Research Article

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Evaluation of Financial Performance of Software Firms Using Grey Relational Analysis Method

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Abstract: The software sector is one of the important sectors that has been widely present in many sectors and is expected to increase its level of influence and scope in many sectors in the future. In this study, the Grey Relational Analysis (GRA) method was used to evaluate the financial performance of software firms in a scope that has not been previously examined in the literature. For this purpose, GRA analysis was performed on the financial ratios included in the scope of the study for five software firms with high market capitalization included in the analysis. According to the analysis results, Firm 1 ranked first with the highest grey relational grade in 2023 (n=0.8099), 2022 (n=0.8173) and 2021 (n=0.7326), while Firm 5 ranked first with the highest grey relational grade in 2024 (n=0.7834). It is thought that this study can provide useful information to researchers and practitioners.

Keywords: Software, Grey Relational Analysis, MCDM, Financial Performance

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INTRODUCTION

The software sector is one of the important sectors that has been able to catch a growth trend. According to Statista data, the software sector is estimated to be 896.20 billion dollars in 2029. Figure 1 shows the estimated growth of the software industry.

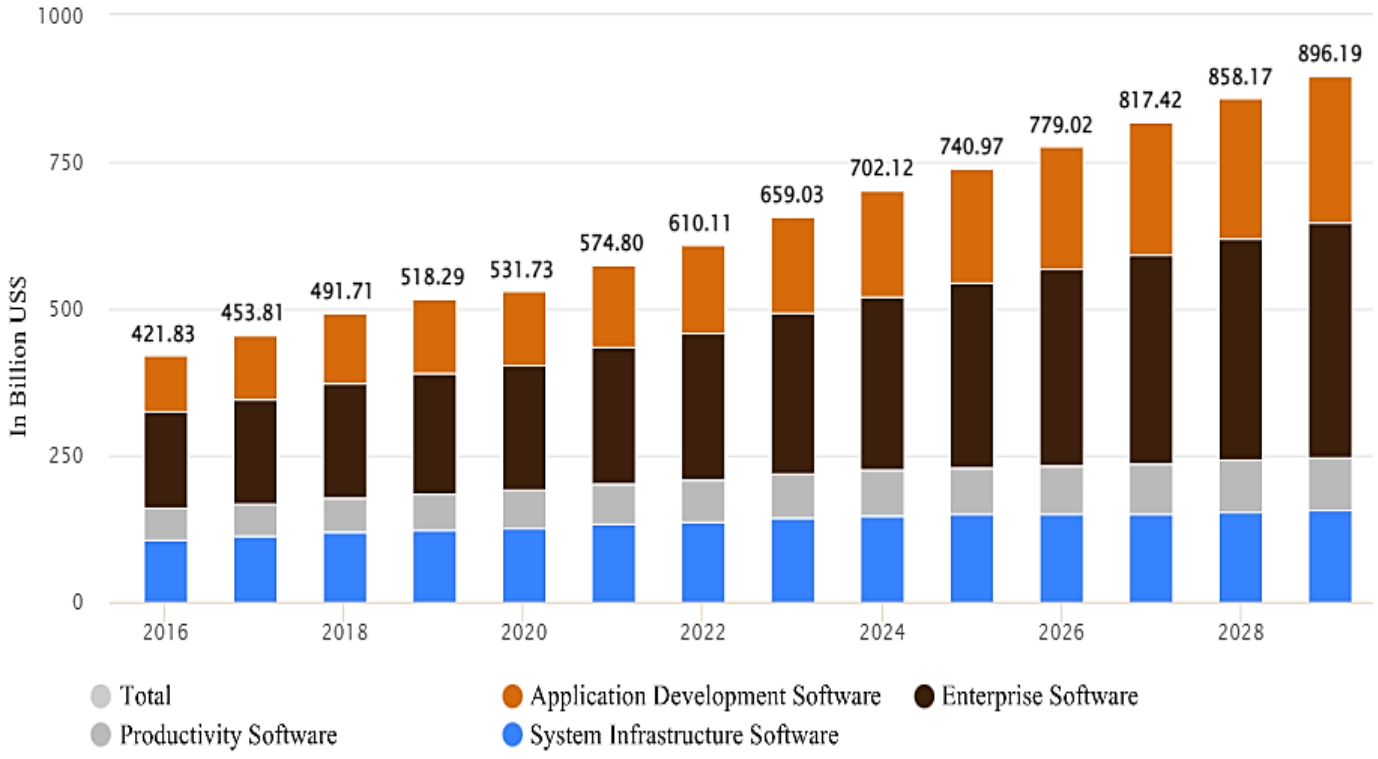

Figure 1: Estimated growth of the software industry

Source: (Statista Market Insights, 2024)

