBLSM) components are used in the study. Since the two indices heavily overlap, 13 of the 14 sample companies are present in both indices. Annual consolidated financial reports of 14 technology companies for which data are available are obtained from the state-run KAP (Public Disclosure Platform) website and financial ratios are computed using accounting data in the annual reports. The ratios are calculated annually for each of the five years covering 2012-2016 period. The monthly share prices used to calculate returns are downloaded from www.investing.com. The technology index is randomly selected, there is no other criteria in the sample selection, except that financial industries are not considered for this study since their books and accounting methods differ from other industries. The list and symbols of companies included in the sample is given in Table 1 below. From here onwards, companies will be quoted by their symbols.

Table 1. Sample Companies

No	Symbol	Full Name
1	ALCTL	ALCATEL LUCENT TELETAŞ TELEKOMÜNİKASYON A.Ş.
2	ANELT	ANEL TELEKOMÜNİKASYON ELEKTRONİK SİSTEMLERİ SANAYİ VE TİCARET A.Ş.
3	ARENA	ARENA BİLGİSAYAR SANAYİ VE TİCARET A.Ş.
4	ARMDA	ARMADA BİLGİSAYAR SİSTEMLERİ SANAYİ VE TİCARET A.Ş.
5	DGATE	DATAGATE BİLGİSAYAR MALZEMELERİ TİCARET A.Ş.
6	DESPC	DESPEC BİLGİSAYAR PAZARLAMA VE TİCARET A.Ş.
7	ESCOM	ESCORT TEKNOLOJİ YATIRIM A.Ş.
8	INDES	İNDEKS BİLGİSAYAR SİSTEMLERİ MÜHENDİSLİK SANAYİ VE TİCARET A.Ş.
9	KAREL	KAREL ELEKTRONİK SANAYİ VE TİCARET A.Ş.
10	KRONT	KRON TELEKOMÜNİKASYON HİZMETLERİ A.Ş.
11	LINK	LİNK BİLGİSAYAR SİSTEMLERİ YAZILIMI VE DONANIMI SANAYİ VE TİCARET A.Ş.
12	LOGO	LOGO YAZILIM SANAYİ VE TİCARET A.Ş.
13	NETAS	NETAŞ TELEKOMÜNİKASYON A.Ş.
14	PKART	PLASTİKKART AKILLI KART İLETİŞİM SİSTEMLERİ SANAYİ VE TİCARET A.Ş.

Returns are calculated as annual buy-and-hold returns (BHR). In the spirit of Ritter (1991), BHR are obtained as 12-monthly compounded returns and converted to wealth relatives for ease of interpretation. The arithmetic procedure is as follows:

$$R_i = \prod_{t=1}^{12} (1 + r_{it})$$

where R_i is the annual BHR and r_{it} is the raw monthly return calculated for company i in month t. Monthly returns are calculated as:

$$r_{it} = \frac{P_{i,t_{last}} - P_{i,t_{first}}}{P_{i,t_{first}}}$$

where P_{it} is the opening and closing price of the share i in the month t. The wealth relatives show performance of a particular share relative to the selected benchmark. In this study, annual BIST100 buy-and-hold returns are used as benchmark. The wealth relatives are calculated by the following equation:

$$WR_i = \frac{1 + BHR_i}{1 + BHR_{BIST100}}$$

A wealth relative greater than 1 indicates better performance for share relative to benchmark, a wealth relative smaller than 1 indicates that share underperforms benchmark. Wealth relatives are calculated each year for annual performance and as 5-year average wealth relatives to show the average performance in the study period. The results are presented in Table 2 below. Companies are ranked in the table from the highest to lowest wealth relative. For example, LOGO provides the highest average return in the five year period and ESCOM earns the lowest average return. *TECH* shows the average index return in case investor holds the equally weighted portfolio. This allows the researcher to evaluate performance of a company relative to other index members in a particular period. Index underperforms BIST100 benchmark in 2012, 2013, and 2016, average *TECH* returns falling below 1.00 wealth relative score. Only two companies, LOGO and INDES, outperform the benchmark in all years. 2012 appears to be a particularly bad year for the industry, 12 out of 14 companies underperforming the benchmark. Three underperformers (DESPC, ARMADA, ALCTL) in this year, however, perform better than index average. This provides a useful insight on performance as similar situations are observed in the remaining years.

