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RESEARCH ARTICLE

Website Performance Evaluation by Grey Relational Analysis: A Research on Companies in BIST Technology and Informatics Index

Gri İlişkisel Analiz ile Web Site Performans Değerlendirmesi: BIST Teknoloji ve Bilişim Endeksi Üzerine Bir Araştırma

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ABSTRACT

Since websites are the visible face of companies, they are a significant determinant of how customers perceive interactions. Websites give the first impression of ensuring customer satisfaction and meeting expectations. Therefore, a quality website will provide competitive advantages. In this study, the website performance of 27 businesses in the BIST Technology and Informatics Index was evaluated, and 24 websites were analysed because the websites of three companies gave analysis errors. Website performance was measured by Page Size (Mb), Onload Time (s), First contentful paint (ms), Performance Score (%), Largest Contentful Paint (ms), Total Blocking Time (ms) and Speed Index (ms) criteria. The performance evaluation criteria of the websites were determined based on the literature and expert opinion. The data of the websites were obtained from GTmetrix automated test tool and analysed by using the Grey Relational Analysis (GRA) method. As a result of the analysis, companies' websites were ranked according to their performance score. Accordingly, Alcatel-Lucent, Plastik Kart, Escort, Smartiks, and Papilon have the highest website performance scores and are in the top five. Aselsan, Index, Datagate, Despec and Mia Teknoloji have the lowest performance scores.

Keywords: Website performance evaluation, Grey Relational Analysis (GRA), GTmetrix

ÖZ

Web siteler, işletmelerin görünen yüzü olduğundan işletmelerin müşteriler tarafından nasıl algılanacağının önemli belirleyicisidir. Müşteri memnuniyetinin sağlanması ve beklentilerin karşılanması noktasında web siteler ilk izlenimi vermektedir. Dolayısıyla kaliteli bir web sitesine sahip olmak işletmelere rakipleri karşısında avantajlar sağlayacaktır. Bu çalışmada BİST Teknoloji ve Bilişim Endeksi'nde yer alan 27 işletmenin web site performansı değerlendirilmiş olup üç işletmenin web sitesi analiz hatası verdiği için 24 web sitesinin analizi yapılmıştır. Web sitelerin performansı sayfa boyutu, yüklenme süresi, FCP (First Contentful Paint), performans skoru, LCP (Largest Contentful Paint), toplam engelleme süresi ve hız endeksi kriterleri kullanılarak ölçülmüştür. Kriterler uzman görüşüne ve literatüre dayanarak belirlenmiştir. Web sitelere ait veriler GTmetrix otomatik test aracı kullanılarak elde edilmiş olup Gri İlişkisel Analiz (GRA) yöntemi kullanılarak analiz edilmiştir. Analizler sonucunda şirketlere ait web siteler performans skorlarına göre sıralanmıştır. Buna göre Alcatel-Lucent, Plastik Kart, Escort, Smartiks, ve Papilon şirketleri en yüksek web sitesi performans skoruna sahiptir ve ilk beşte sırada yer almaktadır. Ayrıca Aselsan, Index, Datagate, Despec ve Mia Teknoloji şirketleri en düşük web sitesi performans skoruna sahiptir.

Anahtar Kelimeler: Web site performans değerlendirmesi, gri ilişkisel analiz (GRA), GTmetrix

1. INTRODUCTION

The rapid increase in internet usage worldwide increases the importance of websites for companies and customers. Since websites are the visible face of companies, they are an essential determinant of how customers perceive interactions. Websites give the first impression of ensuring customer satisfaction and meeting expectations. Companies and customers initially interact through websites and customers obtain basic data and information about companies from the websites. Therefore, a quality website will provide companies with advantages over their competitors (Ozbek, 2020). There are many factors that determine the quality of a website. Some quality factors are related to design dimensions (colors, font, font size, photos, etc.), while others are more technical (page speed, page size, HTTPS request, etc.). In this framework, the performance of websites can be evaluated in the context of different quality factors.

Website quality and performance have a significant impact on customers' perceptions and attitudes about the companies. The websites that have high quality and high performance create a more favorable impression on customers (Rababah ve Masoud, 2010; Ozbek, 2020). This phenomenon is the same for investors and other stakeholders. Like customers, investors in the stock market get their initial impressions and information about companies from websites. Companies in the IT sector in particular provide consultancy services about technology and informatics to other companies and individual users. In this case, it is expected that the website performance of IT companies will be high. Therefore, in this study, the website performance of 27 businesses in the BIST Technology and Informatics Index was evaluated, and 24 websites were analysed because the websites of three companies gave analysis errors. The performance evaluation criteria of the websites were determined based on the literature and expert opinion. In this regard, the website performance of 24 companies was measured by using seven criteria which are Page Size (Mb), Onload Time (s), First contentful paint (ms), Performance Score (%), Largest Contentful Paint (ms), Total Blocking Time (ms) and Speed Index (ms). Data were obtained using the GTmetrix automated testing tool. Also, data were analysed using the Grey Relational Analysis (GRA) method, and 24 companies' websites were ranked according to their performance score.

