“Ranking of firms by performance using I-distance method”

AUTHORS	Nurdan Değirmenci https://orcid.org/0000-0002-8759-8871 Tuba Yakici Ayan https://orcid.org/0000-0002-5222-3500

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Nurdan Değirmenci (Turkey), **Tuba Yakici Ayan** (Turkey)

RANKING OF FIRMS BY PERFORMANCE USING I-DISTANCE METHOD

Abstract

The objective of this article is to rank firms by their financial performance using statistical I-distance method, which has the ability to determine both ranking and important factors. For this purpose, the method was first applied to 110 Turkish industrial firms without any sectorial separation and then to 7 different sectors, and various findings about firms, sectors and variables were obtained. The I-distance method is used to get rid of the high correlation between variables during the analysis. The reason for choosing the I-distance method is that it allows you to sort the variables by importance and eliminate insignificant variables, as well as take into account correlations between variables. The authors believe that the method is superior to other alternative methods thanks to these qualities. Through a number of analyses, it was possible to see positions of firms both within the whole sample and their own sectors. Furthermore, this method provided valuable information on which factors were important in assessing firms' financial performance. It has been observed in the analyses that the most effective factors in ranking firms and separating them from each other were profitability ratios, and the fact that liquidity and financial leverage ratios are not effective at all. When examined from a sectoral perspective, the nonmetal mining sector and the chemical, petroleum and plastic sectors seem to be better than other sectors in the performance rankings.

Keywords multivariate analysis, I-distance, financial performance, ranking

JEL Classification C38, C44, G39

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Nurdan Değirmenci, Assistant Professor, Department of International Trade and Logistic, Recep Tayyip Erdoğan University, Turkey.

Tuba Yakici Ayan, Professor, Dr., Department of Econometrics, Karadeniz Technical University, Turkey.

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INTRODUCTION

One of the most important objectives of enterprises is to meet the expectations of their shareholders at the maximum level by increasing their market value. It is of vital importance for firms to achieve this objective in today's increasingly competitive environment. In particular, firms operating in the same sector need to make the right decisions so as to increase their competitiveness in the national and international area. While these decisions are made based on the experience of the management, the past financial information of the enterprise is also of great significance. This is because the performance of any firm can be evaluated with the help of the financial ratios that are calculated using the firm's financial information.

There are various indicators that can be used for financial analyses with the aim of examining the current status of firms and making comparisons. By using these indicators, which are mostly proportional, it is possible to acquire information about the liquidity status of firms, the usage status of their assets, their financial structures, profitability statuses and market values. The analysis results provide detailed information about the performance of the firm in terms of managers, shareholders, credit institutions, customers and investors.

The performance evaluation of the firms can be based on a single variable or multiple variables. Some examples of evaluation based on

single variable include the ISO 500[1], Fortune 500 Turkey and Fortune Global 500[2] lists, which rank firms by their net sales revenue every year. The multivariate evaluations of firms are often made with multi-criteria mathematical decision making methods, such as Data Envelopment Analysis (DEA), Analytic Hierarchy Process (AHP), Technique for Order Preference by Similarity to Ideal Solution (TOPSIS), Elimination and Choice Translating Reality English (ELECTRE), or VIKOR. Almost all these methods have to take into account the importance of each decision criterion. Therefore, in order to determine the criteria weights, it is possible to use methods based on subjective judgment of the decision maker or more objective methods, which calculate from the decision matrix (Stillwell, Seaver, & Edwards, 1981). One of the methods that use the decision matrix, which shows the numerical values of the alternatives to be sorted in terms of each criterion (factor), is ENTROPY method (Wang & Lee, 2009).

When we look at the studies in the literature made for the purpose of performance evaluation, no full consistence can be observed regarding the variable selection. Although the selection of variables varies relatively per sector, it seems that arbitrary choices are made in general. However, the first and the most important stage of a quantitative research is correct selection of the variables. As we mentioned above, many studies that have been conducted up to this point have used multivariate mathematical methods. The main reasons for such extensive use of these methods are: not requiring any assumption, having a simple theoretical structure and arbitrary selection of variables. Since selection of the analysis variables is based on subjective value judgments in such mathematical methods, it is possible to encounter very different variables in different studies on the same subject. In addition, these methods cannot take the relationships between variables into account sufficiently.

Excessive number of variables used in any research can complicate the analysis and increase the workload. On the other hand, if some important variables are excluded from the research, a considerable amount of information would be ignored, which prevents the analysis findings from being reliable.

High correlations between explanatory variables in statistical analyses are certainly undesirable, because only one of the highly correlated variables already contains the information necessary for the research and the duplication of the same information leads to erroneous results.

Following the above explanations, when selecting variables in any research, it is very important to include as much information as possible, on the one hand, and to avoid unnecessary and repetitive knowledge, on the other hand.

In this study, we have used a number of indicators to take into account as much information as possible while assessing Turkish industrial enterprises according to their financial performance. We select the I-distance method to get rid of the high correlation between variables during our analysis. The reason for choosing the I-distance method is that it allows you to sort the variables by importance and eliminate insignificant variables, as well as take into account correlations between variables. We believe that the method is superior to other alternative methods thanks to these qualities.