Table 2. Performance of High-Tech Companies Based on Wealth Relatives

This table displays order of firm observations based on annual and average periodical return. Observations are listed from highest to lowest return. Following Ritter (1991), annual returns are calculated as 12-monthly compounded buy-and-hold returns (BHR) from January to December, and wealth relatives are calculated as (1+BHR) divided by (1+BIST100 return). A wealth relative score smaller than 1 suggests underperformance. *TECH* is the average index wealth relative for the relevant period.

2012		2013		2014		2015		2016		5Year	
	1.42		1.41						1.16		
LOGO	1	ANELT	7	LOGO	3.173	KRONT	2.722	INDES	1	LOGO	1.654
	1.16		1.19						1.08		
INDES	5	LOGO	0	DGATE	2.703	ALCTL	1.843	LOGO	6	DGATE	1.368
	0.96		1.10	ARMD					1.05		
DESPC	9	PKART	6	A	1.597	DGATE	1.529	LINK	8	KRONT	1.262
ARMD	0.95		1.07			ARMD			1.05	ARMD	
A	2	INDES	8	*TECH*	*1.373*	A	1.507	ESCOM	5	A	1.199
	0.90	ARMD	1.03						1.04		
ALCTL	6	A	2	LINK	1.371	NETAS	1.454	ARENA	8	INDES	1.131
	0.86		1.00						1.04		
TECH	*1*	ARENA	5	DESPC	1.301	*TECH*	*1.402*	KRONT	6	*TECH*	*1.119*
	0.81		*0.98*						1.02		
DGATE	7	*TECH*	*8*	ARENA	1.255	LOGO	1.399	DESPC	1	ALCTL	1.111
	0.81		0.93						1.01		
ARENA	4	KAREL	4	ESCOM	1.175	DESPC	1.246	KAREL	4	DESPC	1.088
	0.78		0.93						0.98		
PKART	8	KRONT	2	INDES	1.063	KAREL	1.196	ALCTL	8	ARENA	1.049
	0.75		0.91						*0.97*		
NETAS	8	DGATE	2	NETAS	0.989	INDES	1.184	*TECH*	*4*	LINK	1.041
	0.72		0.90					ARMD	0.90		
LINK	7	DESPC	1	PKART	0.958	LINK	1.183	A	7	NETAS	0.988
	0.72		0.87						0.90		
KAREL	1	ALCTL	4	KRONT	0.944	PKART	1.182	NETAS	7	PKART	0.986
	0.68		0.86						0.89		
ANELT	6	LINK	6	ALCTL	0.941	ANELT	1.136	PKART	6	KAREL	0.958
	0.66		0.83						0.87		
KRONT	5	NETAS	0	KAREL	0.925	ARENA	1.124	DGATE	6	ANELT	0.929
	0.64		0.75						0.57		
ESCOM	6	ESCOM	1	ANELT	0.828	ESCOM	0.925	ANELT	5	ESCOM	0.911

The selection order imposed by wealth relatives will be compared to TOPSIS and ROE selection in the next section. Afterwards, portfolio returns will be computed where portfolios are constructed from the TOPSIS and ROE selection order. The significance of the relationship between returns and TOPSIS, as well as ROE order will be tested by a Spearman rank correlation test.

TOPSIS model includes eight ratios in four groups. Current ratio and acid-test ratio for liquidity group, receivables turnover and asset turnover for operations group, return on assets (ROA), return on equity (ROE), return on sales (ROS) ratios for profitability group, and leverage ratio for leverage group are included following prior literature on multi-criteria decision models.[2] As noted by Wang and Lee (2009) and others, weights of the TOPSIS

[2] Calculation of ratios is as follows: Current ratio is calculated as current assets divided by short term liabilities, acid-test ratio is calculated as current assets minus inventories divided by short term liabilities, receivables turnover is calculated as net sales divided by total trade receivables, asset turnover is calculated as net sales divided by total assets, ROA is calculated as net profit divided by total assets, ROE is calculated as net profit