It is important to determine the weights of the criteria relative to each other when evaluating the performance in the grey relational analysis method. The criteria weights can be accepted as equal or different weight values can be assigned to the criteria by using methods such as the modified digital logic method (Dehghan-Manshadi et al., 2007), Analytical network process (ANP) (Tsai et al., 2011), Analytical hierarchy process (AHP) (Sun et al., 2013; Wang et al., 2012; Sandeep et al., 2011), and Entropy method (Shemshadi et al., 2011; Ayçin, 2018; Vatansever and Akgül, 2018). However, in a study by Kung et al. (2006), the criteria weights were taken equally and it was determined that the profitability ratios affected the ranking obtained as a result of the analyses (Yıldırım et al., 2021).

Many studies use the grey relational analysis (GRA) methods in diverse research areas when the literature is examined. For instance, evaluation of online travel agencies (Gavcar and Organ, 2020) and evaluation of the companies' financial performance (Kula et al., 2016; Ecer and Gunay, 2014; Gunay et al., 2018; Suvvari et al., 2019; Dinler, 2021; Çekici and Babacan, 2022), evaluation of smartphone technical features' significance level (Sahin and Aydemir, 2019), supplier selection (Rajesh and Ravi 2015; Wang et al., 2017; Soylemez et al., 2021), evaluation of energy consumption and CO_2 emission of transportation sector (Yuan et al., 2017), evaluation of bank performance (Guru and Mahalik, 2019), evaluation of social media usage performance of companies (Mercangoz et al., 2018), and evaluation of website performance (Wuwei, 2009; Vatansever and Akgul, 2018; Zhang, 2018).

Studies examining website performance with Grey Relational Analysis are insufficient in the literature. In this study, the website performance of the companies in the BIST technology and informatics index was evaluated using grey relational analysis. In this context, it is thought that this study will contribute to the literature on grey relational analysis and website performance evaluation. In this study, the main reason for choosing the GRA method, which is one of the popular multi-criteria decision-making methods, is its advantage over other methods.

This study is organized as: Section 2 discusses the related works in literature. In Section 3, information about used data and method are given. In section 4, the findings arranged according to the results of the analysis are included. Section 5 accommodates the conclusion.

2. LITERATURE REVIEW

In this section, different decision-making methods used in the performance measurement of websites and some studies published in the literature on grey relational analysis method, especially in the last five years, are presented in chronological order without any sector restrictions.

Kaur et al. (2016), evaluated the performance of 12 university websites by using diverse automated testing tools that are Pingdom, GTmetrix, Website Grader and Site Speed Checker. They analysed performance score, speed, response time, page size, number of requests and load time of websites. In the study, they also compared automated testing tools evaluation results and they revealed measured components of each website from each testing tool.

Beneida and Namoun (2018), evaluated the performance of top-rank Arabic educational websites in their study with seven components, which are efficiency, effectiveness, learnability, memorability, errors, content and satisfaction. Additionally, they evaluate technical performance of the websites using GTmetrix and Web Page Analyser. In this case, page speed, Yslow grade, fully loaded time, total page size, total number of requests, HTML size, image size, script size, CSS size were examined in evaluating the technical performance of Arabic educational websites. They saw that according to the web performance evaluation results of GTmetrix and Web Page Analyser, all educational websites have weak performance scores.

Bilal et al. (2019), evaluated the performance of the top 60 government websites of China and Pakistan according to accessibility and usability issues. They specified seven criteria of websites and analysed these criteria by using automated testing tools. In this context, loading time and page size analysed by using GTmetrix, mobile friendliness were analysed by using Google-Mobile Friendly Tool, broken links were analysed by using Dead Link Checker, HTML5-ARIA and content errors were analysed by using WAVE and accessibility performance of the websites were analysed by using the AChecker testing tool.

Stringam and Gerdes (2019), evaluated and compared load performance of 259 international hotel websites using both mobile and desktop devices. They analysed load time and speed index of hotel websites with the GTmetrix automated testing tool. In the study, they interpreted results according to continent (Africa, Asia, Australia, Europe, North America and South America) and size of hotels.

