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RESEARCH ARTICLE

Increasing Danger in Business After the Pandemic: Adaptation of the Quiet Quitting Scale to Turkish

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Abstract
The awareness created by COVID-19 in people has caused a difference in their thoughts about work-life balance. People who experienced remote working with the idea that they understood the meaning and importance of life better began to resign in this process. Those who cannot resign and have to continue working in their current jobs have started to show quiet quitting behavior, which can pose a risk within the organization, especially in extraordinary situations such as crises. To prevent undesirable results, it is important to measure the level of employees' potential behavior to identify the problem first. This research consists of two main studies. In the first study, the quiet quitting scale developed by Anand et al. (2024) was adapted into Turkish. In this context, a survey was conducted on 414 employees. A one-dimensional scale consisting of six items was obtained by performing necessary reliability and validity analyses (CMIN/DF; 1.672, GFI; .979, AGFI; .944, CFI; .990, NFI; .975, TLI; .981, RMR; .051, RMSEA; 0.057). In the second study, the obtained scale was considered within the scope of the Conservation of Resources Theory, and its validity was tested in two separate models with 287 different employees in which organizational commitment and its subdimensions were the antecedents and job performance and its subdimensions were outcomes.

Keywords: Quiet quitting, scale adaptation, organizational commitment, job performance, conservation of resources theory.

Introduction

Although the concept of quiet quitting (QQ) was first used by economist Mark Boldger (Buscaglia, 2022) to describe Chinese workers moving away from jobs that cause mental health deterioration due to long working hours, the awareness of the phenomenon has increased by a social media video emphasizing the conscious that occurred in working life during the pandemic period (Khan, 2022). QQ generally involves setting limits to enhance work-life balance, restricting one's responsibilities within the job description to prevent working hours, or doing the bare minimum to complete the task at hand (Arar et al., 2023). This concept also

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refers to the tendency to make the least possible effort and not to deliberately go beyond the basic requirements while fulfilling duties and responsibilities due to dissatisfaction arising from individual or organizational reasons (Formica & Sfodera, 2022). Accordingly, although it is emphasized that QQ behavior (QQB) is similar to "work slowdown" and "strike," which are used as union rights in the literature (Kang, et al., 2023), because QQ is individual or less collective (Delery et al., 2023) and is a passive-aggressive psychological reaction (Mahand & Caldwell, 2023), this phenomenon differs from these concepts. In addition, in the relevant literature, it is stated that QQ does not involve the intention to leave the job; there is no actual act of leaving the job within the scope of the phenomenon (Anand et al., 2024), and it does not include low performance because the employees only fulfill their task performance at an adequate level (Srivastava et al., 2023). Therefore, QQ is broadly defined as behaviors that occur when employees do the minimum amount of work to avoid firing, do not go beyond their defined roles in their duties and responsibilities, and emotionally disconnect from work (Anand et al., 2024).

When the basic ideas underlying the QQ tendency are examined, it seems that there are perspectives that evaluate it within the framework of individuals exhibiting negative workplace behaviors due to individual and organizational dissatisfaction (Arar et al., 2023; Srivastava et al., 2023) and/or the precautions individuals take to protect their psychological health against harsh working conditions (Mahand & Caldwell, 2023; Serenko, 2024; Zhang & Rodrigue, 2023). When these perspectives are detailed, several items can be listed, such as workplace dissatisfaction and different levels of perception between generations (Formica & Sfodera, 2022; Kang et al., 2023), disruption of work-life balance (Hamouche et al., 2023; Shah & Parekh, 2023), and heavy and negative working conditions (Anand et al., 2024). Studies in the relevant literature indicate that these substances, which are considered antecedents of QQB, affect people's commitment levels (Hamouche et al., 2023; Serenko, 2024; Shah & Parekh, 2023). Meyer and Allen (1991) stated that individuals' commitment levels may occur in different dimensions for various reasons. Accordingly, emotional closeness and identification with the organization are defined as "affective commitment" (AC). The type of commitment that expresses the financial costs associated with leaving the workplace is referred to as "continuance commitment" (CC), and the type of commitment that reflects the perception of an obligation to stay in the organization is referred to as "normative commitment" (NC). Based on this information, employees who exhibit QQB limit their commitment to the level included in their job descriptions rather than losing their commitment completely (Karrani et al., 2023). Therefore, employees who exhibit QQB consciously decide not to exceed the requirements specified in their official job descriptions while fulfilling assigned duties only to avoid being fired and to avoid making discretionary efforts or engaging in extra-role activities (Anand et al., 2024).

Although QQB is not seen as a threat by organizations because it fulfills the basic job requirements determined within the framework of employees' job descriptions, this pheno-

menon can have harmful consequences for both organizations and employees (Delery et al., 2023). According to Zhang and Rodrigue (2023), QQB negatively affects employee psychology, performance, workplace environment, and corporate sustainability in the long term. It can be stated that these possible QQ results directly affect performance. Although the impact on performance cannot be simply observed, changes in performance level play a key role in QQ conceptualization. This feature causes QQB to pose a silent risk to organizations. Thus, QQ must be examined in detail due to these characteristics. Therefore, measuring QQB using valid and reliable tools is of great importance for understanding this phenomenon in depth. Measuring QQB is necessary to understand the conceptual findings and scope of QQ by presenting the concept with quantitative data, identifying the antecedents and consequences contributing to the concept, and evaluating the effectiveness of interventions applied to the relevant concept. (Anand et al., 2024; Karrani et al., 2023). Additionally, building a valid scale will enable empirical studies and quantitative evidence to support conceptual research findings. When the relevant literature was examined for these purposes, it was observed that various scales aimed at measuring QQB have been developed.

Literature Review

When the national literature was examined, the QQ scale (QQS) developed by Savaş and Turan (2023) was first encountered. However, this study preferred university students as the sample during the scale development phase. Considering the content and definition of the concept, which is related to people's attitudes toward their work, we believe that the sample chosen to create the scale is not "exactly" suitable. Another scale was developed by Avcı (2023). It can be seen that the relevant research was conducted with 153 higher education graduates working in local governments. There is concern that the study may be inadequate in terms of the representativeness of the concept due to the low number of participants and the fact that it was applied to the employees of a single institution. Karaşin and Öztırak (2023) developed the scale by conducting a survey on healthcare workers, and the study developed by Yücedağlar et al. (2024) aimed to measure QQB in teachers. Similarly, Yılmaz et al. (2024) developed the relative phenomenon scale for teachers. It was thought that since relevant studies dealt with QQB in a single business line and that it is affected by factors such as the nature, characteristics, and culture of the business, there may be problems in the generalizability of the phenomenon to all business lines. To overcome this issue, two studies were found in the literature. When the scale study developed by Boz et al. (2024) was examined, the psychometric measurement power and heterogeneous features of the sample were found to be good. However, the scale items consisted of 25 statements and 5 dimensions. Similarly, Bulut et al. (2024) developed a scale consisting of 48 items within 5 dimensions. These two studies advanced by obtaining favorable results for CFA and developing the relevant phenomenon scale in a heterogeneous sample. However, Smith et al. (2000) emphasized the advan-

tage of developing short-scale forms due to criteria such as the researcher's time constraint, the focus of attention of the participants not being distracted, and their tendencies regarding the relevant subject being accurately determined. Considering this warning, it is thought that there may be problems in obtaining reliable results, considering the scale length in the aforementioned studies. When the issues identified for the scales in the national literature are evaluated, the need to develop the QQS can be seen to continue.

When the international literature was examined, we encountered a scale development study in Greece (Galanis et al., 2023). Greek culture is somehow close to Turkish culture. However, there is more than one judgment in the items included in the scale study, and although at least three-factor loadings are needed for factor formation (Karaman et al., 2017), the presence of factors consisting of two items indicates that the developed scale may cause psychometric measurement errors. Another scale study is the one involving the QQS developed by Anand et al. (2024). The fact that the scale used in the study was applied to different professional groups ensures its high generalizability. When the content of the scale items was examined, it was determined that they comprised statements that comprehensively addressed the concept of QQB and that there was only one judgment in the items. Additionally, when the psychometric values of the scale study were examined, EFA and CFA were found to provide good results. Therefore, considering both the universality of the concept and of the knowledge, there are many scales in the relevant literature, as well as a qualified study in the literature with the understanding that it would be more appropriate to use a universal and common scale with high validity and reliability. It is believed that this scale should be translated into Turkish. In line with this purpose, we aimed to adapt the QQS developed by Anand et al., (2024) into Turkish. The sub-purpose of this research is to test the scale on two models. In the models created with the variables of organizational commitment, job performance, and their subdimensions, which are most related to the concept of QQB as we have witnessed (e.g. Mahand & Caldwell, 2023; Schwarz et al., 2020; Suhendar et al., 2023; Uraon & Gupta, 2021), this study examined these antecedents and consequences within the scope of the Conservation of Resources Theory (COR). In this study, the theoretical framework within the scope of the models in which the scale to be adapted is tested is first processed. Then, two separate studies are included within the scope of the method. In the first study, the process of adapting the QQS to Turkish is mentioned, and its findings are included. The second study includes the testing process and findings of the adapted scale within the scope of the antecedent and consequence. In the last section, the findings are discussed, and suggestions for future studies are provided.

Theoretical Background

Researchers working on the theoretical background of QQB state that COR provides a theoretical basis to explain QQB (Anand et al., 2024; Arar et al., 2023; Hamouche et al.,

2023). COR, proposed by Hobfoll et al. (2018), is used to describe the process of resource interaction (physical, psychological, social, and personal characteristics) between individuals and the environment. According to COR, individuals feel uncomfortable when faced with a threat or loss of resources and display an attitude that attempts to minimize such threats or losses (Meng & Choi, 2021). According to theory, this attitude is a motivational state that is at the center of human behavioral genetics and can be explained based on the evolutionary need to acquire and protect resources for survival (Hobfoll et al., 2018). COR is built on the structure of resources and defines resources as everything that an individual perceives to help oneself achieve one's goals (Hobfoll et al., 2018). Studies in relevant literature have expanded the definition of resource and defined organizational commitment as an individual resource (Hobfoll et al., 2018; Wright & Hobfoll, 2004). In this context, when employees have factors that nourish their motivation with their organization, their organizational commitment is positively affected by acquiring resources (Mowday et al., 2013). However, when they encounter a threat or loss arising from individual or organizational reasons, their commitment levels toward the workplace decrease to protect their resources (Wright & Hobfoll, 2004).