criteria depend on the opinion of the researcher, causing subjectivity bias. Various methods, including fuzzy TOPSIS and entropy-based objective weights models (Wang and Lee, 2009) are developed to address subjectivity bias. This study employs two weighting methods to address the issue. In the first design, weights are calculated from the normalised decision matrix, dividing sum of each criterion by the total sum of all criteria. The resulting score is the weight of the respective criterion/ratio. Although this arithmetic procedure does not involve subjectivity of researcher, the calculated weights are not likely to represent the relative importance of ratios in determining performance or investor decision-making. In the second design, equal weights are assigned to each criteria. The weights used in the models are given in Table 3 below. As expected, a brief look at the table reveals major inconsistencies. Most of the variation in weights is observed in profitability ratios. This is likely to be due to flexibility of profitability, they are the only ratios that can take negative values. In addition, earnings are often managed for various reasons. ROA weights, for example, range from 3.1% to 13.3% across years. Given a certain industry, such variation in time is not reasonable. Earnings are also heavily underrated in 2012, three profitability ratios have a combined weight of only 7.3%, while turnover ratio weights total 41.5%. Therefore, interpreting the weights on the basis of ratio importance is not possible in this study design. The arithmetic procedure, however, is a necessary adjustment to avoid subjectivity bias.

Table 3. Ratio Weights

First six rows display weights calculated from the normalised decision matrix. The procedure involves dividing sum of all cells in a column by the sum of sums of all columns. Repeating this procedure for each ratio and column yields ratio weights. The last row shows equal weights assigned to ratios in the second TOPSIS test.

Year	Current Ratio	Acid-test Ratio	Receivables Turnover	Asset Turnover	ROA	ROS	ROE	LEV
2012	0.152	0.143	0.212	0.203	0.031	-0.035	0.077	0.215
2013	0.143	0.128	0.168	0.166	0.101	0.055	0.054	0.181
2014	0.127	0.120	0.124	0.149	0.130	0.058	0.139	0.149
2015	0.131	0.125	0.132	0.137	0.131	0.047	0.145	0.148
2016	0.145	0.137	0.155	0.149	0.133	-0.044	0.153	0.168
5Year	0.116	0.109	0.148	0.141	0.134	0.071	0.130	0.150
EqW	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125

5. OPERATING PERFORMANCE AND PORTFOLIO RETURNS

Companies are ranked from the highest to lowest TOPSIS performance score in the Table 4 below. The rankings are then compared with the return rankings based on wealth relatives in Table 2. One caveat of this procedure is that ratio elements contributing to the TOPSIS score do not cause a simultaneous effect on returns. It is therefore customary to use lagged ratios in the literature to investigate returns (e.g. Cohen et al., 2002; Fama and French, 2006). This caveat may not apply in the single criterion selection by ROE if earnings are assumed equal to the analyst forecasts for the corresponding year. Since market prices would absorb expected earnings, the returns would reflect year-end ROE performance.

divided by total equity, ROS is calculated as net profit divided by net sales, leverage is calculated as total liabilities divided by total assets.

Table 4. Performance of High-Tech Companies Based on TOPSIS

This table shows highest-to-lowest order of firm performance based on TOPSIS model with weights calculated from normalised decision matrix. First five columns display firm-year TOPSIS scores, and the last column displays TOPSIS scores based on five year average ratios.

2012		2013		2014		2015		2016		5Year	
PKART	0.575	LINK	0.533	ANELT	0.565	LINK	0.507	LINK	0.495	LINK	0.548
LINK	0.541	PKART	0.449	LINK	0.455	PKART	0.474	KRONT	0.482	LOGO	0.448
ARMDA	0.453	DESPC	0.403	LOGO	0.421	DESPC	0.399	DGATE	0.461	DESPC	0.442
ARENA	0.445	ARENA	0.399	DESPC	0.419	DGATE	0.399	PKART	0.418	PKART	0.418
DESPC	0.419	ESCOM	0.384	DGATE	0.365	KRONT	0.384	INDES	0.411	DGATE	0.383
DGATE	0.415	ARMDA	0.375	ARENA	0.353	INDES	0.377	DESPC	0.401	INDES	0.375
INDES	0.405	INDES	0.351	INDES	0.351	LOGO	0.361	ALCTL	0.348	ARMDA	0.373
ALCTL	0.403	LOGO	0.346	ARMDA	0.347	ARMDA	0.357	LOGO	0.348	ARENA	0.365
ESCOM	0.362	DGATE	0.315	KRONT	0.322	ARENA	0.342	ARMDA	0.332	ESCOM	0.294
LOGO	0.338	ALCTL	0.276	PKART	0.266	ANELT	0.335	ARENA	0.304	ALCTL	0.262
ANELT	0.303	KAREL	0.260	ALCTL	0.254	ALCTL	0.319	KAREL	0.236	ANELT	0.259
KAREL	0.301	KRONT	0.253	ESCOM	0.242	NETAS	0.223	NETAS	0.208	KRONT	0.249
NETAS	0.297	NETAS	0.247	KAREL	0.208	KAREL	0.211	ESCOM	0.165	KAREL	0.227
KRONT	0.202	ANELT	0.207	NETAS	0.208	ESCOM	0.062	ANELT	0.161	NETAS	0.205