Salvio and Palaoag (2019), evaluated the performance of 5 selected Philippine e-government websites by using Website Grader, GTmetrix and Pingdom automated testing tools. They analysed performance score, page size, page requests and page speed of the websites. In the context of each analysed parameters, they also made various recommendations to increase performance of each website.

Ozdemir and Turna (2020), evaluated the performance of 10 commercial banks' websites in Turkey by using AHP, TOPSIS and VIKOR MCDM methods. They determined six performance criteria: load time, page speed, markup, page views, visitors and speed index. Accordingly, they used five automated testing tools, which are Pingdom, GTmetrix, Validator, Webpagetest and Websiteinformer, to evaluate performance of websites. They obtained data at the same time of the day by using the same devices over the 60-day period.

Csontos and Heckl (2021), evaluated the performance of 25 Hungarian public sector websites based on accessibility, usability and security components. For testing the accessibility component, they used the WAVE automated testing tool, however for testing usability they used GTmetrix and for security issue they used Securi online checker. In this regard, they analysed page speed, page load time, YSlow value, total size of websites, number of total requests, GDPR compliance and multilingual support of websites.

Hossain et al. (2021), evaluated the performance of 10 e-commerce websites in Bangladesh by considering nine parameters: first byte, load time, start render, speed index, first contentful paint (FCP), largest contentful paint (LCP), total blocking time, cumulative layout shift (CLS) and interactive time. They collected data from WebpageTest, PageSpeed Insights and GTmetrix testing tools.

Maruf and Ozdemir (2021), evaluated the performance of 15 commercial banks' websites in Turkey by using SWARA (Step-wise Weight Assessment Ratio Analysis) and ARAS (Additive Ratio Assessment) methods. They analysed performance score, page speed, fully loaded time, page size, bounce rate, number of visitors, average number of page views, average time spent on websites, world ranking and Turkey ranking of websites. In this regard, to evaluate websites performance they used GTmetrix and Similarweb testing tools.

Al-Sakran and Alsudairi (2021), evaluated the usability and accessibility components of 22 e-government websites from various sectors, such as education, social development, health, environment, finance, foreign affairs and justice etc. in Saudi Arabia. In the first part of the study, they analysed websites with a manual evaluation by experts, and in the second part they used automated testing tools for desktop (GTmetrix, WAVE) and mobile (Dareboost). With GTmetrix they analysed page speed, Yslow grade, fully loaded time, page size and number of requests of e-government websites. According to the findings, e-government websites have usability and accessibility problems that negatively affect website performance.

Belinda et al. (2021), evaluated four websites' (FUTA, UMaT, Yahoo and Google) performance with internal and external usability factors. The internal usability factors are performance, page size, speed, load time, number of requests and the external usability factors are ease of navigate, easy to find information, clear organization of information, pleasant interface, useful image and right presentation of content. They used GTmetrix, Website Grader and Pingdom automated testing tools for evaluating internal usability of websites. However, in the second part of the study they conducted a survey on users to assess the external usability of websites.

Dawis and Setiawan (2022), evaluated the performance of university websites by using the automated testing tool GTmetrix. They analysed page speed, Yslow grade, page load, total page size and number of requests of university website. As a result of the analysis, performance score of the university website was determined as E grade which means the website performance is not satisfactory and needs to be improved.

3. METHODOLOGY

This study aims to test and measure the website quality of companies in BIST technology and informatics index with online web diagnostic tools.

3.1. DATA COLLECTION

In this study, the website performance of 24 companies in the BIST technology and informatics index were examined. For this purpose, first of all, 26 criteria were determined to examine the performance of these websites. Then, the number of criteria was reduced to 7 by taking expert opinion. The expert team consists of four independent individuals, one academician, two web designers and one computer engineer. In addition to the expert opinion, determined criteria were used in the literature for website performance measurement. For instance, page size (Nacar and Ozdemir, 2021; Bilal et al., 2019), onload time, speed index (Stringam and Gerdes, 2019; Hossain et al., 2021), first contentful paint, largest contentful paint, total blocking time (Hossain et al., 2021) and performance score (Al-Sakran and Alsudairi, 2021; Belinda et al., 2021). The criteria utilized in this study and their descriptions are shown in Table 1.