There are software firms with high market capitalization in the sector. Figure 2 shows the top ten software firms' market capitalization.

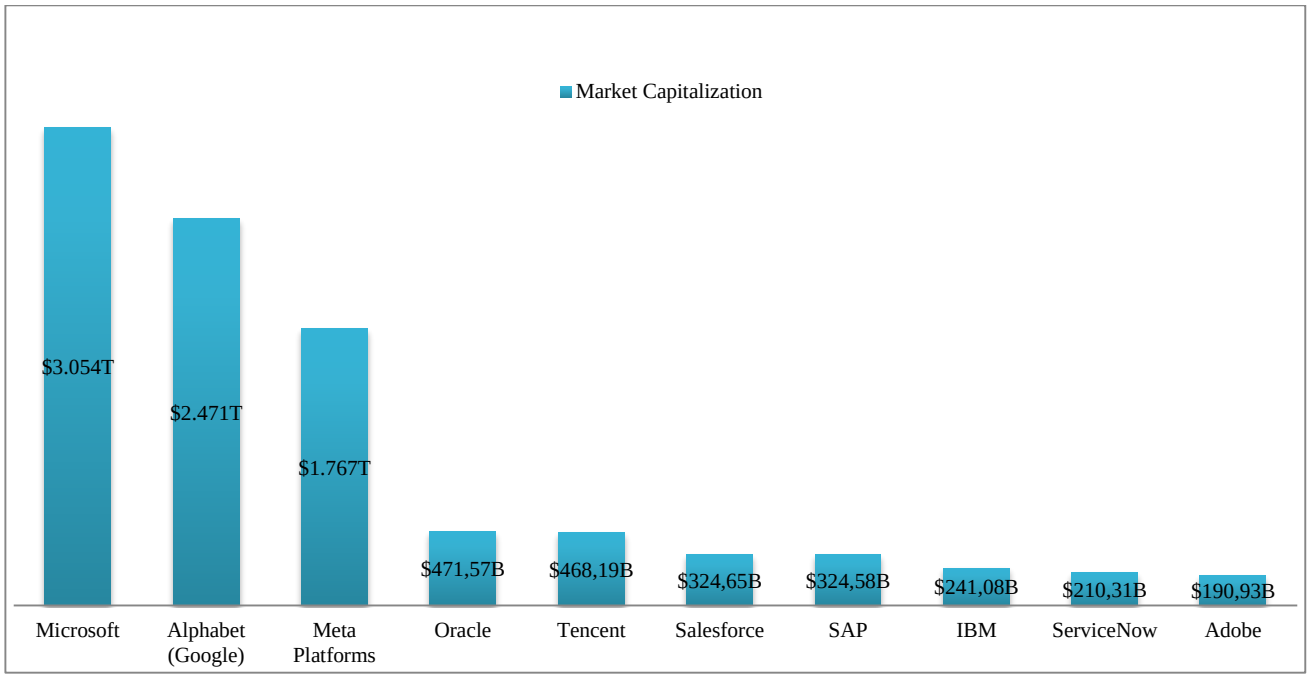

Figure 2: The top ten software firms' market capitalization on 04.02.2025

Source: (InvestingPRO, 2025a, 2025b, 2025c; TradingView, 2025)

It is understood that the three firms with high market capitalization in the software industry are Microsoft, Alphabet and Meta Platforms, respectively.