Organizational commitment (OC) (Meyer & Allen, 1991) is a comprehensive phenomenon expressed in the literature with three sub-dimensions. As AC, NC, and CC, which are mentioned in detail earlier. In the relevant literature, it is stated that employees establish a psychological bond with organizations, especially through AC and NC (Cohen, 2007). This psychological bond is negatively affected in the case of employee dissatisfaction due to individual or organizational reasons, reducing employee desire and motivation. The occurrence of factors that harm employee psychological commitment leads them to tend to protect their resources within the scope of COR. On the other hand, CC differs from the other subdimensions within the scope of this study. According to Sungu et al. (2022), the concept of CC is based on cost, and those who are highly committed are constrained by the expenses that could arise from leaving the organization and from needing to maintain their existing membership. Thus, employees who feel CC exhibit QQB in negative situations.

As negative conditions continue to exist in the work environment, employees change their performance levels to protect their personal resources. The concept of performance has a comprehensive structure that needs to be examined in its subdimensions, similar to OC. Although it is generally defined as behavioral patterns aimed at achieving organizational goals (Schwarz et al., 2020), it is classified into two dimensions, task performance (TP) and contextual performance (CP) (Borman & Motowidlo, 1997). This classification, created in the field of applied psychology by considering the factors that are effective in differentiating individuals' performance levels in the causality dimension, also emphasizes motivation that plays a role in the emergence of performance behavior. In this context, the activities that an organization expects employees to perform within the framework of the job description are called "task performance" (Uraon & Gupta, 2021). Helpful and voluntary behaviors toward

the organization, which are not directly determined by the workplace and are known to be extra-role outside of the employees' job obligations, are referred to as 'contextual performance' (Borman & Motowidlo, 1997). Accordingly, TP has a procedural and instrumental structure, whereas CP has a psychological and social structure (Borman & Motowidlo, 1997). The attitudes and behaviors that individuals have on a psychological basis are more quickly affected by the motivational losses they experience (Sonnentag & Frese, 2002). Therefore, in a work environment where employees have to work despite being dissatisfied, they tend to protect their resources by avoiding extra-role performance while performing their duties. In this model, COR assumes that QQB aims to protect employees' resources based on organizational commitment in terms of its antecedents and performance in terms of its consequences. In this context, COR provides a theoretical basis to explain employees' OC, JP, and QQB.

Methodology

This research consists of two sub-studies. In study 1, QQS, which was developed by Anandt et al. (2024), was translated into Turkish. In study 2, QQB was analyzed with OC and JP, which are claimed to be the most patterned in the theoretical context of the literature. For both studies, to generalize the findings, a heterogeneous structure was obtained by including many types of private and public sector employees who had worked at their current workplace for at least 1 year and were actively working when filling out the survey within the scope of convenience sampling.

Study 1

Sample

In total, 414 collected data were randomly divided into two equal parts. First, the frequency distribution of the demographic information of the 207 participants who make up the first part was analyzed. The result showed that 52.2% of the participants were women (n=108), 54.1% were between the ages of 26-40 (n=112), 70% had a Bachelor's degree (n=145), 40.1% had a monthly income of ₺18001-₺25000, 64.7% of them worked in the private sector (n = 134), and 35.3% had worked in their current workplace for 1-5 years (n = 73).

In the second half of the participants of 207 people; 52.7% were male (n=109), 58.9% were between the ages of 26-40 (n=122), 68.6% had a Bachelor's degree (n=142), 43.5% had a monthly income of 32,001₺. or above (n=90), 65.2% worked in the private sector (n=135), and 61.8% worked in their current workplace for 1-5 years (n=128).

Participants in both parts differ in health, tourism, consulting, education, informatics, management, and so on.

Measures

The QQS developed by Anandt et al. (2024) consists of 8 items and is measured on a 5-point Likert scale (1=*strongly disagree*, 5=*strongly agree*). No item in the scale was coded in reverse logic. Sample items include "*I often avoid working more hours if there is no additional pay*" and "*I feel there is a lack of interest in attending meetings*". The means of items differ from 1.42 to 2.44 with a standard deviation of 0.884–1.340. The items in the original scale were loaded above 0.65, and the reliability was found to be 0.876. These indicators are considered to have good internal consistency. Furthermore, to measure the demographic features of the participants, we developed a scale consisting of items related to their age, gender, educational level, income level, workplace experience, and sector type.

Procedure

In this study, we conducted an adaptation process by following ITC (International Test Commission) steps (ITC, 2018). Therefore, on 04.11.2023, we contacted Amitabh Anand, the corresponding author of the study, to translate the QQS items developed in Anandt et al.'s (2024) study into Turkish, and his written permission was received via e-mail. Then, an application was submitted to the Kırıkkale University Social and Human Sciences Research Ethics Committee on 15.11.2023. The decision taken by the Ethics Committee at the 11th meeting of 20.11.2023 was presented to the authors on 12.12.2023. Between 18.12.2023 and 20.12.2023, relevant scale items were sent to two experts in the field of management and organization and three experts in the field of English translation and interpreting with a request for translation into Turkish. The incoming translations were checked and finalized by the authors, and three experts in the field of English translation and interpreting were requested to translate the relevant Turkish items back into English, provided they were independent of their previous translations. When the authors re-examined the translations, they observed that the translations were very close to the original scale, and it was decided that the final version of the Turkish form of the scale should be as in Appendix 1. Subsequently, the relevant scale form was sent to the 30 participants for the pre-test. The results showed high reliability (Cronbach's alpha = .899) and deleting any item did not increase reliability. We also performed EFA on this sample. We obtained a one-dimensional scale structure. The cumulative variance was 58.85%. Although the items were loaded above .70; only the first item had .583. However, since it was found to be above .40, and to retain the original structure, we decided not to remove this item. Therefore, the survey process was initiated. The data were collected using an online survey technique via Google Forms between 25.12.2023 and 08.01.2024. As a condition for participating in the study, it is mandatory to be between the ages of 18 and 65 and to have worked actively for at least one (1) year in the relevant institution, and no restrictions have been imposed on a sectoral or business line basis. In addition, participants were provided with informed consent to voluntarily participate in our study, with the awareness that their data would not be shared with third parties. We did not set any limits to the extent of our surveys. Instead, we tried to include as many people who met our criteria as possible.

Results

For the first part of the 207 participants, a normality test was conducted. Although the significance level of the Kolmogorov-Smirnov test was .000 ($p<0.05$), because the skewness value was -1.113 and the kurtosis value was .566, the data distribution was accepted as normal (Gravetter & Wallnau, 2014). Next, a reliability analysis was conducted on the scale. Cronbach's alpha was calculated as .886. Finally, via IBM SPSS 22.0, exploratory factor analysis (EFA) was performed on the data. Kaiser-Meyer-Olkin (KMO) coefficient was. 881, and the significance level of Bartlett's sphericity test [$\chi^2(28) = 815.324$, $p = .000$] indicated that the data size was suitable for factor analysis. The 8 items that make up the QQS were gathered into a single dimension, and the explained variance was calculated as 56.254%. Factor loadings and item-total correlations are presented in Table 1. In addition, within the scope of the answers given by the participants in the first part, the QQ level of the participants was found to be at a medium level (M = 2.7585, SD = 1.1).

Table 1
Factor Loadings and Total Item Correlations for the Quiet Quitting Scale

		Initial Eigenvalues				Item-Total Correlations
Items	**Factor 1**	**Component**	**Total**	**variance %**	**% Cumulative**	
QQ1	.680	1	4,500	56,254	56,254	.699**
QQ2	.815	2	,892	11,153	67,407	.807**
QQ3	.796	3	,700	8,745	76,152	.804**
QQ4	.644	4	,618	7,728	83,880	.647**
QQ5	.770	5	,383	4,790	88,670	.770**
QQ6	.680	6	,357	4,465	93,135	.681**
QQ7	.858	7	,294	3,670	96,805	.843**
QQ8	.731	8	,256	3,195	100,000	.722**

$p<0.01$**

For the second part, which consisted of 207 participants, a normality test was first carried out. Although the significance level of the Kolmogorov-Smirnov test was .000 ($p<0.05$), because the skewness value was .383 and the kurtosis value was -.748, the data distribution was accepted as normal (Gravetter & Wallnau, 2014). Within the scope of the answers given by the participants in the second part, it was found that the QQ level of the participants was higher than that of the first group (M = 3.7037, SD = .86). Next, a reliability analysis of the scale was conducted. Cronbach's alpha was calculated as. 860. Then, via AMOS 21.0, confirmatory factor analysis (CFA) was performed on the dataset. It is understood that the 1st and 3rd statements did not have sufficient factor loading and were removed from the revised structure. When the items were re-examined, item 1 was found to be not related to the essence of QQ and was more related to counterproductive work behavior. When the definition of QQ is examined, it is determined that the focus is on "working only enough to fulfill the requirements of the job", but if the employee fulfills the relevant requirement, they will move away from fulfilling these requirements. It is also noted that the relevant item was removed

from the original study after EFA was conducted. Similarly, item 3 was also re-examined. Although the relevant item constitutes the essence of QQ, it seems that it is not discussed at a common point in terms of understanding by the participants. A total of 114 of the participants answered, "strongly disagree" with the relevant item, while 90 of them answered, "I agree". It is believed that this item, for which the standard deviation is high, was not understood correctly. It was determined that the relevant item was removed from the structure after CFA in the original scale. However, as a result of creating covariance between the e4 and e7 error coefficients within the scope of modification indices, the fit index values of the model are; 1.672 for CMIN/DF; .979 for GFI; .944 for AGFI; .990 for CFI; .975 for NFI; .981 for TLI, while It was found to be .051 for RMR and .057 for RMSEA value. Among these values, the CMIN/DF, GFI, AGFI, CFI, NFI, and TLI values were within ideal fit limits, and the RMSEA and RMR values, it is seen that they are within acceptable limits. Because of these findings, the unidimensional structure of QQS adapted into Turkish confirmed.

Table 2
Factor Loadings afterwards CFA, AVE, and CR and CR Values

Items	Factor Loadings	SFL	SMC	CR	AVE
QQ2	0.53	0.2809	0.7191	0.873424	0.53875
QQ4	0.75	0.5625	0.4375		
QQ5	0.81	0.6561	0.3439		
QQ6	0.75	0.5625	0.4375		
QQ7	0.76	0.5776	0.4224		
QQ8	0.77	0.5929	0.4071		

SFL: Standardized Factor Loading, SMC: Squared Multiple Correlation; CR: Composite Reliability; AVE: Average Variance Extracted

Additionally, as shown in Table 2, the AVE value calculated based on factor loadings was found to be 0.53875, and the CR value was 0.873424. The fact that the AVE value is greater than 0.50 and the CR value is greater than 0.70 indicates that the defined factor structure has sufficient reliability and convergent validity (Yaşlıoğlu, 2017). Therefore, the original scale, which consists of a single dimension with 8 items, was adapted to Turkish as a one-dimensional QQS consisting of 6 items, by performing validity and reliability analyses for the reasons stated above.