Table 1
Criteria for Website Performance Measurement

Criteria	Objective	Definition
Page Size (Mb)	Min	Page size is a significant component of website performance as it is directly related to speed and quality. Page size increases depending on the size and quality of images, videos, and excess content on the websites (Nacar and Ozdemir, 2021: 210). The recommended page size for fast-loading websites is<= 12 KB, average is <=2 MB and slow-loading is >= 2 MB (Bilal et al., 2019: 318).
Onload Time (s)	Min	Onload time is defined as completing the processing of the web page and downloading the whole resources (images, videos, texts, font size, etc.) on the page (Gtmetrix, 2022a). In this case, onload time is directly related to the customer waiting time and satisfaction (Zhang et al., 1999).
First contentful paint (ms)	Min	First contentful paint (FCP) measures how quickly visitors can view the actual content of websites (images, videos, texts, etc) and it depends on page load speed (Gtmetrix, 2022b).

Performance Score (%)	Max	The performance score measures how well the website performs from the visitor's perspective. The Performance score is determined by some key performance metrics such as loading performance, interactivity, and visual stability. Since the performance score provides measurement from a visitor perspective, it can vary due to geographic, hardware, and network differences (Gtmetrix, 2022c). The grading scale is between 0-100 and if the score is 90-100, it is indicated by A grade, 80-90 is indicated by B Grade, 70-80 is indicated by C grade, and so on (Al-Sakran and Alsudairi (2021).
Largest Contentful Paint (ms)	Min	Largest Contentful Paint measures how long it takes visitors to see the largest content item (images, videos, heading text, etc.) on the web pages. In this regard, Largest Contentful Paint is a substantial indicator of visitors' perceived speed of web pages (Gtmetrix, 2022d).
Total Blocking Time (ms)	Min	Total blocking time measures the total amount of time the web page is blocked, which is between First Contentful Paint and Time to Interactive (Gtmetrix, 2022e).
Speed Index (ms)	Max	Speed index measures how quickly a web page is visually complete up to the fold. The speed index tells the visibility of the content of the web page to the visitors and analyses the viewport of the web browser (Stringam and Gerdes, 2019: 21).

GTmetrix automatic evaluation tool was used to analyse the performance of 24 websites to be used in the study. GTmetrix is an automated software tool that measures websites performance. GTmetrix use Google Pagespeed and Yahoo YSlow as a machine for website analysis. This tool measures website performance based on available parameters such as website speed and page size (Dawis and Setiawan, 2022; Kaur et al., 2016). The data was collected from 02/01/2022-02/28/2022. Table 2 shows descriptive statistics of the dataset.

Table 2
Descriptive Statistics of the Dataset

Criteria	Mean	Std. Dev.	Max	Min
Page Size (Mb)	6.83	7.71	25.77	0.28
Onload Time (s)	87.98	81.58	283.33	17.81
First Contentful Paint (s)	2.51	0.87	4.17	0.03
Performance Score (%)	53.71	15.98	86	9
Largest Contentful Paint (s)	5.50	3.61	16.22	0.59
Total Blocking Time (ms)	226.25	563.82	2800	0
Speed Index (s)	5.45	3.62	17.67	1.07

Internet speed of visitors is a significant variable in collecting data for website performance measurement with GTmetrix automatic testing tools. Because the data can differ according to the internet quality. For this reason, we also recorded the speed of the internet network via Speedtest.net website. In this regard, during the data collection period, our average ping was 16.3 ms, download speed was 28.84 Mbps and upload speed was 20.2 Mbps.

3.2. GREY RELATIONAL ANALYSIS METHODS

Grey system theory offers a mathematical method for dealing with poor, incomplete, and uncertain information. It was first developed by Deng Julong, to study the uncertainties in system models, to help in prediction and decision making. Grey system theory uses a certain idea of information. It categorizes situations with no information as black and those with perfect information as white. If a system has partially known information, it is called a grey system. But in actual problems, neither of these idealistic scenarios ever happens (Ju-long, Deng, 1982). The grey system theory has five major parts: grey prediction, grey decision, grey relational analysis, grey control, and grey programming (Ju-Long, Deng, 1982; Ju-Long, Deng, 1989).

In the grey relational analysis, also known as the grey relational generation, experimental findings are first normalized in the 0–1 range. To express the link between the desired and actual experimental data, the grey relational coefficient is generated from the normalized experimental data. The grey relational grade is then calculated by averaging each process response's respective grey relational coefficient. The grey relational grade serves as the foundation for the overall assessment of the multiple process answers. As a consequence, the optimization of a single grey relational grade can be replaced by the optimization of the complex multiple process answers. For the multi-response process, the grey relational grade may be thought of as the comprehensive assessment of experimental data (Lin C. L., 2004; Acır et all. 2017; Mia et al. 2018; Ramesh, Baranithara and Sakthivel, 2019; Uzun, 2019).

Table 3
Comparative performance of some well-known MCDM techniques (Wang et al., 2013).