Many studies have been conducted in the literature regarding the software industry. Among these studies, there are many studies such as firm efficiency (Nkambule et al., 2022), competition and licensing (August et al., 2021), innovative human resource practices (Joseph et al., 2024), intellectual property and open innovation (Arunnima et al., 2023), mental well-being (Singh et al., 2024), project success and sustainability (Khalifeh et al., 2023), institutional networks (Girolimo & Diez, 2023), blockchain (Al-Ashmori et al., 2023), company characteristics and human resources (Aggarwal, 2023), electronic knowledge repositories (Chugh & Upadhayay, 2024), sustainability and entrepreneurial capabilities (Kim & Cho, 2024), artificial intelligence (Ainamo & Peltokorpi, 2024; Wael Sh, 2024), corporate social responsibility (Jiménez et al., 2024), learning motivation (Nguyen et al., 2023), agility (Ramasubbu & Bardhan, 2021), customer cost-acceptance level (Wang et al., 2023), project management (Jui et al., 2024).

Many methods, such as regression (e.g., Akinwale et al., 2025; Dwekat et al., 2025; Ginting et al., 2025), multi-criteria decision-making (e.g., Shen, 2024; Sun & Zheng, 2025), data envelopment analysis (e.g., Herwadkar et al., 2022), DuPont (e.g., Açıkgöz & Kılıç, 2021; Shan et al., 2024) can be used in the analysis of financial performance.

There are many studies in the literature examining financial performance in many sectors and firms (e.g., artificial intelligence (Burak, 2023), information and technology (Açıkgöz & Kılıç, 2021; Baysal et al., 2023; Bulut & Şimşek, 2022; Danilov, 2024; Oral & Şenen, 2023), banks and insurance (Safi et al., 2024)). Many financial ratios such as the current ratio (Danilov, 2024; Sanga et al., 2025), acid-test ratio (Sanga et al., 2025), debt to equity

(Ginting et al., 2025), debt to asset (Hu et al., 2025), long term debt to capital (Danilov, 2024), return on equity (Hu et al., 2025; Munir & Ishfaq, 2025; Safi et al., 2024), return on assets (Ginting et al., 2025; Munir & Ishfaq, 2025; Safi et al., 2024; Sanga et al., 2025; Yeon et al., 2025), return on investment (Billi & Bernardo, 2025), profit margin (Munir & Ishfaq, 2025; Safi et al., 2024), total asset and asset turnover (Danilov, 2024; Hu et al., 2025), receivable turnover (Danilov, 2024) have been used in studies.

Many criteria can be taken into account when making a selection. It is important to determine the most appropriate criterion among these criteria. Considering that decision-making can become complex, using statistical and mathematical methods can positively affect the decision-making process (Taherdoost & Madanchian, 2023: 77). Many methods can be used in decision-making regarding multiple criteria. GRA method, which is one of these methods, is a method that has been used and is being used in many studies because it does not require "large sample size, data distribution conditions" (Han et al., 2025). The GRA method has been used in many studies in the literature. These studies include many studies such as supplier selection (Chakraborty et al., 2024; Singh & Pandey, 2024), optimization (Arici et al., 2024; Das & Chakraborty, 2024; Khare et al., 2024; Zhu et al., 2025), financial performance (Akin, 2024; Altan & Akça, 2024; Arıkan Kargı, 2024; Bardi, 2023, 2024; Elma, 2024; Elma et al., 2024; Kaya et al., 2024; Şekkeli & Güçlü, 2023; Vargün & Soylu, 2024; Venugopal et al., 2024), entrepreneurship and innovation (Elevli & Elevli, 2024), production performance (Chen & Yang, 2024), selection of learning platform (mobile) (Başaran & Ighagbon, 2024), effectiveness of club activities (Li et al., 2024), traffic flow prediction (Wu et al., 2024), vehicle charging station selection (Saleh, 2024), power plant site selection (Zhao et al., 2024), project investment risk assessment (Chen et al., 2024), recruitment process (Mohapatra & Choudhary, 2024), aviation management (Ivan et al., 2024).

The growth potential of the software sector cannot be ignored. It is important to evaluate and understand the financial performance of firms that have reached a certain size and market share in this sector. This study aims to evaluate the financial performance of software firms that have not been previously examined in the literature using the GRA method. For this purpose, the methodology is mentioned in the next section, and the GRA method is explained. Then, the GRA results are explained. Finally, the conclusion section is mentioned.