The places of companies in the rankings overall are not important when their place differ from those in Table 2 by a few points. Placing a mediocre or bad performer at the top of the list, however, dents the reliability of the model. The inconsistencies must be major to be taken into account, where a major inconsistency can be defined as a company ranked at the bottom in returns and ranked at the top in the operating performance model. A severe underperformer ranked as a top performer is also a major inconsistency, and vice versa. Several important observations can be made by comparing wealth relatives and TOPSIS rankings. In 2012, where the index overall underperforms the market, the only outperformers LOGO and INDES are ranked in 7th and 10th place by TOPSIS. In 2013, ANELT brings the highest return to investors while it is ranked at the bottom by TOPSIS.[3] Second best performer LOGO is ranked in 8th and the worst performer ESCOM is ranked in 5th place. In another sign of inconsistency, LINK is ranked as top performer by TOPSIS while in reality it underperforms both index and market. In 2014, the worst performer ANELT is ranked at the top by TOPSIS. In 2015, second best performer ALCTL is ranked in 11th place by TOPSIS and top two TOPSIS performers LINK and PKART are in reality ranked in 10th and 11th place based on their returns. Similar observations are made in 2016. Two underperformers in the 13th and 14th place of the list, PKART and DGATE, are ranked in 3rd and 4th place by TOPSIS while 4th best performer ESCOM is ranked second last. The inconsistencies between TOPSIS scores and actual returns demonstrate that financial performance cannot be correctly assessed

[3] ANELT engages in company restructuring in 2013 and 2014. It is a highly leveraged company prior to 2014 with a leverage ratio of over 71%. At the end of 2014, leverage ratio drops to 6% and earnings after tax rise from 13 million loss to 5 million profit. Operating profit, however, drops from 13 million in 2013 to 6 million in 2014. The observed pattern in performance is more consistent with operating profit. The same explanation is also valid for ESCOM. In 2013, ESCOM has a net profit of 18 million, while it shows 0.8 million operating loss. This is due to income from financial investments, a 21 million extra income is provided by the venture capital investment in Alesta Venture Capital, founded in 2012. The performance pattern observed in ESCOM is consistent with the operating profit. Since net profit is used in the calculation of profitability ratios, inconsistencies in the performance rankings may emerge.

by TOPSIS model where the performance is represented by the company ranking in the score list.

Returns of portfolios constructed from TOPSIS performance are given in Table 5. Each company is displayed with its wealth relative for the corresponding period. To calculate returns, the sample is divided into two groups; the first comprised of top seven performers and the second comprised of last seven performers. The returns of portfolios are then calculated as equally weighted average return of seven companies. Table shows that top performers portfolios outperform bottom performers portfolios in the five out of six periods. Only in 2013, bottom portfolio outperforms top portfolio. The TOPSIS portfolios also outperform index portfolio in the same five periods.

Table 5. Portfolio Returns Based on TOPSIS Selection

This table shows returns of year-specific firm observations and portfolios constructed based on TOPSIS selection order. The seven companies with the highest TOPSIS scores are placed in the top portfolio and the seven companies with the lowest TOPSIS scores are placed in the bottom portfolio. Each share is assigned equal weight in the portfolio.