MCDM method	Computational time	Simplicity	Mathematical calculations involved	Stability
GRA	Moderate	Moderately critical	Moderate	Medium
TOPSIS	Moderate	Moderately critical	Moderate	Medium
AHP	Very high	Very critical	Maximum	Poor
ELECTRE	High	Moderately critical	Moderate	Medium
PROMETHEE	High	Moderately critical	Moderate	Medium

The main reason for choosing the GRA method, which is one of the popular multi-criteria decision-making methods in this study is the advantages compared with others. In addition, since the GRA method is independent of a probability distribution, it is known that it provides better results in studies with small sample sizes than other statistical analysis techniques (Kung et al., 2006). Table 3 shows the performance comparison of some popular MCDM methods discussed by Wang et al (2013). According to Table 3, it can be said that the grey relational analysis method clearly outperforms other methods in terms of being more effective in solving complex decision-making problems, having a wide application area, shorter computation time, and flexibility.

The calculation steps of the grey relational analysis are presented as follows:

Step 1: Calculating the decision matrix.

To n alternatives and m criteria, a decision matrix is formulated as $F = \left(f_{ij}\right)_{n\times m}$. Here, f_{ij} is the value of *j*th criterion function for alternative A_i $(i = 1,2,\dots,n\,; j = 1,2,\dots,m)$ and obtained decision matrix is as follows (Wang et al. 2013; Uzun, 2019):

$$F = \left(f_{ij}\right)_{n\times m} = \begin{bmatrix} x_1(1) & \dots & x_1(n) \\ \vdots & \ddots & \vdots \\ x_m(1) & \dots & x_m(n) \end{bmatrix} \quad (1)$$

Step 2: Determination of the series to be compared.

To compare the factors in the decision problem, a reference series is determined and the comparison matrix is obtained by adding this series to the decision matrix.

$x_i^0(k)$ stands for the original data sequence, $x_i(k)$ stands for normalized data, that is, data sequence after pre-processing. $\max x_i^0\,(k)$ denotes the maximum of $x_i(k)$ and $\min x_i^0(k)$ represents the minimum of $x_i(k)$ values (Uzun, 2019).

Step 3: Calculating normalized decision matrix.

In order to acquire normalization values Eq. (2) is calculated as follows:

$$\boldsymbol{x_i(k)} = \frac{\mathbf{\max} x_i^0(k) - x_i^0(k)}{\mathbf{\max} x_i^0(k) - \mathbf{\min} x_i^0(k)} \quad (2)$$

where $i = 1,\dots,m; k = 1,\dots,n.$ m m is the number of experimental data and n is the number of parameters. After the normalization values are determined, the decision matrix is converted to a normalized decision matrix (Uzun, 2019).

Step 4: Determination of grey relational coefficient.

The grey relational grade in grey relational analysis is the measure of the relevance between two systems or two sequences. A local grey relation measurement is what is used when there is just one sequence, $x_0(k)$, that may be used as the reference sequence and all other sequences perform as comparison sequences. After data pre-processing is completed the grey relation coefficient $\xi_i(k)$ for the *k*th performance characteristic in the *i*th experiment may be expressed (Lin, 2004; Acır et al. 2017; Zerti et al., 2018; Mia et all. 2018; Ramesh et al. 2019; Uzun, 2019) as:

$$\boldsymbol{\xi_i(k)} = \frac{\Delta_{\mathbf{min}} + \xi\,\Delta_{\mathbf{max}}}{\Delta_{\mathbf{0i}}(\boldsymbol{k}) + \xi\Delta_{\mathbf{max}}} \quad (3)$$

Where, the reference sequence's and the comparability sequence's deviation sequence is denoted by Δ_{0i}.

$$\Delta_{0i}(k) = |\,x_0(k) - x_j(k)| \quad (4)$$

$$\Delta_{\min} = \min_j \min_k |x_0(k) - x_j(k)| \quad (5)$$

$$\Delta_{\max} = \max_j \max_k |x_0(k) - x_j(k)| \quad (6)$$

Here, the reference sequence is denoted by $x_0(k)$, while the comparability sequence is denoted by $x_j(k)$. In addition, the identifying or distinguishing coefficient is $\xi \in [0,1]$. The value of ξ may be adjusted according to actual system requirements. ξ value is generally used as 0.5 and ξ =0.5 was also used in this study. The value of ξ is the smaller and the distinguished ability is the larger.

Step 5. Determination of grey relational grade.