2. METHODOLOGY

The GRA method was used in this study. GRA was performed by considering the financial data of 5 software firms with high market capitalization.

The firms and their codes included in the analysis were determined as Firm 1 (Microsoft-MSFT), Firm 2 (Oracle-ORCL), Firm 3 (Salesforce-CRM), Firm 4 (ServiceNow-NOW) and Firm 5 (Adobe-ADBE). GRA was carried out by considering the relevant firms' financial ratios between 2021 and 2024. Financial ratios were assumed to have equal importance. The financial ratios and data of the software firms included in the paper were obtained from websites (Macrotrends, 2025; Stock Analysis, 2025).

2.1. Grey Relational Analysis

GRA can be useful in providing evaluation and optimization. To enhance decision-making, a grey relational analysis is utilized to assess conditional probability (Khan et al., 2024: 599; Peng et al., 2021: 2). The financial ratios and data of the software firms included in the paper were obtained from websites (Macrotrends, 2025; StockAnalysis, 2025). GRA steps can be listed as follows (Abdelhady et al., 2024; Han et al., 2025; Rojas et al., 2024):

After the criteria are determined and the decision matrix is created, normalization can be performed on the analysis data (equation(eq) 1 for larger is better, eq 2 for smaller is better).

$$x_i(k) = \frac{x_i(k) - \min x_i(k)}{\max x_i(k) - \min x_i(k)} \quad (1)$$

$$x_i(k) = \frac{max x_i(k) - x_i(k)}{\max x_i(k) - \min x_i(k)} \quad (2)$$

Then, the deviation array, which measures the absolute difference between the normalized values and the reference array, can be calculated with eq 3.

$$\Delta_0 i(k) = |x_0(k) - x_i(k)| \quad (3)$$

Afterwards, the relationship between the grey relational coefficient, reference and comparability series can be quantitatively determined with the Grey Relational Coefficient and eq 4.

$$\xi_i(k) = \frac{\Delta_{min} + \zeta\Delta_{max}}{\Delta_0 i(k) + \zeta\Delta_{max}} \quad (4)$$

In this equation, $\xi i(k)$ is the Grey Relational Coefficient for the i-th response in the k-th condition. Δmin and Δmax are the minimum and maximum deviation sequences. ζ is the discriminant coefficient, which is (usually) set to 0.5 (Jiayu & Haijiang, 2025).

Finally, the Grey Relational Degree can be calculated by eq 5. γi is the Grey Relational Coefficient for the ith experiment.

$$\gamma_i = \frac{1}{n}\sum_{k=1}^{n} \xi_i(k) \quad (5)$$

3. GRA ANALYSIS FINDINGS

The financial ratios examined in the analysis are given in Table 1.

Table 1: Financial Ratios Used in GRA Analyzes

Financial Ratios	*Symbol*	*Ideal Value*
Current Ratio (The ability to pay off short-term liabilities using current assets)	FinR1	Maximum
Acid Test Ratio (Ability to pay short-term liabilities using its most liquid assets (excluding inventories))	FinR2	Maximum
Long-term Debt to Capital Ratio	FinR3	Minimum
Debt to Equity Ratio	FinR4	Minimum
Debt to Assets Ratio	FinR5	Minimum
Gross Margin Ratio (Gross profit over revenue)	FinR 6	Maximum
Net Profit Margin Ratio (Net profit over sales)	FinR 7	Maximum
Return on Equity Ratio (Net profit after tax over total equity) x 100	FinR 8	Maximum
Return on Assets Ratio (Net profit after tax over total assets) x 100	FinR 9	Maximum
Return on Investment Ratio (Gain from investment minus cost of investment, over cost of investment) x 100	FinR 10	Maximum
Asset Turnover (The ratio of total sales to total assets)	FinR 11	Maximum

FinR: Financial Ratio
Source: (Adelia & Khoiriah, 2025; Billi & Bernardo, 2025; Burak, 2023; Gautam & Madhavi, 2024; Micheal et al., 2025; Wang et al., 2025)

First of all, the GRA Analysis stages were carried out based on the data of software firms in the sample year 2024 within the scope of the ratios examined in the study. Afterwards, the results of the GRA analysis regarding the financial performances of software firms between the years 2021-2024 within the scope of the ratios examined in the study were explained together. Table 2 contains the GRA Decisions Matrix for 2024.