Study 2

Sample

When the demographic characteristics of the participants (n=287) from whom the data collected within the scope of the second study were examined, 50.2% of the participants were women (n=144), 64.8% were in the 26-40 age group (n=186), and 64.1% were university graduates. graduate (n=184), 28.9% of them had an income between ₺25,000-₺33,000, and 63.8% were private sector employees. Similar to Study 1, the professions of the participants weary in a range.

Measures

In addition to the demographic information about the participants, the survey consists of four sections, namely, QQB, OC, and JP. While the QQS, consisting of six items and a single dimension obtained within the scope of Study 1, was used for QQB, for OC, the Organizational Commitment Scale (OCS), which was created by Meyer and Allen (1991) and adapted into Turkish by Dağlı et al. (2018), consisting of 18 items and three sub-dimensions, was used. For JP, in addition to the nine items to measure TP compiled by Goodman and Syvantek (1999), the CP scale created by Jawahar and Carr (2007) and its Turkish adaptation made by Bağcı (2014) comprises a total of 17 items. In all the scales, a 5-point Likert-type scale (1=*strongly disagree*, 5=*strongly agree*) was used.

Procedure

Along with ethical permission and the completion of the data collection process in Study 1, data collection began from a different sample group for Study 2. The data collection process started on 10.01.2024 and ended on 30.01.2024. Valid responses were received from 287 participants using the convenience sampling technique. As a condition for participation in Study 2, the participation rules were the same as those in Study 1.

Results

First, a normality test of the JP scale was conducted. Although the significance level of the Kolmogorov-Smirnov test was .000 ($p<0.05$), because the skewness value was .785 and the kurtosis value was 1.616, the data distribution was accepted as normal (Gravetter & Wallnau, 2014). Subsequently, a normality test of the OC scale was conducted. Similarly, although the significance level of the Kolmogorov-Smirnov test was .000 ($p<0.05$) since the skewness value was .587 and the kurtosis value was -.090, the data distribution was accepted as normal to. Finally, a normality test was conducted for QQS within the scope of the relevant sample. Since skewness value -.598; and kurtosis value was. 888, QQS was determined to be normally distributed.

Following the normality test, a reliability analysis of the JP scale was conducted. Cronbach's alpha was calculated as .951. Confirmatory factor analysis (CFA) was performed on the dataset for validity. The AMOS 21.0 program was used for this. It is understood that the 1st and 2nd statements of the second sub-dimension (CP items) did not have sufficient factor loads and were therefore removed from the structure. However, as a result of creating covariance between the error coefficients e3 and e5, e5-e6, e10-e11, and e12-e13 within the scope of modification indices, the fit index values of the model were; 2,769 for CMIN/DF; .908 for GFI; .870 for AGFI; .941 for CFI; .961 for NFI; .961 for TLI; It was found to be .10 for RMR and .079 for RMSEA value. These values are within the ideal fit limits for NFI and

TLI values, whereas other values are within acceptable compliance limits (Doğan & Özdamar, 2017).

Second, a reliability analysis was conducted for the OC scale. Cronbach's alpha was calculated as.828. Then, confirmatory factor analysis (CFA) was performed on the dataset. In order to obtain acceptable values, we needed to remove some items (AC1-2-6; CC6; NC1-2) while keeping the original three sub-dimensions structure. In addition, we had to draw covariances among the error coefficients (NC3-5; NC5-6; CC1-4). Because of the CFA, the values were 3.840 for CMIN/DF; .912 for GFI; .857 for AGFI; .916 for CFI, and 0.10 for the RMSEA value. These values appear to be within acceptable limits (Doğan & Özdamar, 2017).

Although validity and reliability analyses were conducted in Study 1, the QQS was subjected to the same analysis again within the scope of the sample in Study 2. In this context, Cronbach's alpha was calculated as.896. Additionally, as a result of the CFA, the values were 1.475 for CMIN/DF; .987 for GFI; .966 for AGFI; .996 for CFI; .988 for NFI; .996 for IFI; It was found to be .030 for RMR and .041 for RMSEA value. These values appear to be ideal.

When the descriptive statistical information of the scales was examined, QQ was found to be above average (Mean = 3.33, SD = 1.06), and JP was similarly above average (M = 3.5677, SD = .80). However, OC was found to be on average (M= 2.999, SD=.66).

Later, in the first model shown in Figure 1, correlation analysis was conducted to determine the direction and strength of the relationship between OC and its subdimensions and QQ, based on the theory that OC is one of the basic antecedents of QQB.

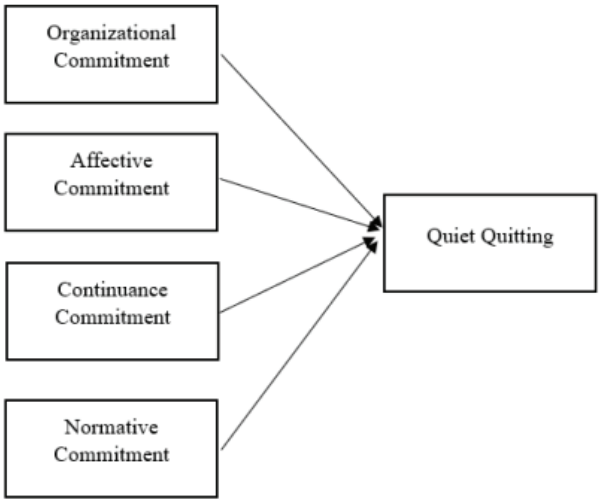

Figure 1. Model 1

Table 3 presents the results of the correlation analysis.

Table 3
Correlation Analysis Results-1

	1	2	3	4	5
QQ (1)	1				
OC (2)	-.423**	1			
AC (3)	-.758**	.540**	1		
CC (4)	.139*	.681**	-.144*	1	
NC (5)	-.355**	.893**	.390**	.497**	1

*p<0.05 **p<0.01

As seen in Table 4, a negative relationship was found between OC and QQ, both based on the main dimension and the subdimensions except for continuance commitment. The strength of the relationship was high between QQ and AC (r=-.758, p<0.01), medium with OC and the NC (r=-.423, p<0.01; r=-.355, p<0.01), and a low level of correlation with CC (r=.139, p<0.05). Regression analysis was performed to determine and measure the impact level, and the results are presented in Table 4.

Table 4
Regression Analysis Results-1

			DV: QQ		
IV	**b**	**R^2**	**Adj. R^2**	**F**	**p**
OC	-.680	.179	.176	61.950	.000
CC	.183	.139	.019	.016	.019
AC	-.710	.758	.574	.573	.000
NC	-.403	.355	.126	.123	.000

**p<0.01 *p<0.05
IV: Independent Variable DV: Dependent Variable

Table 5 shows that OC negatively affects QQ (b=-.680, p=.000) and predicts it significantly (R^2=.179, p<.01); similarly, AC negatively affects QQ (b=-.710, p=.000) and predicts it significantly (R^2=.758, p<.01). NC negatively affects QQ (b=-.403, p=.000) and predicts it significantly (R^2=.3555, p<.01), and finally, it is seen that CC positively affects QQ (b=.183, p=.019) and predicts it significantly (R^2=.139, p<.05).

In the second model shown in Figure 2, correlation analysis was conducted to determine the direction and strength of the relationship between QQ and JP and its subdimensions based on the theory that JP is one of the main consequences of QQ.

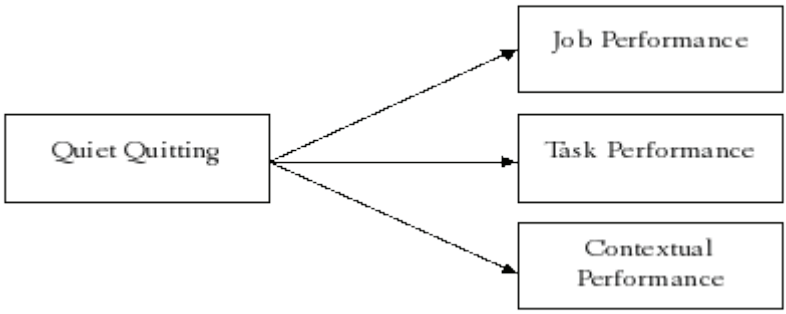

Figure 2. Model 2

Table 5 presents the results of the correlation analysis.

Table 5
Correlation Analysis Results-2

	1	**2**	**3**	**4**
(QQ (1	1	-.191**	.112*	-.465**
(JP (2		1	.889**	.876**
(TP (3			1	.557**
(CP (4				1

*p<0.05 **p<0.01

As shown in Table 5, negative relationships (r=-.191, p<0.01; r=-.465, p<0.01) were found between JP and CP with QQ. In terms of relationship strength, a low level of relationship strength was found between QQ and JP, and a medium level of relationship strength was found between QQ and CP. However, a low-level positive relationship (r=.112, p<0.05) was found between QQ and TP. Regression analysis was performed to determine and measure the impact level, and the results are presented in Table 6.

Table 6
Regression Analysis Results-2

			IV: QQ		
DV	**b**	**R2**	**Adj. R^2**	**F**	**p**
JP	-.144**	.037	.033	10.830	.001
TP	.082	.013	.009	3.636	.058
CP	-.483**	.217	.214	78.760	.000

**p<0.01
IV: Independent Variable; DV: Dependent Variable

Table 6 shows that QQ negatively affects JP (b=-.144, p=.001) and predicts it significantly (R^2=.033, p<.01). However, it was observed that the effect of QQ on TP was not statistically significant (p>0.05); It was determined that its effect on CP was negative, similar to the basic dimension (b=-483, p=0.000) and predicted it significantly (R^2=.214, p<.01).

Discussion

This study was conducted to explain in detail the concept of QQ, which is more visible in business life, especially after the COVID-19 pandemic, and to obtain empirical findings. In QQB, the emotional detachment experienced by employees toward work and the organization despite fulfilling their duties emphasizes the psychological feature of the phenomenon (Hamouche et al., 2023). In the discussions, there are views that the philosophy of QQB of 'only fulfilling specified tasks" causes one of the parties to fail to fulfill their unwritten obligations, which results in a psychological violation (Karrani et al., 2023). In line with these views, it is important to examine the psychological structure of the phenomenon, develop a measurement tool to obtain empirical evidence, and consider its antecedents and consequences.