Different methods sometimes form similar and sometimes different sequences. But based on the findings, it is not logical to judge which of these is better. These methods can only be compared to one another according to their theoretical bases or easiness of calculation. For this reason, instead of making a choice between sequences generated by different methods in such studies, they are seen to be combined into a single sequence using methods such as arithmetic mean or Borda rule (Borda, 1781).

1 The list is compiled and published annually by Istanbul Chamber of Industry.

2 The list is compiled and published annually by Fortune magazine.

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In the next part of our study, we are primarily concerned with major and new works performed on the evaluation of firm performance. Then, we describe the I-distance method and the variables of the research in detail. We sort the firms included in the Turkish Industry Index in their entirety and in their sectors, respectively, and simultaneously determine important variables, per I-distance method. In this study, although I-distance ranking is accepted as the basis, firms are ranked with some other methods as well. For this purpose, weights of the financial ratios used in the study are calculated by ENTROPY method. The firms are then ranked according to their financial performance with TOPSIS and VIKOR methods. We finalize our study by interpreting the findings of the analysis and making sector and method comparisons.

1. LITERATURE REVIEW

In the financial performance literature, the majority of the studies that have been made are conducted using multi-criteria decision making methods, such as regression, Data Envelopment Analysis, gray relational analysis and TOPSIS, AHP, VIKOR, etc. It is noteworthy that TOPSIS, ELECTRE and their fuzzy versions have been widely used, especially in studies made for sorting purposes. Since our aim is to rank firms according to their financial performance, in this chapter, we focus especially on studies with ranking purposes.

Feng and Wang (2000) used the TOPSIS method and used a total of 22 variables as transportation and financial indicators of five Taiwan airline firms in their study on the performance of airline enterprises. In another study by Wang (2008), a fuzzy Multi-Criteria Decision Making (MCDM) method was used to evaluate the financial performance of Taiwanese airline firms, and then used a gray relational analysis to identify important indicators. In addition, Wang (2009) combined fuzzy TOPSIS with gray relational analysis to evaluate the financial performance of Taiwan container lines. Ertuğrul and Karakasoglu (2009) used fuzzy AHP and TOPSIS methods to evaluate the performance of the cement firms in Istanbul Stock Exchange (BIST). The method used determines the ranking of the firms in the same sector from the best to the worst based on the specified financial ratios. Bayrakdaroğlu and Yalçın (2012) evaluated the financial performance of the industrial firms in BIST-30 using financial ratios and fuzzy AHP and VIKOR methods. Yalçın et al. (2012) evaluated the financial performance of firms in the manufacturing sector traded in BIST using a fuzzy AHP method through value-based financial performance measures in addition to traditional accounting-based financial performance measures. Bulgurcu (2013) determined the financial performance of the firms in the Turkish automotive industry by using the TOPSIS method for the years 2009–2012. Çelen (2014) also carried out financial performance evaluations in the Turkish banking sector using the fuzzy TOPSIS method for the period 2002–2010. Wang (2014) evaluated the relative financial competitiveness of container shipping firms with the TOPSIS method. Mandic et al. (2014) attempted to rank the financial performance of banks using the TOPSIS method between 2005 and 2010. Moghimi and Anvari (2014) conducted a study where they ranked the cement firms operating in Iran according to their financial performance using the fuzzy AHP and TOPSIS methods.

As for the I-distance method we use in our study, Mihailovic et al. (2009) made a study for the year 2005 by using non-parametric VZA method and I-distance method together with the help of financial ratios in order to evaluate the performance of the banks in Serbia. Bulajic et al. (2013) successfully used the I-distance method by setting the input and output variables for the 5-year period covering the period 2006–2010 in order to determine the effectiveness of 27 banks in Serbia. Milenkovic et al. (2014) used the I-distance method to measure the socio-economic development levels of 22 MENA countries. Dmitrovic et al. (2016) evaluated the banks operating in Serbia in terms of efficiency, cost effectiveness and profitability with the I-distance method. Popovic et al. (2016) identified the efficiencies of small and medium-sized enterprises operating in the food industry with the I-distance method, based on operating conditions and business results, then, proceeded to rank the firms from the best to the worst according to their overall ranking coefficients.

2. METHODS

Generally, financial ratios are used to evaluate the financial performance of an enterprise. These ratios provide important information about the liquidity, operating efficiency, financial structure, profitability and market value of the enterprise. The ratios we use in this study are provided in Table 1 and grouped as follows (Brigham & Houston, 2007; Brealey et al., 2001).

1. *Liquidity ratios:* measures the ability of firms to meet their short-term debt obligations. The main ratios in this group are the current ratio, acid test ratio and cash ratio.

- *Current ratio:* it shows the ability of firms to cover short-term debts of their current assets so as to continue their activities. It is assumed that the ideal value is generally around 2, although it varies depending on the state of the sector.

- *Acid test (liquidity) ratio:* represents the ability of the remaining current assets to cover the enterprise's short-term debts after stocks are excluded from the current assets. It is desirable that this ratio is around 1.

- *Cash ratio:* shows the capacity of the enterprise to pay short-term debts when the entity's receivables cannot be collected and sales decrease, and it is desirable that it be around 0.20.

2. *Activity ratios:* are useful to determine whether enterprises are actively using their assets. The main ratios in this group are the total assets turnover ratio, receivable turnover ratio, inventory turnover rate and equity turnover ratio.

- *Total assets turnover ratio:* is used to measure the efficiency of the enterprise's assets. A low rate indicates that an enterprise cannot effectively use its assets.