The average value of the grey relational coefficients is taken as grey relational grade (Lin, 2004; Tzeng et al., 2009; Acır et al., 2017). As a result, if criteria weights are determined equally, grey relational grade is defined as follows:

$$\gamma_i = \frac{1}{n} \sum_{k=1}^{n} \xi_i(k). \quad (7)$$

Step 6: Ranking the alternatives.

The values of the grey relationship grade are used to rank the existing alternatives in terms of similarity in the reference series. A higher value means higher similarity (Wang et al., 2013).

4. FINDINGS

In this part of the study, the Grey Relational Analysis method was used evaluate the performance of 24 websites in the BIST Technology and Informatics index. The variables used in the analysis are given in Table 1. In addition, the names and websites of the companies included in the analysis are shown in Table 4.

Table 4
Companies and Websites

Website Code	Companies	Websites	Website Code	Companies	Websites
WS1	Alcatel - Lucent	www.alcatel-lucent.com.tr	WS13	Kron	www.kron.com.tr
WS2	ARD Bilişim	www.ardbilisim.com.tr	WS14	Link	www.link.com.tr
WS3	Arena	www.arena.com.tr	WS15	Logo	www.logo.com.tr
WS4	Armada	www.armada.com.tr	WS16	Manas	www.manas.com.tr
WS5	Aselsan	www.aselsan.com.tr	WS17	Matriks Data	www.matriksdata.com
WS6	ATP	www.atp.com.tr	WS18	Mia Teknoloji	www.miateknoloji.com
WS7	Datagate	www.datagate.com.tr	WS19	Mobiltel	www.mobiltel.com.tr
WS8	Despec	www.despec.com.tr	WS20	Papilon	invest.papilon.com.tr
WS9	Escort	www.escort.com.tr	WS21	Penta	www.penta.com.tr
WS10	Index	www.index.com.tr	WS22	Plastik Kart	www.plastkart.com.tr
WS11	Kafein	www.kafein.com.tr	WS23	Smartiks	www.smartiks.com.tr
WS12	Karel	www.karel.com.tr	WS24	VBT	www.vbt.com.tr

Initially, the data set was arranged by obtaining the minimum and maximum values of each variable. Then, in order to express the whole sample with the same unit, the data were normalized to the range of 0-1 using Equation (2). Normalized data are given in Table 5. While the data were normalized, calculations were made in the direction that the performance score (%) and speed index (ms) criteria were maximum and the others were minimum (Gtmetrix, 2022e).

Table 5
Normalized Values

	min	min	min	max	min	min	max
Website Code	Page Size (Mb)	Onload Time (s)	First contentful paint (ms)	Performance Score (%)	Largest Contentful Paint (ms)	Total Blocking Time (ms)	Speed Index (ms)
WS1	0.97	0.96	0.80	1.00	0.95	0.94	0.03
WS2	0.86	0.82	0.42	0.61	0.70	0.99	0.21
WS3	0.95	0.91	0.39	0.51	0.85	0.87	0.14
WS4	0.69	0.67	0.39	0.45	0.53	1.00	0.31
WS5	0.70	0.02	0.42	0.51	0.53	0.96	0.26

WS6	0.77	0.69	0.13	0.44	0.00	0.97	1.00
WS7	0.07	0.01	0.59	0.61	0.62	0.96	0.13
WS8	0.05	0.00	0.65	0.61	0.54	0.96	0.21
WS9	0.98	0.95	0.57	0.87	0.91	1.00	0.15
WS10	0.42	0.53	0.62	0.30	0.15	0.95	0.39
WS11	0.83	0.93	0.40	0.43	0.71	0.99	0.20
WS12	0.91	0.85	0.12	0.57	0.75	0.99	0.21
WS13	0.87	0.87	0.52	0.62	0.81	0.97	0.31
WS14	0.95	0.90	0.46	0.70	0.85	1.00	0.15
WS15	0.84	0.87	0.46	0.43	0.74	0.90	0.32
WS16	0.88	0.81	0.23	0.58	0.60	1.00	0.26
WS17	0.97	0.89	0.46	0.62	0.74	1.00	0.17
WS18	0.64	0.83	0.00	0.00	0.64	0.00	0.77
WS19	0.96	0.90	0.28	0.48	0.76	0.92	0.32
WS20	0.96	0.96	0.38	0.73	0.85	1.00	0.15
WS21	0.82	0.80	0.36	0.57	0.78	0.94	0.24
WS22	1.00	0.97	0.71	0.88	0.88	1.00	0.08
WS23	0.00	1.00	1.00	0.86	1.00	0.81	0.00
WS24	0.74	0.54	0.14	0.55	0.59	0.95	0.34
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00

After that, the distance matrix was determined with the help of Equation (3-6) to find the grey correlation coefficient. The distance matrix is shown in Table 6.