The main purpose of this research was to adapt a valid and reliable scale. In this context, a study was conducted to adapt the QQS, developed by Anand et al., (2024), to Turkish. Although 8 items were gathered in a single dimension in the original scale structure, in the final structure, one item was removed and completed as 7 items in a single dimension. However, when we contacted the corresponding author of the original scale, he stated that the original scale consisted of 8 items, but the first item was removed from the data of their study, but he suggested that we use all 8 items. Similar to the original study, the first item was removed from the scale, and an additional item (third item) was removed and adapted to Turkish as 6 items and a single dimension. It can be concluded that the scale structure obtained because of this adaptation has an ideal structure. The final adapted version of the scale was evaluated by two experts in the fields of management and organizations, and it was determined to be sufficient to measure the relevant phenomenon.

With the scale adapted in line with the sub-objective of the research, the concept of OC as an antecedent and JP was considered within the scope of the consequence and tested in two models. In this context, within the framework of the first model, a negative and moderate relationship was found between OC and its subdimensions and QQ, except for CC. This result provides empirical evidence for studies in the relevant literature that address the issue of QQ within the scope of OC (Arar et al., 2023; Galanis et al., 2023; Hamouche et al., 2023; Mahand & Caldwell, 2023). Because of the regression analysis, it was observed that OC and its subdimensions negatively affected QQB but not CC. It can be stated that the results obtained are consistent with Smith's (2022) study, which reported that 50% of today's employees prefer to limit their commitment to their jobs. Subsequently, QQB has become more prominent.

Negative and moderate relationships were found between AC and QQB. In the regression analysis, it was observed that the AC negatively affected the QQB, and the explanation level of the model was determined to be 57.4%. The result responds to the call in the literature that the emotional aspect of QQB should be focused on (Karrani et al., 2023) and provides empiri-

cal support for the definition of QQB as loss of AC or emotional detachment in the workplace (Hamouche et al., 2023; Serenko, 2024).

Negative and low-level relationships were found between NC and QQB. In addition, NC was found to negatively affect QQB, and the explanation level of the model is low. Aligned with the fact that even employees express their commitment to the workplace within the scope of their moral and ethical consciousness levels (Meyer & Allen, 1991), different views exist on the ethical and moral nature of such a concept. While Zenger and Folkman's (2022) statements 'QQ is not about bad employees, but about bad management' emphasize that the relevant concept does not indicate any ethical or moral deficiency. There are also studies stating that the phenomenon is a complete ethical violation (Meriac et al. 2023; Scheyett, 2023). The contradictory views in the literature may explain the low representation power of QQB at the antecedent level by NC.

Finally, a weak but positive relationship is found between continuance commitment (CC) and QQB. In addition, CC positively affects QQB, and the explanation level of the model is low. This positive relationship is natural because CC expresses the obligatory situations (such as the cost of leaving) that require individuals to work at their jobs; thus, individuals may exhibit QQB against the negative situations they experience at workplace.

In the second model, the structure between QQBs and JPs is discussed. There are two reasons why JP is preferred in the model: First, JP is considered the most important variable that QQB can affect; the second is to observe the differentiation in the performance levels that QQ affects by its nature. In other words, individuals who display QQB deliberately demonstrate TP by fulfilling minimum job requirements (Delery et al., 2023) but also avoid performing CP because they are deliberately reluctant to perform outside of their role (Zenger & Folkman, 2022). The possibility that QQB exerts different effects in different types of performance was evaluated. In this context, a negative and low-level relationship was detected between QQB and JP. In addition, it was determined that the model was statistically significant and that QQB negatively affected JP. The results obtained are important in terms of providing empirical evidence for both the theoretical content of QQB and studies in the literature that address the negative impact of the relevant phenomenon on performance. (Arar et al., 2023; Hamouche et al., 2023; Zenger & Folkman, 2022; Zhang & Rodrigue, 2023).

Positive and low-level relationships were found between QQB and TP. This result obtained by Delery et al. (2023) supports the finding that individuals exhibiting QQB continue their work within the scope of their duties and prefer to remain silent to avoid situations that may lead to management detection and negative performance evaluation or dismissal. However, the model that examined the effect of QQB on TP was found to be statistically insignificant. Considering different perspectives, QQB cannot be considered poor performance (Srivastava et al., 2023), despite its evaluation within the scope of counterproductive behavior (Mahand

& Caldwell, 2023; Shah & Parekh, 2023; Srivastava et al., 2023). Thus, the impact level on TP may have a more complex structure.

Considering the other dimension of performance in the model, a negative and moderate relationship was found between QQB and CP. It can be concluded that the obtained result is compatible with the nature and theoretical background of the QQ. Although individuals exhibiting QQB continue to work, they avoid CP, which explains the level of negative relationships achieved. In addition, QQB has a negative effect on CP, and the explanation level of the relevant model is 21%. When the results obtained within the scope of the second model of the research were examined, the unique structure of the concept of QQ on the basis of performance was met at the empirical level.

Conclusion

This study, which centers on QQB, focused on scale adaptation and testing because it was thought that the relevant phenomenon needs to be developed. For this reason, the model discussed in this study was chosen to be suitable for comparing the theoretical framework of the concept with its empirical results. The study will provide authors to measure QQB as a new concept in Turkish culture with other managerial and organizational issues using a scale that we adapted with a heterogeneous sample with one factor of six items.

This study has some limitations. First, in study 2, which analyzes the antecedents and consequences of QQB within the scope of cause and effect, we conduct a cross-sectional study. Although the general acceptance of the concept of QQ is that the phenomenon started to occur after the COVID-19 pandemic, the concept head existed beforehand. For this reason, longitudinal studies can be conducted in future research to obtain findings that are free from the pandemic effect and to determine changes after the pandemic. In addition, we only analyzed the causes and effects of organizational commitment and job performance. Therefore, it is important for the development of literature that studies on QQB consider the relevant concept as a dependent, independent, and mediating variable in further research. Other related factors, such as subjective well-being, job satisfaction, bore-out syndrome, etc. should be better analyzed using the QQB. Additionally, apart from the COR theory, which we preferred to use, models that can be created within the scope of other theories should be examined to contribute to the literature. It is also recommended to develop the concept of QQ through studies at different institutions and business lines and to examine the possible effects and consequences of the relevant phenomenon.

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Ethical Approval: The study was approved by ethics committee of Kırıkkale University on 20.11.2023 (register number: XX).
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Appendix 1

*Turkish Adaptation of QQS**

Madde Kodu	**Madde**
QQ1	İşe sıklıkla geç gelip erken ayrılırım.
QQ2	Eğer ek ücret almayacaksam fazla mesai yapmaktan çoğunlukla kaçınırım.
QQ3	İşten atılmayacak şekilde minimum düzeyde iş yaparım.
QQ4	Çalıştığım kurumda öğrenme ve gelişme olanaklarının eksik olduğunu hissediyorum.
QQ5	Çalıştığım iş bana anlamlı gelmiyor.
QQ6	Toplantılara katılmaya ilgi duymuyorum.
QQ7	Elimden gelenin fazlasını yapacak heves ve isteği kendimde bulamıyorum
QQ8	İşverenimin beni önemsemediğini hissediyorum.

**The final version of the scale comprises items QQ2, QQ4, QQ5, QQ6, QQ7, and QQ8*

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RESEARCH ARTICLE

Evaluating the Effect of Artificial Intelligence on Perceived Business Performance of Turkish Firms in Technology Development Zones in Türkiye

Salih Caner[1]

Abstract

Artificial intelligence (AI) has become integrated into many areas of business and daily life; however, its strategic impact on organizations in Türkiye has not been thoroughly studied. This study addresses this gap by empirically assessing the effect of AI adoption on perceived business performance. Additionally, using previously developed AI business strategy perspectives, the differences in strategic approaches between AI-adopting and non-adopting companies were examined.

The research surveyed firms located in Technology Development Zones (TDZs) in Türkiye, which are generally more technology-oriented, validating previously constructed AI business strategy perspectives and examining AI's effect on perceived business performance. The study found a statistically significant, albeit low-level, positive correlation between AI implementation and perceived business performance. Furthermore, it revealed differences in strategic approaches between AI-adopting and non-adopting companies based on previously constructed AI business strategy perspectives.

The study concludes that AI adoption shows promise in enhancing business performance, but its effect is modest in TDZs in Türkiye. This research contributes to the growing body of knowledge on AI in business by providing empirical evidence of AI's effect on perceived business performance in an emerging economy context and highlighting strategic differences between AI adopters and non-adopters. These findings have important implications for managers considering AI adoption and policymakers shaping AI-related regulations.

Keywords: Artificial intelligence; Business strategy; Systematic literature review; Perceived business performance; Technology development zone

Introduction

AI products are not far from the daily life of an ordinary person. For example, AI is the engine behind the new word "googling" that people have begun to use in their daily conversations to mean researching on the internet. AI is the technology behind Alexa, Siri, or Google's Digital Assistant, which you may communicate with via voice. AI isae filter in your email box that automatically moves junk e-mails to the spam folder. We are all experiencing a new technological revolution.

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Global consultancy firms and other prestigious institutions have published reports on the impact of AI. These reports have generally urged companies to include AI on their agendas. It can be suggested that technology-oriented companies demonstrate greater interest in AI, whereas other firms may be hesitant due to their limited understanding of AI.

AI applications have become a source of real business value due to three significant developments: better AI algorithms, massive data storage, and improved hardware. Thanks to improvements in these three areas, AI has surpassed human cognitive abilities in various areas, such as vision and speech processing (Caner & Bhatti, 2020).

When delving deeper into AI technology, many other technical terms like machine learning, deep learning, generative AI, and neural networks, may cause confusion, particularly for people in non-information technology-related fields. Therefore, AI is assumed to be an umbrella term that encompasses these technologies, allowing us to focus more on the business perspective of AI.

Various AI definitions can be found in the literature. This study proposes a definition of AI that includes different core features from various AI definitions. By highlighting some key terms asserted by prominent scholars, the following more comprehensive definition of AI is proposed:

AI is the science and engineering of making intelligent machines, especially intelligent computer programs (McCarthy, 2007) that perceive, reason, and act (Winston, 1992) based on data in ways that simulate human intelligence, learn over time through the acquisition of new data and information, and adapt to changes in their environment (Canhoto & Clear, 2020) .