- *Receivable turnover rate:* shows the ability of the enterprise to collect its receivables. A high ratio means that the collection of receivables is not problematic and that it has an efficient collection policy.

- *Inventory turnover ratio:* shows how effectively an enterprise turns its inventory into sales. A high rate indicates that the enterprise has an effective inventory policy and that it has increased its ability to compete with its competitors.

- *Equity turnover ratio:* this is used to determine the effectiveness of the investments financed by the shareholders of the enterprise. A high ratio indicates that the funds that shareholders have allocated to the firm are used efficiently.

3. *Financial leverage ratios:* this group of ratios shows the firm's capital structure, i.e. its ability to meet its long-term debt obligations. The main ratios in this group are the leverage ratio, the debt-equity ratio and long-term debt ratio.

- *Leverage ratio:* shows how much of the firm assets are covered by debt. A higher rate indicates greater financial risk for the firm.

- *Debt-equity ratio:* shows the relationship between the firm's foreign assets and its own equity capital.

- *Long-term debt ratio:* shows how much the enterprise has long-term debts in its total debts.

4. *Profitability ratios:* shows the firm's ability to make profits over its sales, assets and equity. The main ratios in this group are the return on assets, net profit margin, gross profit margin, return on equity, operating margin, and earnings before interests and taxes margin. It is desirable that these ratios are as high as possible.

- *Return on assets (ROA):* shows how effectively the firm's assets are being used.

- *Net profit margin:* shows how much profit the firm has in proportion to net sales after taxes.

- *Gross profit margin:* shows how much gross profit the firm has in proportion to net sales.

- *Return on equity (ROE):* this shows the return of the shareholders on their capital invested in the firm.

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- *Operating margin:* shows how profitable business operations are.

- *Earnings before interests and taxes margin (EBIT):* shows the profitability of the enterprises before interest, depreciation and tax compared to net sales.

5. *Market value ratios:* these rates, which are generally applicable to public firms, show the effect of the stocks of the enterprises on the market value. They are considered to be reflecting the investors' thoughts about past and future performance of the enterprise. For this reason, other market value ratios except for the earning per share ratio are somewhat subjective. Hence, we use only the earning per share ratio of the market value ratios in this research.

- *Earnings per share (EPS):* this ratio is one of the most important factors determining the market value of a firm. Using this ratio, an investor can see how much profit one makes per each share of the firm owned.

We have only used earnings per share as a market value ratio, as can be seen in Table 1. However, there are also other indicators under this main group, such as market value/book value and price to earnings ratio. But since they are of interest only to stock investors and, based on subjective evaluations, we did not include them in this study.

The I-distance method was first used by Ivanovic (1973) to rank countries according to their socio-economic development levels, based on a large number of indicators. I-distance is a multivariate statistical method with the ability to synthesize a large number of variables with different units of measure in a single numeric value. The I-distance method allows for the iterative determination of significant variables among a large number of variables according to their numeric values, taking into account the correlations between the variables.

Let $e_r = (x_{1r}, x_{2r}, ..., x_{kr})$ and $e_s = (x_{1s}, x_{2s}, ..., x_{ks})$ be two units defined by k number of variable. The I-distance between these two units is determined by the following formula:

$$D(r,s) = \sum_{i=1}^{k} \frac{|d_i(r,s)|}{\sigma_i} \prod_{j=1}^{i-1} (1 - r_{ji.12...j-1}), \quad (1)$$

where $d_i(r,s) = x_{ir} - x_{is}$, $i\{1, ..., k\}$ represents the distance between e_r and e_S units according to the variable x_i. In other words, $d_i(r,s)$ is the discriminant effect of the variable x_i. σ_i is the standard deviation of x_i and

Table 1. Financial ratios used in the study

Main groups	Ratio	Calculation	Best value
Liquidity ratios	Current ratio	Current assets/current liabilities	2
	Acid test (liquidity) ratio	(Current assets-inventories)/current liabilities	1
	Cash ratio	(Cash + cash equivalents + invested funds)/current liabilities	0.20
Activity ratios	Total assets turnover ratio	Sales/total assets	Maximum
	Receivable turnover rate	Net credit sales/average account receivable	Maximum
	Inventory turnover ratio	Net sales/average inventory	Maximum
	Equity turnover ratio	Net sales/total equity	Maximum
Financial leverage ratios	Leverage ratio	Total debt/total assets	0.50
	Debt-equity ratio	Total debt/shareholders equity	1
	Long-term debt ratio	Long term debt/total debt	Maximum
Profitability ratios	Return on assets	Net income/total assets	Maximum
	Net profit margin	Net income/net sales (revenue)	Maximum
	Gross profit margin	Gross profit/net sales (revenue)	Maximum
	Return on equity	Net income/average shareholders equity	Maximum
	Operating margin	Operating income/net sales	Maximum
	Earnings before interests and taxes margin	EBIT/net sales	Maximum
Market value ratios	Earnings per share	Net profit/share number	Maximum

$r_{ji.12...j-1}$ is the partial correlation coefficient between x_i and $x_j\,(j<I)$ (Ivanovic, 1977).

In the I-distance method, the distance of each unit to a reference unit is calculated. This reference unit may be a hypothetical unit with the best value, the worst value or the average value for each variable.