2012		2013		2014		2015		2016		5Year	
Top Portfolio											
PKART	0.788	LINK	0.866	ANELT	0.828	LINK	1.183	LINK	1.058	LINK	1.041
LINK	0.727	PKART	1.106	LINK	1.371	PKART	1.182	KRONT	1.046	LOGO	1.654
ARMDA	0.952	DESPC	0.901	LOGO	3.173	DESPC	1.246	DGATE	0.876	DESPC	1.088
ARENA	0.814	ARENA	1.005	DESPC	1.301	DGATE	1.529	PKART	0.896	PKART	0.986
DESPC	0.969	ESCOM	0.751	DGATE	2.703	KRONT	2.722	INDES	1.161	DGATE	1.368
DGATE	0.817	ARMDA	1.032	ARENA	1.255	INDES	1.184	DESPC	1.021	INDES	1.131
INDES	1.165	INDES	1.078	INDES	1.063	LOGO	1.399	ALCTL	0.988	ARMDA	1.199
Average	0.890	Average	0.962	Average	1.671	Average	1.491	Average	1.006	Average	1.209
Bottom Portfolio											
ALCTL	0.906	LOGO	1.190	ARMDA	1.597	ARMDA	1.507	LOGO	1.086	ARENA	1.049
ESCOM	0.646	DGATE	0.912	KRONT	0.944	ARENA	1.124	ARMDA	0.907	ESCOM	0.911
LOGO	1.421	ALCTL	0.874	PKART	0.958	ANELT	1.136	ARENA	1.048	ALCTL	1.111
ANELT	0.686	KAREL	0.934	ALCTL	0.941	ALCTL	1.843	KAREL	1.014	ANELT	0.929
KAREL	0.721	KRONT	0.932	ESCOM	1.175	NETAS	1.454	NETAS	0.907	KRONT	1.262
NETAS	0.758	NETAS	0.830	KAREL	0.925	KAREL	1.196	ESCOM	1.055	KAREL	0.958
KRONT	0.665	ANELT	1.417	NETAS	0.989	ESCOM	0.925	ANELT	0.575	NETAS	0.988
Average	0.829	Average	1.012	Average	1.075	Average	1.312	Average	0.941	Average	1.029

In the next step, portfolio returns based on ROE are investigated. Table 6 shows the rankings of companies by ROE and portfolios constructed based on the ratio. Inconsistencies in the rankings similar to Table 4 are observed, although on a lesser scale. In 2013, the worst performer ESCOM is ranked second in the list, and the best performer ANELT is ranked second last by ROE. As explained in footnote 3, this inconsistency is due to sudden changes in net profit which are related to restructuring efforts at ANELT and other income from venture capital investments at ESCOM. The abnormality in performance is eliminated by switching from net to operating profitability. In 2016, the second worst performer DGATE is ranked in 5^{th} place by ROE. As far as portfolios are concerned, top ROE portfolios outperform bottom ROE portfolios in the same five periods out of six. As observed in TOPSIS portfolios, top ROE portfolio is outperformed in the year 2013 by bottom portfolio. The difference in top and bottom portfolio returns are, however, larger compared to that of TOPSIS model.

Table 6. Portfolio Returns Based on ROE Selection

This table shows returns of year-specific firm observations and portfolios constructed based on ROE selection order. The seven companies with the highest ROE are placed in the top portfolio and the seven companies with the lowest ROE are placed in the bottom portfolio. Each share is assigned equal weight in the portfolio.

2012		2013		2014		2015		2016		5Year	
Top Portfolio											
LOGO	1.421	LOGO	1.191	LOGO	3.173	LOGO	1.399	KRONT	1.046	LOGO	1.654
ALCTL	0.907	ESCOM	0.751	DGATE	2.703	DGATE	1.529	LOGO	1.086	DESPC	1.088
ARMDA	0.952	DESPC	0.901	KRONT	0.944	KRONT	2.722	INDES	1.162	ARMDA	1.199
DESPC	0.969	ARMDA	1.032	INDES	1.063	ALCTL	1.843	ALCTL	0.988	INDES	1.131
ARENA	0.814	KRONT	0.932	ARMDA	1.597	INDES	1.184	DGATE	0.876	DGATE	1.368
INDES	1.165	ARENA	1.005	DESPC	1.301	ANELT	1.136	DESPC	1.021	ARENA	1.049
KAREL	0.722	KAREL	0.934	ANELT	0.828	ARMDA	1.508	ARMDA	0.908	ALCTL	1.111
Average	0.993	Average	0.964	Average	1.659	Average	1.617	Average	1.012	Average	1.228
Bottom Portfolio											
ESCOM	0.646	LINK	0.866	ARENA	1.255	DESPC	1.247	PKART	0.896	ESCOM	0.911
PKART	0.788	PKART	1.106	KAREL	0.925	LINK	1.183	LINK	1.059	KRONT	1.262
DGATE	0.817	INDES	1.078	ESCOM	1.176	NETAS	1.454	KAREL	1.014	KAREL	0.958
NETAS	0.759	NETAS	0.830	LINK	1.371	ARENA	1.124	ARENA	1.048	PKART	0.986
ANELT	0.686	DGATE	0.913	NETAS	0.989	PKART	1.182	ESCOM	1.055	LINK	1.041
LINK	0.727	ANELT	1.417	PKART	0.958	KAREL	1.196	NETAS	0.907	NETAS	0.988
KRONT	0.665	ALCTL	0.874	ALCTL	0.941	ESCOM	0.925	ANELT	0.575	ANELT	0.929
Average	0.727	Average	1.012	Average	1.088	Average	1.187	Average	0.936	Average	1.011