It is clear that AI is a hot technological topic for people, governments, and companies. Well-known technology entrepreneurs and top political leaders from around the world have been discussing the investments and future risks of AI. The main question for company executives is how to assess the effect of AI on business performance and what strategy should be for implementing AI in their businesses. Therefore, a study that measures the effect of AI on perceived business performance is required.

Caner and Bhatti (2020) proposed six business strategy perspectives to better understand the AI phenomenon (Figure 1). Assessing the credibility of AI business strategy perspectives can help legitimize the study.

Considering the increasing potential of AI, a study that examines the effects of AI on perceived business performance and validates AI business strategy perspectives is required.

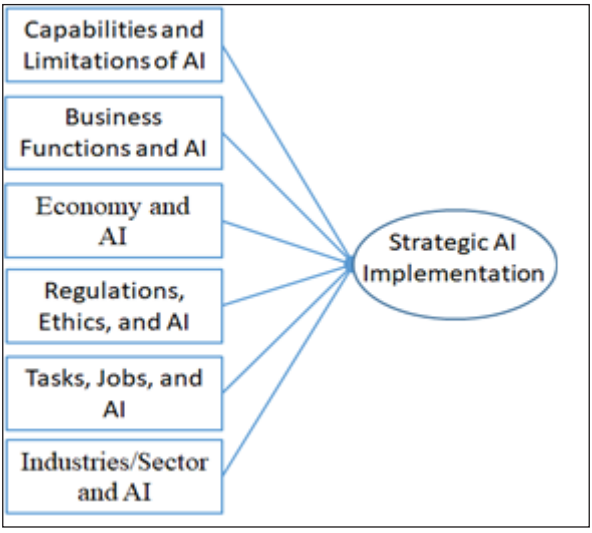


Figure 1. The proposed "Strategic AI Implementation"

Literature Review

A variety of studies in the literature have found a positive effect of R&D on firm performance (Jimenez-Jimenez & Sanz, 2011; Uotila, Maula, Keil, & Zahra, 2009), but there are limited studies specifically on companies in Türkiye. A study analyzed 62 companies listed on the BIST Industrial Index in Türkiye and examined their R&D expenditures over seven consecutive years (2012-2018). The findings reveal that R&D investments positively impact company profits after a two-year lag. (Güzen & Başar, 2019).

Mikalef and Gupta (2021) found that AI capability positively influences organizational creativity and firm performance. They asserted that AI capability's effect on firm performance is partially mediated by organizational creativity, highlighting the importance of fostering creative processes alongside AI implementation. The study was conducted using survey data from 202 chief information officers and IT managers in Norway by implementing structural equation modeling (SEM).

Dubey, Bryde, Foropon, Tiwari, Dwivedi, and Schiffling (2021) proposed a composite AI readiness index for manufacturing and supply chain firms and found that AI readiness positively impacts operational performance. The authors argued that top management commitment and organizational learning culture are crucial for successful AI adoption and performance improvement. This study uses data from 205 manufacturing and supply chain firms in India. The methodology involved a survey-based approach with data analysis using partial least squares structural equation modeling (PLS-SEM).

Dwivedi, Hughes, Ismagilova, Aarts, Coombs,Crick, and Williams (2021) conducted a multidisciplinary study exploring the challenges and opportunities of AI adoption across various sectors. They argued that while AI offers significant potential for improving business performance, organizations must address ethical concerns, data privacy, and the need for human-AI collaboration. The study synthesized insights from 30 invited expert contributions across different domains by employing a qualitative approach to develop a comprehensive perspective on AI's impact.

Mahmoud, Buheji, El-Den, and Ahmed (2021) examined the effect of AI on small and medium enterprises (SMEs), finding that AI adoption can lead to improved efficiency and competitiveness. They concluded that SMEs face unique challenges in AI adoption, including resource constraints and the need for specialized skills. This research focused on SMEs in the Gulf Cooperation Council (GCC) countries using a mixed-methods approach, combining a literature review and qualitative analysis of SME cases in the GCC region.

Tønnessen, Dhir, and Flåten (2021) conducted a multi-method study examining the relationship between digital capabilities, including AI, and organizational performance. They found that digital capabilities, particularly those related to AI, positively impact financial and non-financial performance metrics. The study was conducted using a survey of 178 Norwegian firms and in-depth interviews with 10 executives. The methodology involved quantitative analysis of survey data using statistical techniques such as regression and SEM combined with qualitative analysis of interview data.

Chen, Esperança, and Wang (2022) found that AI capability indirectly affects firm performance through three mediators: AI capability, AI management, and AI-driven decision-making. They argued that the effect of AI on firm performance is moderated by marketing capability, highlighting the importance of aligning AI initiatives with existing organizational competencies. The researchers collected data through questionnaires from e-commerce companies in China and used partial least squares structural equation modeling (PLS-SEM) for data analysis.

Mahboub and Ghanem (2022) conducted a systematic review of AI's effect on business performance across various industries. They argued that although AI generally improves business performance, its effectiveness depends on several factors, such as organizational readiness, data quality, and the specific application context. This review analyzed 45 peer-reviewed articles published between 2015 and 2021.

Kim, Park, and Kim (2022) examined the effect of AI on firm performance considering both direct and indirect effects. They found that AI has a positive effect on firm performance, which is mediated by process and product innovation. The research was conducted using data from 334 Korean manufacturing firms and analyzed using SEM.

Despite numerous applications of AI in different domains, the effects of AI on business performance have been rarely studied, especially in Türkiye. Therefore, the main research question of this study is as follows:

Research Question 1: What is the impact of AI on business companies in Türkiye?

After determining the sample space, the specific research question for the empirical study is as follows:

Research Question 1 (Revised):What is the effect of AI on firms' perceived business performance of the firms in TDZs of Türkiye?

Based on this, the following hypothesis was developed.

Hypothesis.1. AI usage positively affects a firm's perceived business performance.

Six Business Strategy Perspectives

Petticrew and Roberts (2006) defined systematic literature review (SLR) as "literature reviews that adhere closely to a set of scientific methods that explicitly aim to limit systematic error (bias), mainly by attempting to identify, appraise and synthesize all relevant studies (of whatever design) in order to answer a particular question (or set of questions)."

The author of this study previously conducted a systematic literature review to explore perspectives related to business AI strategies.

Caner and Bhatti (2020) used the studies of Tranfield, Denyer, and Smart (2003) and Gough, Oliver, & Thomas, (2013) to implement their SLR.

Caner and Bhatti (2020) argued that although AI has great potential to improve business performance, most valuable academic studies are related to information technology. This conclusion was based on a query they performed in October 2020, which searched for "artificial intelligence" in the topics of articles in the Web of Science. Their findings revealed that 90% of the studies were from IT-related disciplines, whereas only 4.1% were from social science disciplines. Caner and Bhatti (2020) proposed the following six business strategy perspectives to better understand AI.

1. Capabilities and limitations of AI
2. Business function perspective of AI
3. Economy perspective on AI
4. Tasks, jobs, intelligence, and AI
5. The regulation perspective of AI
6. Industry perspective on AI

Capabilities and limitations of AI

The essence of this perspective is to understand how AI works. However, AI studies in a firm should not be confined to technical departments. Higher management engagement is needed on various issues, such as defining AI investment strategies and prioritizing and assessing ethical, security, and privacy concerns (Caner and Bhatti, 2020).

Business Functions and AI

The core idea of this perspective is to evaluate the possible use cases of AI in different business functions, such as production, process management, and marketing. This evaluation requires assessments based on the collaborative synergy of different business functions, strategic thinking, available data, leadership, characteristics of each business function, and basic AI know-how.

According to a survey implemented by The IBM Institute for Business Value and Oxford Economics, AI applications can be categorized into three groups based on the structure of the organization: front office, middle office, and back office (Abercrombie, Ezry, Goehring, Marshall and Nakayama, 2017, as cited in Caner and Bhatti, 2020).

Front office positions deal with customer-oriented jobs, such as sales and marketing. AI can help increase customer retention using purchase data.

Middle office concerns related to production issues such as logistics, manufacturing, and innovation. AI can optimize production, supply, and logistics processes.

The back office is responsible for supporting departments like IT, human resources, and accounting. In the back office, AI can perform repetitive tasks.

Economy and AI

Agrawal et al. (2017) stated that the economic impact of AI will depend on the prediction cost. They argue that AI will both lower the cost of prediction-related tasks and substitute some economic activities. AI reduces the cost of prediction; thus, human prediction will be used less frequently for tasks that can be replaced by AI.

Gillham, Rimmington, Hugh, Verweij, Rao, Roberts, and Paich (2018) suggest that unskilled jobs, which account for 67% of all jobs, will be gradually replaced by AI (as cited in Caner and Bhatti, 2020).

The economy and AI perspective focuses on defining an investment strategy for AI by evaluating macroeconomics, foresight into AI, firms' investment priorities, investment timeline, and budget.

Tasks, Jobs, and Intelligence

This perspective entails two key considerations:

1. Managers should determine how to facilitate collaboration between human workers and artificial intelligence.

2. There is a need to redefine the descriptions of tasks and jobs.

AI can enhance firm performance by allowing human experts to perform complex tasks that require intuitive intelligence while managing simpler tasks. For example, a call center manager might allow AI to handle standardized and routine customer calls and divert more complicated questions to a human expert (Caner and Bhatti, 2020).

Regulations, ethics, and artificial intelligence

Autonomous decision capability is the differentiator facet of AI compared to other IT technologies. As this new paradigm brings new challenges, the regulations and ethics perspective highlights the complexities of implementing AI-enabled products. If this dimension is not handled properly, legal disputes may arise, or the company's reputation could be at stake.

For example, a cliché question concerning AI and ethics asks who is responsible when an AI-assisted autonomous vehicle is involved in an incident.

Moreover, regulatory standards are needed to materialize AI-enabled products (Caner and Bhatti, 2020).

Industries and AI

AI can be applied to any sector that produces data, uses machinery, or performs routine laborious tasks. Each business domain has different dynamics and regulations. Although AI can reduce costs by helping to use less energy or replace human work in some sectors, it can also be destructive in other sectors, especially when combined with robotics.

The empirical evidence for AI was examined based on the six proposed AI strategies in line with Research Question 1. Consequently, the following research question was developed.

Research Question 2: Do TDZ companies differ from AI business strategy perspectives?