The I-distance value depends on the calculation sequence of the variables. That is to say, the discriminant value of the most important variable (which provides the most information) should be calculated first, and then other variables are to be added according to the significance order.

The partial correlation coefficients shown in equation (1) are intended to prevent duplication (being used repeatedly) of the information contained in variables. However, the presence of negative partial correlations necessarily leads to duplication. To avoid this, I-squared distance given in equation (2) below should be used instead of I-distance in practice:

$$D^2(r,s)=\sum_{i=1}^{k}\frac{d_i^2(r,s)}{\sigma_i^2}\prod_{j=1}^{i-1}\left(1-r_{ji.12...j-1}^2\right). \qquad (2)$$

The I^2-distance values can be used to rank the units, on the one hand, and for the determination of the significance levels of the variables, on the other hand. For this purpose, simple correlations of each variable with I^2-distance are used. The correlation coefficient indicates whether the variable in question has a differential effect on the examined phenomenon and, if so, gives information about its degree.

3. ANALYSIS AND FINDINGS

In this study, 110 companies from 144 manufacturing companies in BIST Industry Index were ranked in terms of their performance based on 2015 data using a multi-variable method. Due to the fact that the data are not available or bad, we have not included 34 firms in the analysis. We used various financial ratios as variables in the ranking. We have

Table 2. The results of the I^2-distance method first calculation

Firm	I^2-dist	Rank	Firm	I^2-dist	Rank	Firm	I^2-dist	Rank	Firm	I^2-dist	Rank
EGEEN	227,1288	1	COLA	353,4553	29	SAYAS	376,7187	57	ASUZU	407,2536	85
TUPRS	271,3876	2	GOODY	354,1465	30	SASA	376,8132	58	CEMTS	407,4356	86
POLTK	297,9463	3	PETUN	354,2925	31	PNSUT	377,0125	59	DAGI	408,0839	87
BAGFS	299,0931	4	BRISA	355,5832	32	TATGD	378,7401	60	DENCM	408,365	88
ADEL	299,4811	5	ATEKS	355,9127	33	AVOD	378,7855	61	DERIM	408,4707	89
ADANA	300,3653	6	BLCYT	356,6588	34	KORDS	379,6326	62	ANACAM	409,2903	90
TTRAK	307,969	7	HEKTS	359,0401	35	ERBOS	379,9544	63	MERKO	410,0801	91
DGZTE	318,2283	8	VESBE	359,3932	36	KARTN	382,316	64	DMSAS	410,3917	92
FROTO	323,2902	9	BTCIM	360,771	37	TMSN	382,7804	65	BRSAN	413,5331	93
BOLUC	324,7289	10	IZOCAM	361,3482	38	JANTS	382,9539	66	BAKAB	414,4486	94
AYGAZ	325,4874	11	CMBTN	361,3512	39	ALKA	385,8883	67	PENGD	414,6997	95
AKCNS	326,6794	12	GUBFR	362,285	40	KUTPO	387,014	68	VESTL	414,8624	96
TBORG	329,0719	13	AKSA	362,3899	41	GOLTS	388,6852	69	BNTAS	415,9954	97
BFREN	329,4161	14	TUKAS	362,5847	42	DEVA	389,7568	70	BRKSN	416,9179	98
CIMSA	332,8129	15	UNYEC	363,273	43	ULUSE	390,0631	71	YUNSA	417,7831	99
GEREL	333,1305	16	CUSAN	363,5897	44	PARSN	394,3052	72	ARSAN	423,6662	100
TOASO	337,2487	17	YATAS	363,6118	45	KNFRT	396,3113	73	EMKEL	425,8953	101
NUHCM	337,2821	18	ULKER	363,7329	46	TMPOL	397,6368	74	USAK	426,4014	102
EGGUB	340,12	19	AR3ELİK	365,1793	47	DYOBY	398,9731	75	GEDZA	428,6231	103
PETKM	343,2496	20	KENT	366,0761	48	ALCAR	399,8561	76	TIRE	430,5977	104
KONYA	345,602	21	PRKME	366,993	49	BOSSA	399,9993	77	HATEK	439,2831	105
SODA	345,6667	22	OTKAR	367,6796	50	TRKCM	401,82	78	TUCLK	440,099	106
KATMR	346,8256	23	FMIZP	368,0357	51	AFYON	402,3664	79	IHEVA	443,8189	107
ASLAN	349,3437	24	EREĞLİ	372,6977	52	COMDO	402,5841	80	KRSTL	451,0313	108
EGSER	351,1168	25	BSOK	373,105	53	PRKAB	403,3229	81	ACSEL	454,6421	109
ALKIM	351,8323	26	KLMSN	373,6861	54	ULUUN	403,5797	82	PRZMA	485,1037	110
RTALB	351,8671	27	SARKY	374,6564	55	CMENT	405,4177	83	–	–	–
MRDIN	352,9687	28	BUCIM	376,3395	56	SAMAT	405,4481	84	–	–	–

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selected seventeen variables from the main groups of liquidity, activity, financial leverage, profitability and market value ratios. First, we calculated the I^2-distance values for each firm and ranked the firms accordingly with the assumption that there are no correlations between variables. We assumed that all variables are of equal importance at this stage. I^2-distance shows the square of the distance of firms from a reference point. In our study, we accepted a hypothetical firm with the best value for each variable as a reference point. The best values are the maximum values for 12 of the 17 variables and the fixed values as described in Table 1 for the remaining 5. They are 2 for current ratio, 1 for liquidity ratio, 0.20 for cash ratio, 0.50 for leverage ratio and 1 for debt-equity ratio. According to the results provided in Table 2, the top 5 firms with the best performance at this stage are ranked as EGEEN, TUPRS, POLTK, BAGFAS and ADEL.