Table 2: GRA Decisions Matrix for 2024

Ratio	*FinR1*	*FinR2*	*FinR3*	*FinR4*	*FinR5*	*FinR6*	*FinR7*	*FinR8*	*FinR9*	*FinR10*	*FinR11*
Reference	1,28	1,14	0,12	0,16	0,11	89,04	35,96	113,29	18,39	30,49	0,71
Firm 1	1,28	1,14	0,14	0,19	0,19	69,76	35,96	32,83	17,21	28,32	0,48
Firm 2	0,72	0,61	0,89	9,40	0,67	71,41	19,76	113,29	7,42	12,24	0,38
Firm 3	1,09	0,96	0,12	0,16	0,14	75,50	11,87	6,93	4,14	6,08	0,35
Firm 4	1,10	0,97	0,13	0,16	0,11	79,18	12,97	14,83	6,99	12,84	0,54
Firm 5	1,07	0,95	0,23	0,40	0,20	89,04	25,85	39,42	18,39	30,49	0,71

After creating the GRA decision matrix, the GRA normalized matrix was created. Table 3 includes the GRA normalized matrix.

Table 3: GRA normalized matrix for 2024

Ratio	*FinR1*	*FinR2*	*FinR3*	*FinR4*	*FinR5*	*FinR6*	*FinR7*	*FinR8*	*FinR9*	*FinR10*	*FinR11*
Reference	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00	1,00
Firm 1	1,00	1,00	0,98	1,00	0,86	0,00	1,00	0,24	0,92	0,91	0,36
Firm 2	0,00	0,00	0,00	0,00	0,00	0,09	0,33	1,00	0,23	0,25	0,07
Firm 3	0,67	0,66	1,00	1,00	0,96	0,30	0,00	0,00	0,00	0,00	0,00
Firm 4	0,68	0,68	0,99	1,00	1,00	0,49	0,05	0,07	0,20	0,28	0,52
Firm 5	0,63	0,64	0,87	0,97	0,84	1,00	0,58	0,31	1,00	1,00	1,00

After the GRA normalized matrix was created, GRA absolute value matrix was created. Table 4 includes the GRA absolute value matrix.

Table 4: GRA absolute value matrix for 2024

Ratio	*FinR1*	*FinR2*	*FinR3*	*FinR4*	*FinR5*	*FinR6*	*FinR7*	*FinR8*	*FinR9*	*FinR10*	*FinR11*
Firm 1	0,00	0,00	0,02	0,00	0,14	1,00	0,00	0,76	0,08	0,09	0,64
Firm 2	1,00	1,00	1,00	1,00	1,00	0,91	0,67	0,00	0,77	0,75	0,93
Firm 3	0,33	0,34	0,00	0,00	0,04	0,70	1,00	1,00	1,00	1,00	1,00
Firm 4	0,32	0,32	0,01	0,00	0,00	0,51	0,95	0,93	0,80	0,72	0,48

Firm 5	0,37	0,36	0,13	0,03	0,16	0,00	0,42	0,69	0,00	0,00	0,00

After the GRA absolute value matrix was created, grey relational coefficient matrix was created. . Analysis was carried out with ζ value as 0.5.Table 5 includes the grey relational coefficient matrix.

Table 5: Grey relational coefficient matrix for 2024

Ratio	*FinR1*	*FinR2*	*FinR3*	*FinR4*	*FinR5*	*FinR6*	*FinR7*	*FinR8*	*FinR9*	*FinR10*	*FinR11*
Firm 1	1,00	1,00	0,97	0,99	0,78	0,33	1,00	0,40	0,86	0,85	0,44
Firm 2	0,33	0,33	0,33	0,33	0,33	0,35	0,43	1,00	0,39	0,40	0,35
Firm 3	0,60	0,60	1,00	1,00	0,92	0,42	0,33	0,33	0,33	0,33	0,33
Firm 4	0,61	0,61	0,97	1,00	1,00	0,49	0,34	0,35	0,38	0,41	0,51
Firm 5	0,58	0,58	0,79	0,95	0,76	1,00	0,54	0,42	1,00	1,00	1,00

As a result of the analysis, software firms' financial performance grey relational grade rank for 2024 is included in Table 6.