The following hypotheses were proposed for each of the abovementioned perspectives. The respondents were categorized into two groups based on their responses to AI usage in the survey: either "Using AI" or "Not Using AI". Accordingly, the "Using AI" and the "Not Using AI" groups were compared using significance tests. The following hypotheses were studied.

Hypothesis.2(Capabilities-Limitations): There is not a significant difference between the "Using AI" and the "Not Using AI" groups with respect to AI's capabilities and limitations perspective.

Hypothesis.3(Business Functions): There is not a significant difference between the "Using AI" and the "Not Using AI" groups with respect to AI's business functions perspective.

Hypothesis.4(Economy): There is no significant difference between the "Using AI" and the "Not Using AI" groups with respect to AI's economic perspective.

Hypothesis.5(Task-Jobs): There is not a significant difference between the "Using AI" and the "Not Using AI" groups with respect to AI's tasks and jobs perspective.

Hypothesis.6(Regulations-Ethics): There is not a significant difference between the "Using AI" and the "Not Using AI" groups with respect to AI regulations and ethics perspective.

Methodology

This research can be classified as descriptive or exploratory. This research has two main purposes:

1. To investigate the effects of AI on perceived business performance.

2. To reveal differences between firms from the six AI business strategy perspectives.

To address these concerns, a questionnaire was prepared to quantitatively measure the effects of AI on perceived business performance.

Survey

The survey approach is an empirical data collection method that allows quantitative statistical analysis. Data can be obtained via mail questionnaires, telephone interviews, or electronic forms via email or internet platforms. Statistical analysis tools enable the discovery of relationships between dependent and independent variables (Gable, 1994).

However, some scholars debate the drawbacks and advantages of surveys. The benefits of conducting a survey include:

- Ease of implementation

- Use of standardized and objective tools to measure empirical data

- Ability to reveal relationships between variables

- Generalizability of findings to the population under investigation

- Easy replicability and allowance for comparison among different populations. (Chin, Marcolin, & Newsted, 2003)

Questionnaire

The questionnaire used in this study consisted of six sections as listed below.

1. Section: Anonymous descriptive company information including: number of employees, region of the company, sector of the company, and respondent status.

2. Section: Eight questionnaire items used to measure firms' perceived business performance were adopted from Aydiner, Tatoglu, Bayraktar, Zaim, and Delen (2019).

3. Section: This section inquires about the AI implementation history of the firm and reasons for not using AI.

4. Section: This section analyzes the general AI knowledge of the firm.

5. Section: This section explores AI business strategy perspectives.

6. Section: Questions related to the AI competitive perspective of the firms.

The GoogleForms online survey platform was used to collect the responses. Despite concerns such as low response rates, privacy issues, and security issues raised regarding online surveys, fast response, low cost, easy administration, and convenience factors have made online surveys more preferable than other conventional survey methods (Vasantha, & Harinarayana, 2016).

Sampling Strategy

Sampling consists of three consecutive stages: unit of analysis, description of the sample frame, and selection of the sampling technique.

The unit of analysis defines the object of analysis based on the researcher's target. The unit of analysis in this study was TDZ firms, or more specifically, individuals who have the authority to fill out the questionnaire on behalf of the company.

The second step of the sampling procedure was to describe the sampling frame. This involves determining the accessible portion of the population that the researcher believes rep-

resents the characteristics of the population. After facing challenges in acquiring responses from different domains, the researcher chose companies located in TDZs of Türkiye as the sampling frame.

Although 6,005 companies are listed in TDZs throughout Türkiye according to the report by the Ministry of Technology and Industry of Türkiye, notifications were sent to approximately 3,100 official email addresses of TDZ companies (Technology Development Zone, 2020).

It can be argued that census sampling was used in this study because the researcher gathered all available email addresses of TDZ companies by checking the official websites of TDZ administrations and firms.

Data Collection

Challenges were encountered during the data collection process for the survey.

First, the researcher sought the consent of the administration of the Cyprus Turkish Chamber of Industry to inform member companies about the online questionnaire. A very low response rate was achieved from these companies, as TRNC is a tourism-oriented small country and does not have many technology companies.

In a second attempt, the company database of the Union of Chambers and Commodity Exchanges of Türkiye, which is the highest level of representative organization of the private sector in Türkiye and covers over one million firms, was used as the sampling space. Due to the very low response rate observed despite various invitation attempts, the researcher selected TDZ companies in Türkiye as the sampling space.

TDZs in Türkiye were established under the Technology Development Regions Law of Türkiye. This law aims to enable the national industry to compete in the international arena, to support companies to become export-oriented, and to create a technological knowledge environment.

In this study, companies in 44 TDZs throughout Türkiye were reached, and approximately 3,300 email addresses of TDZ companies were collected. The researcher requested permission from TDZ administrations to use their own announcement systems to inform companies about the study. Considering the number of blocked emails and unreachable email notifications, approximately 3,100 TDZ companies were reached via email. After various invitation attempts, 100 respondents completed the questionnaire.

Sampling size

According to a report on TDZs in Türkiye published by the Ministry of Industry and Tech-

nology of Türkiye, there are 6,005 TDZ companies in Türkiye (Technology Development Zone, 2020). However, 3,300 of the 6,005 companies had information either on the TDZ's administration website or their own websites. Using a %95 confidence level and %5 margin of error, the required sample size would be 362 samples (345 samples for a 3,300 population size). Despite efforts to encourage companies to participate in the survey, 100 responses were obtained from TDZ companies. However, appropriate analysis tools were used to compensate for the disadvantage of a small sample size. Ethics committee approval was obtained from Girne American University Faculty of Business for the study (Date: 10.12.2019; No.: 2018-2019-Fall-0047). Informed consent was obtained from all participants.

Mann–Whitney U Test

When the distribution of the data in two independent sample groups is not normal and the sample size is small, a non-parametric test is suitable for comparing the two groups. The Mann–Whitney U test is a popular nonparametric test that is widely used for comparing Likert-scaled data (Sullivan, n.d.). Hypotheses 2 to 6 were tested using the Mann–Whitney U Test with 95% confidence by grouping TDZ firms into either the "Using AI" or the "Not Using AI" groups.

Partial Least Squares-Structural Equation Model

Structural equation modeling (SEM) is a popular multivariate data analysis tool in the social sciences because of its ability to test construct variables and measure the strength of the path relationships between construct variables. While initial SEM models were designed to be covariance-based, the SEM model was improved by tackling issues like non-normal distribution and small sample size with the variance-based model called Partial Least Squares (PLS) (Chin, et al., 2003).

Chin (2010) explained various reasons for preferring PLS-SEM. The most emphasized rationales are presented below.

1. Non-normal distribution

2. Small sample size

3. Formatively measured constructs.

Goodhue et al. (2012) conducted a study using 500 data sets to examine the accuracy of different analysis techniques, including PLS-SEM, on different sample sizes and data distributions. They claimed that PLS-SEM did not perform better than regression or covariance-based structural equation models (CB-SEM) for small sample sizes or non-normal data distributions.

Hair & Alamer. (2022) suggested that PLS-SEM is a useful method in situations that require the evaluation of complex theoretical models, working with non-normal data, having small sample sizes, and investigating the model's predictive capability.

Despite different views, PLS-SEM is still used as a convenient tool for identifying theoretical path relationships in social science research. Therefore, $Hypothesis_1$ is tested with PLS-SEM.

Implementing PLS-SEM

When implementing the PLS-SEM method, the researcher followed the guidelines specified by Hair et al., (2014). The PLS-SEM model requires execution of three consecutive steps:

1. Model specification

2. Outer model evaluation

3. Inner model evaluation

The model specification involves defining inner and outer models. The inner model concerns relations between latent variables and the identification of dependent (endogenous) and independent (exogenous) constructs.

Outer Model Evaluation

After specifying the model, the PLS-SEM algorithm is executed to assess the reliability and validity of the latent variables and indicators. However, indicator variables can be either reflective or formative based on their relationship with the latent variable.

The reliability and validity testing procedures for the reflective indicators were as follows.

1. The construct's indicators' internal consistency reliability

2. Confirm the validity of reflective indicators.

- Assess the construct's convergent validity for indicators

- Assess discriminant validity.

Inner Model Evaluation

The model's predictive accuracy was calculated using the coefficient of determination (R^2).

R^2 is a measure of an exogenous latent variable's contribution in explaining the variance of an endogenous latent variable. Hair et al. (2014) emphasize that while R^2 can be increased by adding more exogenous constructs to the model, even if the contribution of the exogenous construct is not meaningful. The researcher should use adjusted R^2 to neutralize the effects of model complexity. However, Benitez, Henseler, Castillo, and Schuberth (2020) suggested that "when the research phenomena are already quite well understood, one would expect a high R^2. When the phenomena are not yet well understood, a lower R^2 is acceptable."

- Determine the inner model's predictive relevance via cross-validated redundancy (Q^2)

- Evaluate an exogenous latent variable's contribution strength in explaining an endogenous latent variable using effect size (f^2).

- Assess the significance of the path coefficients of linking latent variables.

The implementation of the Smart-PLS model was performed using SmartPLS3 version 3.3.2. (Ringle, Wende, & Becker, 2015).

Reconsidering Sample Size Using PLS-SEM

The construct relations of the model were tested using the PLS-SEM method, which is considered an appropriate technique for working with small sample sizes. However, there are different arguments for defining the minimum sample size for PLS-SEM. and Hadaya (2016) proposed that based on the gamma exponential method, without knowing the previous value of the path coefficients with the minimum absolute magnitude, the minimum sample size would be 146. According to and Hadaya (2016), the smallest sample size used in a PLS-SEM study published in a prestigious Information System research journal was 17. They further argued that despite the popularity of the "10 times rule" which suggests that the sample size should be 10 times more than the number of links in the model, this approach leads to inaccurate predictions.

Sarstedt, Hair, Pick, Liengaard, Radomir, and Ringle (2022) conducted a study on 239 marketing research articles that were implemented using PLS-SEM. According to the study, 85 of 476 models mentioned in these articles relied on sample sizes less than 100 (the smallest sample size was n=29). Sarstedt et al. (2022) stated that 17 out of 476 models failed to conform to the 10-times rule, while arguing that the 10-times rule is still considered an appropriate standard for determining the sample size.

Based on the 10 times rule, the minimum sample size of the model was 30.

Common Method Bias

To identify whether common method bias exists in the collected questionnaire data,

Harman's single-factor test was used because it is accepted as a simple and widespread statistical tool among researchers (Rodríguez-Ardura, & Meseguer-Artola, 2020). According to Harman's single-factor test, common method bias might exist if a single component accounts for more than 50% of the covariance between items and criterion constructs. This test was conducted using IBM SPSS, and the maximum covariance value of a single component was found to explain 15.6% of all components.