We looked at the simple linear correlation coefficients between the rankings and the variables in Table 2 in order to exclude the insignificant variables from the analysis by specifying the significance levels of the variables. Table 3 shows

Table 3. The correlation between the I^2-distance and the initial indicators

Variable	Correlation (*r*)
Return on equity	–0.80677**
Return on assets	–0.77750**
Net profit margin	–0.61949**
Operating margin	–0.60379**
Earnings per share	–0.60068**
Earnings before interests and taxex margin	–0.55869**
Gross profit margin	–0.37607**
Receivable turnover rate	–0.34025**
Inventory turnover ratio	–0.26926**
Total assets turnover ratio	–0.26131**
Current ratio	–0.22426**
Cash ratio	–0.12498
Debt-equity ratio	0.12274
Leverage ratio	–0.10018
Long-term debt ratio	–0.08238
Equity turnover ratio	0.06620
Liquidity ratio	0.02130

Note: $^{**}p < 0.01$; $^{*}p < 0.05$.

Table 4. The results of the I^2-distance method final calculation

Firm	I^2-dist	Rank	Firm	I^2-dist	Rank	Firm	I^2-dist	Rank	Firm	I^2-dist	Rank
EGEEN	155,1777	1	ALKIM	266,8719	29	PNSUT	290,7159	57	PENGD	314,1653	85
DGZTE	175,6242	2	FROTO	269,5922	30	KLMSN	291,4363	58	SARKY	314,5111	86
ADEL	212,7854	3	PETUN	270,7154	31	AVOD	291,5213	59	ARSAN	314,61	87
BAGFS	216,0203	4	EGSER	271,5608	32	KUTPO	292,1726	60	MERKO	315,2577	88
FMIZP	216,3516	5	BLCYT	271,7058	33	AR3ELİK	292,5595	61	BRSAN	315,876	89
TUPRS	218,3571	6	HEKTS	272,4316	34	ERBOS	292,6985	62	CEMTS	317,5132	90
ADANA	219,148	7	TUKAS	272,7046	35	VESBE	293,2906	63	GEDZA	318,2473	91
POLTK	230,9206	8	KENT	273,5434	36	DEVA	293,328	64	EMKEL	319,7237	92
KONYA	241,9201	9	BSOK	274,6595	37	PARSN	293,6817	65	ACSEL	319,7513	93
TBORG	245,9588	10	COLA	274,9677	38	ALCAR	294,0637	66	SAMAT	319,8286	94
BFREN	246,784	11	BTCIM	276,6356	39	ULUSE	294,4616	67	DERIM	320,8007	95
BOLUC	248,1716	12	GOODY	277,2776	40	TMSN	294,7228	68	PRKAB	322,1708	96
EGGUB	248,9488	13	GUBFR	278,881	41	BUCIM	294,9161	69	VESTL	322,3275	97
AKCNS	251,2291	14	KARTN	279,5173	42	KORDS	295,0019	70	IHEVA	322,782	98
CIMSA	251,2293	15	AKSA	280,0675	43	ALKA	296,3434	71	ASUZU	323,4407	99
ATEKS	253,1034	16	AFYON	281,5975	44	TATGD	297,9779	72	YUNSA	323,4854	100
SODA	253,1938	17	BRISA	281,6716	45	GOLTS	299,5542	73	USAK	324,1832	101
TTRAK	254,2372	18	ULKER	282,1366	46	SASA	300,1375	74	BRKSN	325,8236	102
NUHCM	257,0088	19	OTKAR	283,0664	47	CMENT	302,4895	75	DMSAS	326,5719	103
GEREL	257,3535	20	EREĞLİ	284,6578	48	TRKCM	302,6491	76	BAKAB	328,3723	104
AYGAZ	258,4167	21	KATMR	285,0097	49	BOSSA	307,0024	77	ULUUN	329,3291	105
RTALB	258,7284	22	KNFRT	285,3584	50	DAGI	307,013	78	PRZMA	333,3547	106
MRDIN	259,1786	23	CUSAN	285,3664	51	TMPOL	309,1191	79	HATEK	334,7839	107
ASLAN	260,8636	24	IZOCAM	285,4945	52	DENCM	311,651	80	TUCLK	335,7488	108
PRKME	262,0458	25	CMBTN	286,518	53	ANACAM	311,9272	81	TIRE	337,2677	109
UNYEC	264,1638	26	YATAS	289,2789	54	BNTAS	312,373	82	KRSTL	340,9853	110
PETKM	265,1108	27	SAYAS	289,613	55	DYOBY	313,7333	83	–	–	–
TOASO	266,3128	28	JANTS	290,6694	56	COMDO	313,8255	84	–	–	–

the results of this review. As you can see, 11 out of 17 variables were significant at the level of 0.01. Liquidity ratio, equity turnover ratio, long-term debt ratio, leverage ratio, debt-equity ratio and cash ratio are permanently excluded from the analysis, because they are insignificant, i.e. they do not have any distinctive effect on firm performance ranking. The magnitude of the correlation coefficients between variables and ranking also informs us of the order in which the variables should be introduced into the distance calculation in the next step. Accordingly, the most important variable in the second phase is return on equity, and it should be included first in the calculation.