Table 7 presents equally weighted TOPSIS performance rankings and portfolio returns. Some of the major inconsistencies between TOPSIS ranking and returns include ESCOM and LINK shares in 2013, where they are ranked as best and second best performer by TOPSIS while their actual performance is last and third last respectively. Another major inconsistency is that ANELT is selected as top performer in 2014 and 2015 while it actually performs last and third last in respective years. Interestingly, two TOPSIS models give close results. For example, all companies ranked last in Table 4 are also ranked last in Table 7. There are changes in the company rankings, some companies moving up a few places and others moving down, however the changes are not major. One exemption is ANELT, moving up 10 places to top place in 2015. The portfolio returns are also similar to those based on prior TOPSIS model. Top portfolios constructed from equally-weighted TOPSIS scores outperform bottom portfolios in all periods except 2013. This result is identical to the findings in Table 5. The changes in weights do not appear to impose major changes in returns. It should be noted, however, the weights in the models are free from subjectivity bias. The similarities in performance rankings and returns can be interpreted as a result of elimination of this bias.

Table 7. Portfolio Returns Based on Equally Weighted TOPSIS Selection

This table shows returns of year-specific firm observations and portfolios constructed based on equally weighted TOPSIS selection order. The seven firms with the highest TOPSIS scores are placed in the top portfolio and the seven firms with the lowest TOPSIS scores are placed in the bottom portfolio. Each share is assigned equal weight in the portfolio.

2012		2013		2014		2015		2016		5Year	
Top Portfolio											
PKART	0.788	ESCOM	0.751	ANELT	0.828	ANELT	1.136	LINK	1.058	LINK	1.041
LOGO	1.421	LINK	0.866	LINK	1.371	LINK	1.183	KRONT	1.046	LOGO	1.654
DESPC	0.969	LOGO	1.190	ESCOM	1.175	PKART	1.182	DGATE	0.876	DESPC	1.088
ALCTL	0.906	DESPC	0.901	LOGO	3.173	DGATE	1.529	PKART	0.896	ESCOM	0.911
ARMDA	0.952	PKART	1.106	DESPC	1.301	DESPC	1.246	DESPC	1.021	PKART	0.986
ARENA	0.814	ARENA	1.005	DGATE	2.703	KRONT	2.722	INDES	1.161	ANELT	0.929
INDES	1.165	ARMDA	1.032	ARENA	1.255	INDES	1.184	ALCTL	0.988	DGATE	1.368
Average	1.002	Average	0.978	Average	1.686	Average	1.454	Average	1.006	Average	1.139
Bottom Portfolio											
DGATE	0.817	KRONT	0.932	INDES	1.063	LOGO	1.399	LOGO	1.086	INDES	1.131
KAREL	0.721	INDES	1.078	ARMDA	1.597	ARMDA	1.507	ARMDA	0.907	ARMDA	1.199
ESCOM	0.646	KAREL	0.934	KRONT	0.944	ARENA	1.124	ARENA	1.048	ARENA	1.049
LINK	0.727	NETAS	0.830	PKART	0.958	ALCTL	1.843	ESCOM	1.055	KRONT	1.262
NETAS	0.758	DGATE	0.912	ALCTL	0.941	NETAS	1.454	KAREL	1.014	ALCTL	1.111
ANELT	0.686	ALCTL	0.874	KAREL	0.925	KAREL	1.196	NETAS	0.907	KAREL	0.958
KRONT	0.665	ANELT	1.417	NETAS	0.989	ESCOM	0.925	ANELT	0.575	NETAS	0.988
Average	0.717	Average	0.996	Average	1.055	Average	1.349	Average	0.941	Average	1.099