Results

Descriptive Analysis

This study aims to assess the effect of AI on firms' perceived business performance. Therefore, firm representativeness was an important parameter. Consequently, most respondents (99%) played a managerial role in their firms (Table 1).

Table 2 presents the distribution of personnel working in the respondent's firms. As shown in Table 2, 88% of the respondent firms had fewer than 50 personnel, and half of the firms had fewer than 10 personnel. Considering that the average number of personnel working at TDZ firms in Türkiye is roughly 10 people, the distribution of personnel working in the respondent's firms seems consistent with the sample population (Technology Development Zone, 2020).

AI Usage of the Samples

Table 3 shows the distribution of AI usage periods by firms. Of the respondents, 56% stated that they were not using AI in their firms. Approximately 90% of the companies (44) that use AI have started to work on this topic in the last 5 years.

Table 1
Distribution of samples by job category

Variable	Category	Frequency = Percentage (N=100)
Type of respondent	Founder or Managerial Title	92
	Engineer or Technical Expert	7
	Manager Assistant	1

Table 2
Distribution of samples by firm size

Variable	Category	Frequency = Percentage (N=100)
Number of personnel	Less than 10	51
	10-49	37
	50-99	6
	100-500	3
	More than 500	3

Table 3
Number of years of AI use by the firm

Variable	Category	Frequency (N=100) & (%)
Number of years of AI use	No AI use	56
	1-2	25
	3-5	14
	More than 5	5

Six AI business strategy perspectives

To simplify the difference between the "Not Using AI" and the "Using AI" groups, the agreement ("Agree" plus "Strongly Agree") and disagreement ("Disagree" plus "Strongly Disagree") phrases were merged .

AI and Industries

Table 4 exhibits the distribution of respondent companies by industry. More than half of the respondents are IT-related (55%). Similarly, 47% of all 6,005 TDZ companies in Türkiye are in the IT sector, according to a report published by the Ministry of Industry and Technology of Türkiye (Technology Development Zone, 2020). Therefore, the sector distribution of the respondent's firms is consistent with the overall sector profiles.

Capabilities and Limitations of AI

The exact differentiation between firms that have AI capability and those that do not has has already been obtained by grouping them into two groups, namely, the "Not Using AI" and the "Using AI" groups.

Table 4
Sector of the respondent's firm

Sector of the firm	Total frequency/percentage	Not Using AI		Using AI	
		Frequency	%	Frequency	%
IT/ICT/IT Security	55	27	48.2	28	63.6
Biology/Genetics	3	3	5.4	0	0.0
Environment	1	1	1.8	0	0.0
Electric/Electronic	14	10	17.9	4	9.1
Material Science/Nanotechnology	2	2	3.6	0	0.0
Automotive/Mechanic	2	1	1.8	1	2.3
Health	6	3	5.4	3	6.8
Defense/Security	3	0	0.0	3	6.8
Energy/Mining	2	0	0.0	2	4.5
Other	12	9	16.1	3	6.8
Total	100.0	56.0	100.0	44.0	100.0

The propositions for this perspective are as follows.

Statement 1: The company has knowledge about the duration of implementation of AI-enabled products or services ($p<0.05$)

Statement 2: As the accuracy rate of AI-enabled production or services has increased, more customers request AI products or services ($p<0.05$)

As a result, a significant difference was found between the two groups. Therefore, hypothesis H_2 is not supported.

Business Functions and AI

As mentioned in the previous sections, AI implementation can be explained from the front office, middle office, and back office perspectives. Therefore, the researcher examined this view with the following propositions.

Statement 1: AI is used in business processes such as production, marketing, sales, finance, customer service, distribution, and warehousing ($p<0.05$)

Statement 2: AI is used in internal business processes such as human resources, IT, and accounting ($p<0.05$)

Consequently, according to the Mann–Whitney U test results, there was a significant difference between the two groups. Therefore, hypothesis H_3 is not accepted.

Economy and AI

The economics and AI aspects involve describing an investment plan by evaluating the middle and long-range economic effects of AI. This perspective was assessed using the following two statements.

Statement 1: The company has knowledge about the cost of implementing AI-enabled products or services ($p<0.05$)

Statement 2: The company made investments in AI ($p<0.05$)

The test results confirmed that there was a significant difference between the two groups in this regard. Therefore, hypothesis H_4 is not accepted.

Tasks, Jobs, and AI

The tasks, jobs, and AI perspective is related to the assessment of current tasks and jobs in a firm with the capabilities of AI to maximize the benefits from employees and AI technology.

The respondents' opinions were measured using the following two statements.

Statement 1: AI causes unemployment (Likert scale, p=0.395)

Statement 2: Symbiosis of humans and AI obtains better and more effective results (Likert scale, p=0.053)

Based on the results, it can be concluded that research-oriented TDZ companies do not have a negative stance on the effect of AI on human labor and favor the symbiosis of the human labor force and AI. Therefore, hypothesis H_5 is accepted. There is no difference between the two groups in this respect.

Ethical Concerns, Regulations, and AI

Despite AI having surpassed human cognitive abilities in some fields such as visual recognition and language processing, AI applications have to be scrutinized at the managerial level because of possible harmful consequences such as unfair recruiting decisions, misled scientific or medical prognoses, or distorted loan decisions of AI-enabled systems. To measure the difference between the two groups from this perspective, the researcher used two statements.

Statement 1: Our company has knowledge about the risks associated with AI implementation ($p<0.05$)

Statement 2: As the usage of AI-based products and services has increased, the need for regulation has arisen (p=0.860)

Although there was a significant difference in the first statement, no significant difference was found in the second statement. It can be concluded that there was common sense regarding this perspective. Therefore, hypothesis H_6 is accepted

Evaluation of the Structural Model

Because of the challenges in reaching more respondents throughout the study, the researcher decided to build a basic model to assess the effect of AI on firms. The fundamental construct is the assessment of the effect of AI on business, which is hypothesized below.

H: Use of AI has a positive effect on a firm's perceived business performance.

To evaluate firm performance, Aydıner, et al.'s (2019) scale was adopted. The latent variable perceived business performance indicators were designed as reflective because they were considered the concrete components of the latent variable, as used in Aydıner, et al.'s (2019) study. In other words, causality is from the construct to the indicators.

The independent indicator AIUsage was adopted from the feature described in Table 3.

When recalling items in Table 3, an indicator value of zero indicated the "Not Using AI" group, and the remaining values 1, 2, and 3, which represent the number of years of AI usage, were used for the "Using AI" group.

The indicator names and corresponding questionnaire statements are presented in Table 5, and the proposed relational model is illustrated in Figure 2.

Reliability Evaluation of Model 1

The endogenous latent variable perceived business performance, which is composed of 8 reflective indicators, and the exogenous latent variable AI Implementation were used to represent the relation of Model 1.

The Composite Reliability of Model 1 (0.69) was slightly lower than the threshold value (0.70), and Cronbach's α (0.76) was greater than the threshold value (0.7). The validity of indicators (Average Variance Extracted) (0.3) was also lower than the threshold value (0.5).

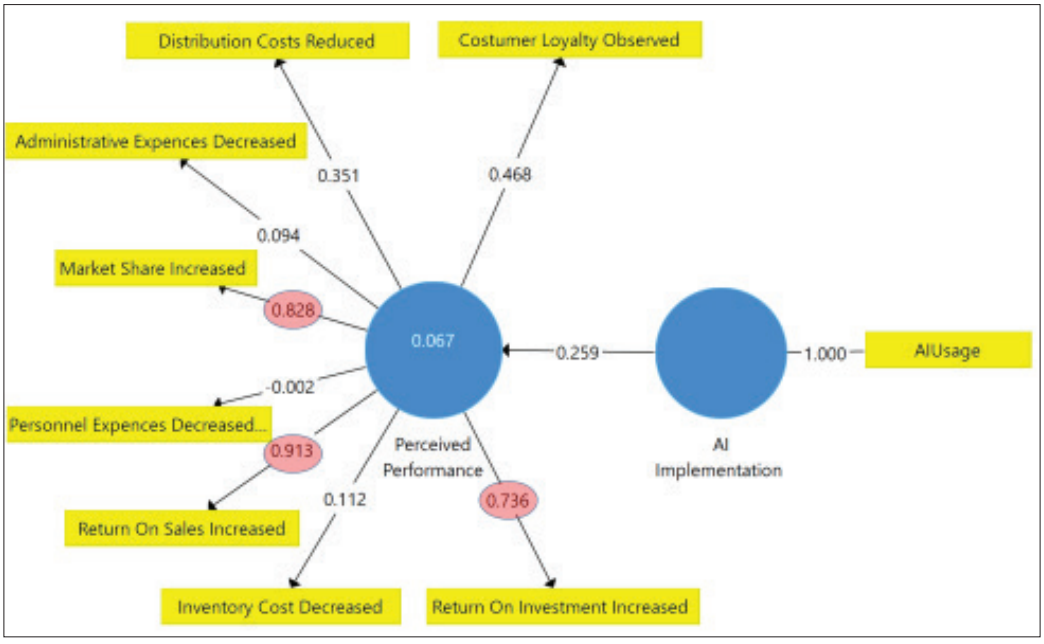


Figure 2. AI usage and Perceived Business Performance Relation Model 1

The validity of the outer model is supported when each indicator's outer loading is greater than 0.70 and each construct's average variance extracted is equal to or greater than 0.50. The outer loading values of the three indicators passed the validity threshold value, as shown in Figure 2.

Table 5
Reflective indicators of Perceived Business Performance construct

Indicator Name	Questionnaire statement
Return on sales	Our firm has achieved high sales return
Distribution cost reduction	Our firm's distribution costs have been reduced.
The market share increased	Our firm has increased its market share.
The return on investment is reduced	Our firm has achieved a high return on investment.
Administrative expenses were reduced	Our firm's administrative expenses have been reduced.
Inventory cost reduction	Our firm's inventory cost has been reduced.
Staff cost reduction	Our staff costs have also been reduced.
Customer loyalty is achieved	Our firm has achieved a higher level of customer loyalty

As internal consistency reliability and convergent validity failed to surpass the threshold values, the researcher redesigned the model. Therefore, five indicators whose outer loading values failed to exceed the threshold value were removed from the model. Consequently, a new model was proposed based on the previous evaluation, as shown in Figure 2.