The current ratio with the correlation coefficient of 0.03929 in the second phase of our analysis, and the total assets turnover ratio with the correlation coefficient of 0.11887 in the third phase were insignificant. Table 4 shows the I^2-distance values calculated based on the remaining 9 variables and the final firm ranking. The top 5 firms were ranked as EGEEN, DGZTE, ADEL, BAGFS and FMIZP. While the three companies were still in the top, DGZTE, which was the 8th in the initial ranking, rose to the second position and FMISP, which was the 51st, rose to the fifth place. These changes reveal the misleading results of the presence of the variables that are gradually excluded from the analysis.

The final variables and correlation coefficients provided in Table 5 indicate that all the remaining variables are significant. It is clear that the most important variable here is return on assets, and the least important is the inventory turnover ratio. Although there is a significant difference between the correlation coefficients for these two variables, both are significant at the level of 0.01 due to the size of our sample volume.

Table 5. The correlation between the I^2-distance and the final variables

Variable	Correlation (*r*)
Return on assets	–0.82977**
Net profit margin	–0.78544**
Return on equity	–0.74703**
Operating margin	–0.64762**
Earnings before interests and taxes margin	–0.63947**
Earnings per share	–0.60277**
Gross profit margin	–0.47485**
Receivable turnover rate	–0.32855**
Inventory turnover ratio	–0.37567**

Note: $^{**}p < 0.01$; $^{*}p < 0.05$.

We have conducted performance evaluations of firms in the BIST Industry Index without introducing any subsector divisions, and then applied

Table 6. The correlation between I^2-distance and variables in respect of sectors

Financial ratio	Food, beverage	Chem., petrol, plastic	Basic metal	Metal products, machine	Wood, paper, printing	Nonmetal mining product	Textile, leather
Total assets turnover ratio	–	–	–	–	–0,806*	–	–
Return on assets	–0.799**	–0.888**	–0.928**	–0.934**	–0.921**	–0.913**	–0.888**
Receivable turnover rate	–	–	–	–0.523*	–0.882**	–	–
Debt-equity ratio	–	–	–	–	–	–	–
Gross profit margin	–0.737**	–	–	–	–	–0.419*	–
Current ratio	–	–0.440*	–	–0.502*	–	–	–
Operating margin	–0.854**	–0.656**	–0.892**	–0.891**	–	–0.690	–0.702*
Earnings before interests and taxes margin	–0.876**	–0.655**	–0.674*	–0.861**	–0.742*	–0.597**	–
Earnings per share	–0.729**	–0.528*	–	–0.674**	–	–0.492*	–0.639*
Leverage ratio	–	–	–	–	–	–0.459*	–
Liquidity ratio	–	–	0.714*	0.523*	–	–	–
Cash ratio	–	–		–0.534**	–0.807*	–	–
Net profit margin	–0.812**	–0.817**	–0.919**	–0.822**	–0.905**	–0.841**	–0.787**
Inventory turnover ratio	–	–	–	–0.471*	–0.790*	–	–
Long-term debt ratio	–	–	–	–	–	–	–
Equity turnover ratio	–	–	–	–	–	–	–
Return on equity	–0.817**	–0.837**	–0.847**	–0.821**	–0.932**	–0.898**	–0.874**

Note: $^{**}p < 0.01$; $^{*}p < 0.05$.

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the same analyses separately to each sector and obtained the findings shown in Table 6. The subsectors to which the firms belong are provided in the appendix A. When Table 6 is examined, it could be seen that some variables are not significant in any sector. These are long term debt ratio, debt-equity ratio and equity turnover ratio. According to Table 5, these variables were not found to be significant in the total rankings of BIST industry index firms as well. Another noteworthy point in Table 6 is that ROA, ROE and net profit margin variables were significant with high correlation values in all the sectors. In addition, variables that are significant in six of the 7 sectors are operating margin and EBIT. According to these findings, we can say that the profitability ratios of the firms are determinant in the in-sector performance evaluations of firms.

When the sectors are examined separately, it could be seen that in the metal products and machine sector, firm rankings were calculated according to 11 of the 17 variables, whereas in the textile, leather sector only 5 variables were used. This can be explained by the fact that the firms in the textile sector have more similar values than the firms in the other sectors in terms of many financial ratios.

For comparison purposes, the firms are ranked with TOPSIS (Hwang & Yoon, 1981) and VIKOR (Opricovic & Tzeng, 2004), in addition to I^2-distance method. The variable weights required for these methods were obtained by ENTROPY (Wang & Lee, 2009).