As additional measures of profitability, performance of companies are ranked by ROA and ROS. Subsequently top and bottom portfolios are constructed in the same manner, with first seven performer entering the top and last seven performer entering the bottom portfolio. Rankings and portfolio returns are displayed in Table 8. Only results based on ROA are shown, however they can be extrapolated to ROS performance since their rankings and performance are largely identical. Comparing with wealth relatives, ANELT share is ranked the exact opposite of returns in 2013, 2014 and 2015. ESCOM share is ranked top in 2013, while its actual performance is at the bottom. The top portfolios constructed based on ROA and ROS rankings outperform bottom portfolios, again, in the exact five periods out of six. As in prior selection models, only in 2013 top portfolio is outperformed by bottom portfolio. The return profiles of top and bottom portfolios are, however, much closer in ROA and ROS models than ROE and TOPSIS models.

Table 8. Portfolio Returns Based on ROA Selection

This table shows returns of year-specific firm observations and portfolios constructed based on ROA selection order. The seven companies with the highest ROA are placed in the top portfolio and the seven companies with the lowest ROE are placed in the bottom portfolio. Each share is assigned equal weight in the portfolio.

2012		2013		2014		2015		2016		5Year	
Top Portfolio											
LOGO	1.421	ESCOM	0.751	ESCOM	1.176	ANELT	1.136	ESCOM	1.054	ESCOM	0.911
DESPC	0.722	LOGO	1.191	LOGO	3.174	ESCOM	0.925	KRONT	1.046	ANELT	0.929
ALCTL	0.969	LINK	0.866	KRONT	0.944	KRONT	2.722	LOGO	1.086	LOGO	1.654
PKART	0.906	KRONT	0.932	ANELT	0.828	LOGO	1.399	LINK	1.058	KRONT	1.262
ARMDA	0.788	KAREL	0.934	LINK	1.371	LINK	1.182	ALCTL	0.988	LINK	1.041
KAREL	0.758	DESPC	0.901	DESPC	1.301	ALCTL	1.843	DESPC	1.021	DESPC	1.088
ARENA	0.646	PKART	1.106	KAREL	0.925	DESPC	1.246	PKART	0.896	KAREL	0.958
Average	0.887	Average	0.954	Average	1.388	Average	1.493	Average	1.021	Average	1.121
Bottom Portfolio											
ESCOM	0.952	ARMDA	1.033	DGATE	2.703	NETAS	1.454	KAREL	1.014	ALCTL	1.111
NETAS	0.814	ARENA	1.005	ARMDA	1.597	KAREL	1.196	ARMDA	0.907	PKART	0.986
INDES	1.165	NETAS	0.83	ARENA	1.255	PKART	1.182	NETAS	0.907	NETAS	0.988
DGATE	0.817	INDES	1.078	NETAS	0.989	ARMDA	1.507	INDES	1.161	ARMDA	1.199
ANELT	0.686	DGATE	0.913	INDES	1.063	DGATE	1.529	DGATE	0.876	ARENA	1.049
LINK	0.727	ALCTL	0.874	PKART	0.958	INDES	1.184	ARENA	1.048	INDES	1.131
KRONT	0.665	ANELT	1.417	ALCTL	0.941	ARENA	1.124	ANELT	0.575	DGATE	1.368
Average	0.832	Average	1.021	Average	1.358	Average	1.312	Average	0.927	Average	1.118

After investigating performance rankings and portfolio returns with two TOPSIS models and three profitability models, results so far tend to suggest insignificant differences between models as far as investor wealth is concerned. Differences exist between operating performance rankings, with ROE rankings having the least major inconsistencies with corresponding period wealth relatives, followed by ROA and ROS models providing close results. TOPSIS models produce the most major inconsistency in the rankings. These findings alone do not provide any economic interpretation. To interpret the findings in an economic sense, the correlation between performance and returns must be shown.

Table 9 shows periodical Spearman rank correlations between performance rankings and wealth relatives rankings. In the first panel, correlations between returns and TOPSIS rankings are displayed. The results indicate no significant correlation between corresponding annual pairs, and in general no significant correlation between performance and return rankings is observed. Since causality runs from operating performance to returns, the only significant correlation is between TOPSIS2016 rankings and 5-year average returns. Correlations for equally-weighted TOPSIS rankings –not reported- are overall identical to the reported insignificance with the exception that returns and performance rankings are significantly correlated in 2012. ROA and ROS-based performance rankings also fail to show significant correlations between corresponding pairs except year 2012, hence they are not reported. Rankings based on ROE show significant correlation with 2012, 2015 returns and 5-year averages. Moreover, 5-year average returns are significantly correlated with ROE rankings in 2014, 2015 and 2016. This indicates that ROE can be used as a base model for investment for buy-and-hold investors.