Table 6
Distance Matrix

Website Code	Page Size (Mb)	Onload Time (s)	First contentful paint (ms)	Performance Score (%)	Largest Contentful Paint (ms)	Total Blocking Time (ms)	Speed Index (ms)
WS1	0.03	0.04	0.20	0.00	0.05	0.06	0.97
WS2	0.14	0.18	0.58	0.39	0.30	0.01	0.79
WS3	0.05	0.09	0.61	0.49	0.15	0.13	0.86
WS4	0.31	0.33	0.61	0.55	0.47	0.00	0.69
WS5	0.30	0.98	0.58	0.49	0.47	0.04	0.74
WS6	0.23	0.31	0.87	0.56	1.00	0.03	0.00
WS7	0.93	0.99	0.41	0.39	0.38	0.04	0.87
WS8	0.95	1.00	0.35	0.39	0.46	0.05	0.79
WS9	0.02	0.05	0.43	0.13	0.09	0.00	0.85
WS10	0.58	0.47	0.38	0.70	0.85	0.06	0.61
WS11	0.17	0.07	0.60	0.57	0.29	0.01	0.80
WS12	0.09	0.15	0.88	0.43	0.25	0.01	0.79
WS13	0.13	0.13	0.48	0.38	0.19	0.03	0.69
WS14	0.05	0.10	0.54	0.30	0.15	0.00	0.85
WS15	0.16	0.13	0.54	0.57	0.26	0.10	0.68
WS16	0.12	0.19	0.77	0.42	0.40	0.00	0.74
WS17	0.03	0.11	0.54	0.38	0.26	0.00	0.83
WS18	0.36	0.17	1.00	1.00	0.36	1.00	0.23
WS19	0.04	0.10	0.72	0.52	0.24	0.08	0.68
WS20	0.04	0.04	0.62	0.27	0.15	0.00	0.85
WS21	0.18	0.20	0.64	0.43	0.22	0.06	0.76
WS22	0.00	0.03	0.29	0.12	0.12	0.00	0.92
WS23	1.00	0.00	0.00	0.14	0.00	0.19	1.00
WS24	0.26	0.46	0.86	0.45	0.41	0.05	0.66
Max	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Min	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Then, using the obtained distance matrix and Equation (3), the grey correlation coefficients were determined.

Table 7
Grey Relational Coefficient

Website Code	Page Size (Mb)	Onload Time (s)	First contentful paint (ms)	Performance Score (%)	Largest Contentful Paint (ms)	Total Blocking Time (ms)	Speed Index (ms)
WS1	0.9499	0.9317	0.7143	1.0000	0.9018	0.8917	0.3392
WS2	0.7813	0.7375	0.4646	0.5620	0.6249	0.9838	0.3872
WS3	0.9137	0.8429	0.4490	0.5033	0.7722	0.7973	0.3681
WS4	0.6201	0.6022	0.4493	0.4783	0.5131	1.0000	0.4198
WS5	0.6278	0.3370	0.4622	0.5033	0.5150	0.9340	0.4039
WS6	0.6892	0.6153	0.3639	0.4724	0.3333	0.9365	1.0000
WS7	0.3495	0.3350	0.5506	0.5620	0.5662	0.9265	0.3647
WS8	0.3454	0.3333	0.5851	0.5620	0.5183	0.9174	0.3868
WS9	0.9580	0.9113	0.5387	0.7938	0.8479	1.0000	0.3696
WS10	0.4640	0.5129	0.5678	0.4162	0.3712	0.9009	0.4493
WS11	0.7429	0.8723	0.4532	0.4667	0.6341	0.9715	0.3853
WS12	0.8517	0.7709	0.3620	0.5385	0.6653	0.9838	0.3883
WS13	0.7878	0.7895	0.5090	0.5704	0.7241	0.9479	0.4207
WS14	0.9066	0.8269	0.4811	0.6260	0.7727	1.0000	0.3692
WS15	0.7577	0.7961	0.4798	0.4667	0.6622	0.8289	0.4248
WS16	0.8045	0.7203	0.3943	0.5461	0.5541	0.9993	0.4023
WS17	0.9426	0.8253	0.4829	0.5704	0.6618	0.9986	0.3746
WS18	0.5813	0.7462	0.3333	0.3333	0.5791	0.3333	0.6852
WS19	0.9177	0.8302	0.4110	0.4904	0.6728	0.8690	0.4228
WS20	0.9257	0.9236	0.4483	0.6471	0.7663	1.0000	0.3697
WS21	0.7321	0.7161	0.4391	0.5385	0.6990	0.8940	0.3978
WS22	1.0000	0.9476	0.6317	0.8105	0.8061	0.9908	0.3517
WS23	0.3333	1.0000	1.0000	0.7778	1.0000	0.7216	0.3333
WS24	0.6540	0.5184	0.3684	0.5238	0.5465	0.9132	0.4328

Finally, grey relational degrees are determined by using Equation (7).