Table 7. Weights of the variables by ENTROPY

Variable	Weight
Liquidity ratio	0.14615
Cash ratio	0.14536
Debt-equity ratio	0.12347
Earnings per share	0.12209
Inventory turnover ratio	0.09724
Leverage ratio	0.06473
Current ratio	0.06014
Net profit margin	0.04129
Return on assets	0.03786
Return on equity	0.02966
Equity turnover ratio	0.02462
Operating margin	0.02455
Long-term debt ratio	0.0228
Receivable turnover rate	0.02195
Earnings before interests and taxes margin	0.01746
Total assets turnover ratio	0.01094
Gross profit margin	0.00964

When the weights of the variables in Table 7 are compared with Table 5, there are remarkable differences. For example, liquidity ratio, cash ratio and debt-equity ratio, which are not included in Table 5, since they are excluded from analysis, are the most important variables by ENTROPY meth-

Table 8. The firm ranking by TOPSIS

Firm	Rank	Firm	Rank	Firm	Rank	Firm	Rank	Firm	Rank	Firm	Rank
EGEEN	1	SARKY	20	VESBE	39	TMSN	58	PRKME	77	TRKCM	96
DGZTE	2	TUCLK	21	KATMR	40	KLMSN	59	HEKTS	78	BOLUC	97
CMBTN	3	ULUUN	22	IZOCAM	41	COLA	60	PETKM	79	MRDIN	98
TUPRS	4	PNSUT	23	SAMAT	42	ULUSE	61	AKCNS	80	ALCAR	99
OTKAR	5	ASUZU	24	PENGD	43	AKSA	62	ALKIM	81	BNTAS	100
KARTN	6	USAK	25	KRSTL	44	BUCIM	63	KONYA	82	UNYEC	101
DYOBY	7	BRSAN	26	SASA	45	ANACAM	64	POLTK	83	RTALB	102
ADEL	8	BAKAB	27	AVOD	46	KUTPO	65	ALKA	84	ULKER	103
VESTL	9	KNFRT	28	AR3ELİK	47	KENT	66	EREĞLİ	85	BAGFS	104
GOODY	10	CEMTS	29	PETUN	48	SAYAS	67	NUHCM	86	ADANA	105
PRZMA	11	TIRE	30	EMKEL	49	BRISA	68	ASLAN	87	ATEKS	106
DERIM	12	GOLTS	31	BOSSA	50	PARSN	69	CIMSA	88	BSOK	107
TTRAK	13	DMSAS	32	TATGD	51	DEVA	70	TUKAS	89	SODA	108
AYGAZ	14	BRKSN	33	CMENT	52	ARSAN	71	ACSEL	90	FMIZP	109
EGGUB	15	COMDO	34	YATAS	53	CUSAN	72	GEDZA	91	AFYON	110
FROTO	16	HATEK	35	KORDS	54	IHEVA	73	BFREN	92		
ERBOS	17	MERKO	36	TMPOL	55	BTCIM	74	GEREL	93		
PRKAB	18	YUNSA	37	JANTS	56	DAGI	75	BLCYT	94		
TOASO	19	DENCM	38	GUBFR	57	EGSER	76	TBORG	95		

od. Reason for this is that, in I-distance method, the probable effects of these variables are already made by other variables in the analysis. To put it more precisely, since the ENTROPY method does not eliminate the variables, the weights determined by it do show only the absolute importance of each variable. On the contrary, since the I-distance method eliminates variables by considering partial correlations between them, the remaining variables include discrimination effects of some variables that are eliminated, as well as their own effects.

TOPSIS and VIKOR results obtained by using ENTROPY weights are presented in Tables 8 and 9, respectively. The TOPSIS method determined EGEEN, DGZTE, CMBTN, TUPRS and ATKAR as the top 5 firms, while VIKOR method placed ADEL, TTRAK and EGEEN in the top row. As shown in Table 9, the VIKOR method places them in the same order of superiority, as it can not find sufficient evidence to distinguish some firms from each other. As a result, the resulting image resembles a sort of clustering rather than ranking.

In the examinations made, the greatest difference between I^2-distance and TOPSIS was seen for FMZIP firm. FMZIP was ranked 109th by TOPSIS while taking the 5th place by I^2-distance method. The VIKOR method placed this firm into the 10th group.

As another example, BAGFS firm is in the 4th place in I^2-distance, is in the 104th place in TOPSIS and in the 2nd group in VIKOR. The reason for these different findings can be explained by the variables considered and their significance ratings, but it may be useful to evaluate these firms in detail for each variable to determine which the correct rank is. Even though there are individual differences, matrix of serial correlation is established in Table 10 to see if there is any truly meaningful difference between the sequences of the methods. According to this matrix, it is seen that the sequence formed by I^2-distance has a meaningful and positive relation with ones formed by both TOPSIS and VIKOR.

Table 9. The firm ranking by the VIKOR

Firm	Rank
ADEL, TTRAK, EGEEN	1
BAGFS, GOLTS, TUKAS, KARTN	2
BRSAN, AKSA, COMDO, FROTO, KONYA, GEREL, AKCNS, BRISA, ERBOS, TUPRS, BOSSA, GOODY, EGSER, CMENT, BLCYT, ALCAR, PNSUT, ATEKS, AYGAZ, PRKME, VESBE, IZOCAM, HEKTS, TOASO, CEMTS, KENT, KORDS, SASA, OTKAR, POLTK, ASLAN, JANTS, GUBFR, PRKAB, DGZTE, TIRE, BTCIM, TATGD, SARKY, PETKM, MERKO, KATMR, BSOK, AVOD, ARSAN, AR3ELİK, EGGUB, ALKIM, BUCIM, DAGI, CUSAN, KUTPO, DENCM, ASUZU, ULKER, RTALB, BAKAB, SAYAS, HATEK, COLA, EREĞLİ, CIMSA, TBORG, ADANA, TRKCM, BOLUC, TMPOL, BRKSN, EMKEL, UNYEC, ULUSE, BNTAS, YATAS, DERIM, NUHCM, ANACAM, KLMSN, SAMAT, CMBTN, ALKA, MRDIN, PETUN, YUNSA, SODA, PENGD	3
KNFRT, TMSN, BFREN, TUCLK, ULUUN, DEVA	4
IHEVA, KRSTL, USAK	5
AFYON, PARSN, DYOBY	6
VESTL, GEDZA	7
DMSAS	8
ACSEL, PRZMA	9
FMIZP	10