Table 9. Spearman Correlations Between Returns and Performance Rankings

This table shows Spearman rank correlations between wealth relatives and performance rankings. Company performance is ranked by TOPSIS and ROE models. WR stands for wealth relative. * represents significance at or greater than 5% level.

	WR2012	WR2013	WR2014	WR2015	WR2016	WR5Year
Correlations between TOPSIS rankings and wealth relatives						
TOPSIS2012	0.3714	0.0901	0.4681	-0.2967	0.0242	0.0462
TOPSIS2013	0.2527	-0.1077	0.5209	-0.1692	0.3934	-0.0374
TOPSIS2014	0.2923	0.4242	0.4110	0.1297	0.1209	0.2923
TOPSIS2015	0.3187	0.1868	0.4154	0.3978	0.0813	0.4242
TOPSIS2016	0.2396	-0.0593	0.3143	-0.1560	0.2132	0.5560*
TOPSIS5Year	0.5473*	0.1692	0.7231*	0.2923	0.3495	0.3582
Correlations between ROE rankings and wealth relatives						
ROE2012	0.7495*	0.2044	0.3275	0.0945	0.2615	0.3319
ROE2013	0.0857	-0.0066	0.4901	-0.1473	0.5560*	0.1473
ROE2014	0.3582	0.4242	0.4857	0.2923	0.2264	0.6923*
ROE2015	0.4857	0.3011	0.2747	0.6659*	0.0242	0.8374*
ROE2016	0.5429*	0.1736	0.2967	0.6484*	0.3670	0.8505*
ROE5Year	0.7846*	0.1648	0.6615*	0.2747	0.4110	0.7011*

Overall, findings of the study suggest selection of ROE as a model for performance measurement over TOPSIS, ROA, and ROS. Portfolios based on these models produce similar returns, however performance rankings based on ROE have the least contradictions with the actual return rankings. Performance rankings based on TOPSIS, ROA and ROS models are generally uncorrelated with the corresponding annual returns while ROE rankings are correlated with the corresponding returns in the half of periods examined. More importantly, only ROE appears to provide long term value for buy-and-hold investors.

6. CONCLUSION

This study investigates power of TOPSIS multi-criteria decision model and simple profitability-based models in measuring financial performance using publicly available data from Borsa Istanbul. The basis for this investigation lies in the relevance and subjectivity of TOPSIS score output, which is harder to interpret economically and financially than single-criteria model of profitability. Results conclusively show that measuring performance via multiple ratios incorporated into TOPSIS model does not provide an improvement over single-criterion performance measurement by ROE, ROA and ROS. TOPSIS models have the most conflicting performance rankings relative to actual return rankings and portfolios based on TOPSIS rankings are outperformed by ROE-based portfolios. Of the models examined, only ROE appears to link long term operating performance with long term returns.

The study has implications for researchers, investors and managers. It dwells on issues with TOPSIS in measuring financial performance and shows that it does not perform better than simple traditional profitability ratios. Prior research (e.g. Ozden et al. 2012; Orcun and Eren, 2017) blame the lack of investor attention to financial performance in decision-making process for the absence of a meaningful relationship between TOPSIS rankings and returns. Results of this study documents that meaningful relationships exist between ROE and returns, hence the issue is likely to be not the lack of investor attention, rather the choice of model to measure performance. For investors interested in long term investments, the study suggests that ROE-based decisions provide a better alternative to the complex multi-criteria TOPSIS

model. Managers as well can benefit from the findings since their fiduciary duties require them to pursue shareholder value maximisation. To that aim, they can attempt to improve a core selection of financial ratios such as asset turnover, net profit margin and leverage, the combination of which forms ROE. The study indicates that improvements in the components of ROE could assist managers in reaching their performance targets.

This study can be extended in several ways. First, the financial ratios considered in this study are only the basic and most frequently used ratios. Study can be expanded to use a wider selection of ratios. Second, the study can be extended to include other multi-criteria decision models. Third, this study uses ROE and two other profitability ratios as alternative models of performance assessment. Future studies can evaluate other alternatives such as cash flow based models.

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