Table 6: Software firms' financial performance grey relational grade rank for 2024

Firm	*Firm 1*	*Firm 2*	*Firm 3*	*Firm 4*	*Firm 5*
Grade	0,7830	0,4174	0,5634	0,6082	**0,7834**
# Rank	2	5	4	3	**1**

As a result of the analysis, software firms' financial performance grey relational grade rank for 2024-2021 is included in Table 7.

Table 7: Software firms' financial performance grey relational grade rank for 2024-2021

Year	*2024*		*2023*		*2022*		*2021*	
Firm	*Grade*	*#Rank*	*Grade*	*#Rank*	*Grade*	*#Rank*	*Grade*	*#Rank*
Firm 1	0,7830	2	**0,8099**	**1**	**0,8173**	**1**	**0,7326**	**1**
Firm 2	0,4174	5	0,4344	5	0,5056	4	0,6052	3
Firm 3	0,5634	4	0,5207	4	0,4915	5	0,5460	4
Firm 4	0,6082	3	0,6132	3	0,5192	3	0,5195	5
Firm 5	**0,7834**	**1**	0,8041	2	0,7158	2	0,7159	2

According to GRA results, Firm 1 ranked first with the highest grey relational grade in 2023 (n=0.8099), 2022 (n=0.8173) and 2021 (n=0.7326). According to the analysis results, Firm 5 ranked first with the highest grey relational grade in 2024 (n=0.7834) and second with the grey relational grade in 2023 (n=0.8041), 2022 (n=0.7158) and 2021 (n=0.7159).

4. CONCLUSION

This study used the GRA method to evaluate the financial performances of software firms not previously examined in the literature. First, financial performance criteria were determined. The financial ratios of software firms between 2021 and 2024 were analyzed using the GRA method according to the determined criteria.

According to the GRA results within the scope of the financial ratios included in the analysis, Firm 1(MFST) has become the firm with the highest grey relational grade in 2023, 2022, and 2021. It is understood that Firm 1 can present a positive picture financially as a firm with a notable market share in the software industry. Considering the financial ratios included in the GRA, Firm 5(ADBE) was able to show a stable financial image by ranking first in 2024 and second between 2023-2021 with the grey relational grade. Considering that the software sector is expected to grow even more in the coming years, it can be understood that it is important for software firms to draw a successful picture financially in order to fully benefit from the existing and potential opportunities in the software sector with the software they produce.

When the results of the financial evaluation made with the TOPSIS method in information and technology companies in the literature are examined, it is understood that the companies that are ranked first with their stock exchange codes are ARDYZ in 2019 (Bulut & Şimşek, 2022), ESCOM in 2020 and 2021 (Bulut & Şimşek, 2022) and ARDYZ in 2022 (Baysal et al., 2023). When the results of the financial evaluation made with the GRA method in technology companies with stock exchange codes in the literature are examined, it is understood that LINK is ranked first between 2017-2021 (Oral & Şenen, 2023).

This study is limited to the selected firms, the time period in which it was conducted, the selected financial ratio and the applied method. This study is thought to provide helpful information to practitioners and researchers. It is thought that practitioners can have an idea about which financial ratios are important to consider in financial performance analysis. It is thought that practitioners can easily obtain information about the financial performance comparison and financial performance of the software companies included in the study within the framework of the ratios and GRA analysis in the study. Researchers can conduct their own studies by using the analysis method in this study as a guide. This study shows that researchers' knowledge of the evaluation of software companies through GRA analysis and financial performance analysis can ease and encourage them to produce new papers ideas. In future studies, GRA analysis can be performed for different software firms within the scope of different or the same financial ratios, and financial performance analysis can be performed for firms in the software sector by using different methods.

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CONFLICT OF INTEREST DECLARATION

There is no conflict of interest with any institution or person within the scope of the study.

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