Table 10. Serial correlation coefficient between ranking methods

Methods	TOPSIS	VIKOR	I^2-distance
TOPSIS	1	–0.063	0.350**
VIKOR	–0.063	1	0.379**
I^2-distance	0.350**	0.379**	1

CONCLUSION

In this study, the I^2-distance method was used to evaluate the financial performance of Turkish industrial firms based on multiple variables. Through a number of analyses, the positions of firms both within the whole sample and within their own sectors could be seen. Furthermore, this method provided valuable information on which factors were important in assessing firms' financial performance.

The I^2-distance method was compared with TOPSIS and VIKOR methods which are among many methods that can be used in evaluation and ranking problems. The ENTROPY method was used to determine the significance levels of the variables in this comparative study, and it was found that there

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was no significant difference between the general rankings, even though there were small differences between the firms' ranks. Despite this similarity between the findings of the methods, the I^2-distance method is concluded to be superior to the other methods, because it takes into account correlations between variables, eliminates unnecessary variables, and thus reduces the number of variables the researcher has to deal with.

According to the I^2-distance method, considered to be a powerful, reliable and useful method, 16 of the top 20 firms in the total ranking are from 3 sectors, which are the chemical, petroleum, plastic, metal products, machine and nonmetal mining product. Very few of the firms in the other sectors entered the top 20. In terms of the average proximity to the reference points of the sectors, the chemical, petroleum, plastic sector and the nonmetal mining product sector are the closest, while wood, paper, printing, and basic metal are the most distant sectors. Profitability ratios were highly decisive in the total ranking, whereas liquidity and financial leverage ratios had no influence whatsoever.

In separate evaluations of sectors, the variables that are significant differ according to the sectors. The number of variables here ranges from 5 to 11. In these analyses, ROA, ROE and net profit margin proved to be the most important variables.

Firms, which at the bottom in the financial performance ranking, may consider this as a danger signal and they can make new decisions to improve their situation after determining which financial ratios cause this problem. More detailed financial interpretations of the above findings are beyond the objective and scope of this study. However, an improvement that can be made in the implementation part of our study appears in the specification of the reference point in the I^2-distance method. While we used the maximum values in determining the reference points for most of the variables in our study, we used fixed values for some, i.e. for current ratio, acid test (liquidity) ratio, cash ratio, leverage ratio and debt-equity ratio. This is because these values are required to be around a specific, fixed value rather than high or low values. The word "around" here is in fact very appropriate for the concept of fuzziness. For this reason, a fuzzy I^2-distance method can be developed by taking such fixed values as fuzzy.

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APPENDIX

Table A1. The firm list according to sectors

Food, beverage	Chem., petrol, plastic	Basic metal	Metal products, machine	Wood, paper, printing	Nonmetal mining product	Textile, leather	Other
AVOD	ACSEL	BRSAN	ALCAR	ALKA	ADANA	ARSAN	ADEL
COLA	AKSA	CEMTS	AR3ELİK	BAKAB	AFYON	ATEKS	PRKME
KENT	ALKIM	COMDO	ASUZU	DGZTE	AKCNS	BLCYT	SAYAS
KNFRT	AYGAZ	CUSAN	BFREN	KARTN	ANACAM	BOSSA	–
KRSTL	BAGFS	DMSAS	BNTAS	PRZMA	ASLAN	DAGI	–
MERKO	BRISA	ERBOS	EGEEN	SAMAT	BOLUC	DERIM	–
PENGD	BRKSN	EREĞLİ	EMKEL	TIRE	BSOK	HATEK	–
PETUN	DEVA	SARKY	FMIZP	–	BTCIM	KORDS	–
PNSUT	DYOBY	TUCLK	FROTO	–	BUCIM	YATAS	–
TATGD	EGGUB	–	GEREL	–	CIMSA	YUNSA	–
TBORG	GEDZA	–	IHEVA	–	CMBTN	–	–
TUKAS	GOODY	–	JANTS	–	CMENT	–	–
ULKER	GUBFR	–	KATMR	–	DENCM	–	–
ULUUN	HEKTS	–	KLMSN	–	EGSER	–	–
–	PETKM	–	OTKAR	–	GOLTS	–	–
–	POLTK	–	PARSN	–	IZOCAM	–	–
–	RTALB	–	PRKAB	–	KONYA	–	–
–	SASA	–	TMSN	–	KUTPO	–	–
–	SODA	–	TOASO	–	MRDIN	–	–
–	TMPOL	–	TTRAK	–	NUHCM	–	–
–	TUPRS	–	ULUSE	–	TRKCM	–	–
–	–	–	VESBE	–	UNYEC	–	–
–	–	–	VESTL	–	USAK	–	–