Table 8
Grey Relational Grade

Website Code	Company Name	Performance Score	Ranking	Website Code	Company Name	Performance Score	Ranking
WS1	Alcatel - Lucent	0.818	1	WS13	Kron	0.678	8
WS2	ARD Bilişim	0.649	12	WS14	Link	0.712	6
WS3	Arena	0.664	9	WS15	Logo	0.631	16
WS4	Armada	0.583	18	WS16	Manas	0.632	14
WS5	Aselsan	0.540	20	WS17	Matriks Data	0.694	7
WS6	ATP	0.630	17	WS18	Mia Teknoloji	0.513	24
WS7	Datagate	0.522	22	WS19	Mobiltel	0.659	10
WS8	Despec	0.521	23	WS20	Papilon	0.726	5
WS9	Escort	0.774	3	WS21	Penta	0.631	15
WS10	Index	0.526	21	WS22	Plastik Kart	0.791	2
WS11	Kafein	0.647	13	WS23	Smartiks	0.738	4
WS12	Karel	0.652	11	WS24	VBT	0.565	19

Table 8 shows the final results of the analyses. According to the results of the analysis using the data set obtained by taking the average data, the website with the highest performance was the Alcatel-Lucent company. Also, the website of the Plastik Kart company is ranked second, and the website of the Escort company ranked third. The company with the lowest website performance is Mia Teknoloji.

4. DISCUSSION AND CONCLUSION

Today, every company desires to provide a great user experience to the visitors of their websites. With the advancement of technology, user expectations are increasing, and so is better performance of websites which means more satisfied users and companies. However, if the website is slow, various problems will arise, such as the page opening late, and due to such issues,

user satisfaction will decrease, and the website will lose visitors. Because websites are the visible face of businesses, they are an essential determinant of how customers perceive companies. Websites give also the first impression of ensuring customer satisfaction and meeting expectations. Therefore, having a quality website will provide competitive advantages.

The purpose of this study is to evaluate the website performance of 27 companies in the BIST Technology and Informatics Index. Since the websites of 3 companies gave an analysis error, the data could not be obtained, so the websites of 24 companies were evaluated. The performance evaluation criteria of the websites were determined based on the literature and expert opinion. In this context, the website performance of 24 companies was measured by using seven criteria which are Page Size (Mb), Onload Time (s), First contentful paint (ms), Performance Score (%), Largest Contentful Paint (ms), Total Blocking Time (ms) and Speed Index (ms). Data were obtained using the Gtmetrix automated testing tool. Relevant data were analysed using the Grey Relational Analysis (GRA) method, and as a result of the analysis, 24 companies' websites were ranked according to their performance score. In addition, no weight assignment was made for the criteria in the analysis, that is, the criteria weights were accepted as equal.

According to the performance scores calculated as a result of the Grey Relational Analysis method, Alcatel-Lucent (0.818), Plastik Kart (0.791), Escort (0.774), Smartiks (0.738) and Papilon (0.726) have the highest website performance scores and are in the top five. Aselsan (0.540), Index (0.526), Datagate (0.522), Despec (0.521) and Mia Teknoloji (0.512) have the lowest performance scores. These companies' websites are in the last five in the ranking.

When the website performance evaluation literature was examined, studies examining website performance with Grey Relational Analysis were found to be insufficient. In this context, it is thought that the study will contribute to the literature. Also, the website performances of the companies in the BIST Technology and Informatics Index were measured for the first time, and the company's websites were ranked.

As with any study, this study also has some limitations. The most important limitation of the study is the measurement of website performance with seven criteria. In future studies, website performance can be measured using different criteria. The analyses results also differ when other criteria are used. Besides that, obtaining the data of 24 companies using the GTmetrix automatic test tool is a significant limitation. In this case, different tools such as Pingdom, Website Grader, Site Speed Checker, Validator, Webpagetest, Websiteinformer, etc., can be used in future studies. Another limitation of the study is that website performance is only considered using the "speed" measure. A website's performance can also be evaluated using different measures such as content, usability, and user interface. These metrics are beyond the scope of the study. Consequently, the results are valid in the context of criteria, testing tool, and method. Thus, the results might also differ when other website performance criteria, testing tools, measured metrics, and method differ.

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