TDZ companies are not allowed to conduct mass production by law, have special tax incentives, and are research-oriented in nature; thus, removing constructs like distribution cost, inventory cost, administrative expense, and personnel expense is consistent with the organizational structure of TDZ companies.

Reliability and Validity of Model 2

Cronbach's α, Composite Reliability, and AVE values of Model 2 are shown in Table 6, and the outer loadings of the indicators are presented in Figure 3. Model 2 passed the internal consistency and convergent validity tests.

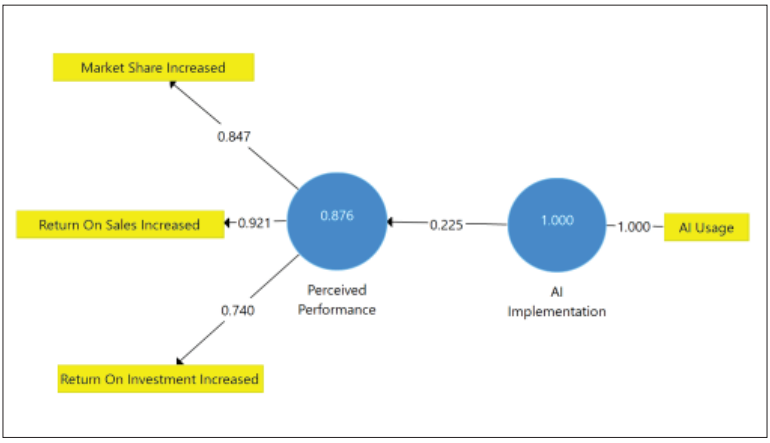


Figure 3. AI usage and Perceived Business Performance Relation Model 2

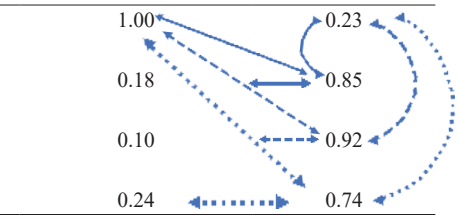
Table 6
Cronbach's α and Composite Reliability values of the Model 2

Latent Variable/Construct	Cronbach's α Threshold 0.7	Composite Reliability Threshold 0.7	Average Variance Extracted (0.5)
AI Implementation	1.00	1.00	1.00
Perceived Business Performance	0.80	0.88	0.70

Discriminant validity can be assessed using either the Fornell–Larcker criterion (diagonal values of Fornell Larcker's table for each construct should be larger than all values in the same row and column) or the cross-loadings test criterion in such a way that latent variables or related cross-loading indicators must share more variance with their indicators than with any other latent variable. Both test results passed the validation criteria (Table 7).

Table 7
Evaluation of discriminant validity using the cross-loading criterion

	AI Implementation	Perceived Business Performance
AI Usage	1.00	0.23
Increased Market Shares	0.18	0.85
Return On Sales Increased	0.10	0.92
Return On Investment, Inc.	0.24	0.74



Inner Model Validation

R^2 is the degree to which the independent (exogenous) variable's combined explanation strength of dependent (endogenous) variables is expressed, and it ranges from 0 to 1. Hair et al. (2014) suggested that an R^2 value below 0.15 is considered a weak contribution. The R^2 value of Model 2 was 0.051. Because only one exogenous variable (AI Implementation) exists in this model, its explanation effect is considered low. In other words, the exogenous latent variable AI Implementation explains 5.1% of the variance in Perceived Business Performance. Benitez et al. (2020) argue that when the research inquiry is not yet well understood, a lower R^2 is acceptable. Hair et al. (2014) suggested that considering a high R^2 as valuable can prove problematic because adding a nonsignificant construct would increase the R^2.

Another quality criterion for the inner model is $(f)^2$, which measures the magnitude of each exogenous variable's effect on the model. Because only one exogenous variable (AI Implementation) exists, its $(f)^2$ magnitude is 0.05, which denotes a small effect as it is at the low-level threshold boundary (0.02-0.15).

Another checkpoint for the quality of the endogenous latent variable is Q^2 , which measures the inner model's predictive relevance. According to Hair et al. (2014), a Q^2 value greater than 0 indicates prediction relevance but does not indicate the quality of the prediction.

Table 8
Significances and Cross-validated redundancy Q^2 of the indicators

Indicator	Outer Loadings	T Statistics of Outer Loadings	Q^2	p-value of the outer loadings
Market Share	0.85	6.31	0.03	< 0.01
Return on Investment	0.74	4.03	0.01	< 0.01
Return on Sales	0.92	7.02	0.04	< 0.01

Table 9
Significance & Cross-validated redundancy Q^2 of the endogenous variable

Endogenous variable	Path Coefficient	T Statistics of Path Coefficient	Q^2	p Value of Path Coef.
Perceived Business Performance	0.23	2.28	0.02	0.02

The path coefficient estimates the hypothesized relationships among the linking constructs. The bootstrap procedure was performed to test the significance of a structural path using T-Statistics using a two-tailed *t*-test with a significance level of 5% and 5.000 bootstrap runs (Benitez, et al., 2020).

The significances, t-statistics, cross-validated redundancy Q^2 of indicators, and the endogenous variable are presented in Tables 8 and 9. The path coefficient was significant because the t-statistic exceeded 1.96.

Model Overview

In this simple proposed model, there are only one dependent and one independent variable, and no mediating or moderating variable is involved in the model.

· Only Market Share, Return on Investment, and return on sales were found as meaningful indicators contributing to perceived business performance out of eight indicators because they passed the validation and reliability criteria of PLS-SEM.

· Market Share, Return on Investment, and Return on Sales, which have loading values of 0.85, 0.74, and 0.92, respectively, are reliable indicators of Perceived Business Performance.

· Outer loadings of Market Share, Return on Investment, and return on sales proved to be significant according to T Statistics.

· AI Implementation can explain 5.1% of the variance in Perceived Business Performance based on R^2. However, some scholars argue that too much reliance on R^2 value can prove problematic.

· The hypothesized path relationship between AI Implementation and Perceived Business Performance is statistically significant.

Table 10
Hypotheses result

	Hypothesis	Result
H_1	AI usage has a positive effect on firms' perceived business performance.	Accepted (Low impact)
H_2 Capability.	There is no difference between "Using AI" and "Not Using AI" groups with respect to AI's capabilities and limitation.	Rejected
H_3 BusFnc.	There is no difference between "Using AI" and "Not Using AI" groups with respect to AI's business function perspective.	Rejected
H_4 Economy	There is no difference between "Using AI" and "Not Using AI" groups with respect to AI's economic perspective.	Rejected
H5 TasksJobs	There is no difference between "Using AI" and "Not Using AI" groups with respect to AI tasks and job.	Accepted
H6 Ethics	There is no difference between "Using AI" and "Not Using AI" groups with respect to AI regulations and ethics.	Accepted (Further Study Needed)

· Based on the R^2 and f^2 values, the model demonstrates low explanatory power.

It should be considered that TDZ companies are innovation-oriented. Moreover, only the R&D activities of major technology companies of Türkiye are permitted in TDZs, and mass production is not allowed in these zones. Therefore, the low AI performance can be considered meaningful.

Therefore, a future study might better explain AI's effect on firms' perceived business performance by considering more factors suited to TDZ companies.

Table 10 presents the hypothesis testing results for TDZ companies in Türkiye.

The questionnaire analysis revealed that investment priority was the main reason that companies did not implement AI. . Given that TDZ companies are research-oriented, those without AI initiatives might be highly focused on their specific research areas and existing competitive advantages. This observation requires further investigation.

Conclusion

This study makes two primary contributions to understanding AI in business contexts. To the best of our knowledge, this is the first study to evaluate the effect of AI on perceived business performance in Türkiye. First, it empirically evaluates AI's effect on perceived business performance in TDZ companies in Türkiye. Second, it examines the differences in the six business strategy perspectives of AI between companies that use AI and those that do not.

AI's Effect on Perceived Firm Performance

The empirical analysis reveals a statistically significant but modest relationship between

AI implementation and perceived business performance. Using PLS-SEM analysis, three key performance indicators emerged as reliable measures: Market Share, Return on Investment, and Return on Sales. AI usage explains 5.1% of the variance in perceived business performance, but this modest effect should be interpreted within the unique context of TDZ companies as follows:

· primarily R&D focused

· The mass production is not permitted

· Operating under specific regulatory frameworks

· Benefit from tax incentives

Six AI business strategy perspectives

The analysis of the six AI business strategy perspectives revealed significant differences between AI-using and non-using companies in the following three areas:

· Capabilities and limitations of AI

· From a business function perspective

· Economic perspective

However, no significant differences were found in

· From the perspective of tasks and jobs

· Ethics and regulation perspective

Notably, both AI- and non-AI-based TDZ companies showed limited interest in AI applications for marketing and sales, which aligns with their R&D-oriented nature. Investment priority emerged as the primary reason for not implementing AI among non-technological firms.

Implications

For TDZ Company Managers:

· Understanding the importance of investment priority in AI adoption

· Recognition that AI usage affects perceived business performance

For Policymakers:

· Understanding the current state of AI adoption by TDZ companies

· Understanding investment priorities as barriers to AI adoption

For Researchers:

· Development of performance metrics better suited to TDZ companies' characteristics

· Potential for a more comprehensive evaluation of AI's effect in research-oriented organizations

Future Research and Limitations

The sample collection phase of the empirical study faced challenges in obtaining data from companies, particularly given the emerging nature of AI technology. Despite various data collection attempts, this study obtained 100 responses from TDZ companies. However, appropriate statistical analysis tools were used to address the small sample size limitation.

This study identified three performance attributes that affect TDZ companies' perceived business performance. Future research should consider developing performance metrics that better align with TDZ companies' R&D-oriented structure to more effectively evaluate AI's impact on their performance. These metrics can be associated with operational efficiency aspects, such as process optimization and energy consumption, human capital elements, including the percentage of PhD personnel, and R&D performance measures like patent generation.

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RESEARCH ARTICLE

Does Auditing Detect and Suppress Earnings Management? Evidence from Türkiye

Ahmet Onay[1], **Serdar Benligiray**[2]

Abstract
This study examines the relationship between auditing factors and earnings management practices. Specifically, it investigates the effects of audit opinion and audit firm size on earnings management. The methodology is a combination of qualitative and quantitative analyses. We constructed multivariate regression models to test research hypotheses. The contextual analysis of qualified audit reports provides definite segmentations for cross-sectional analysis. The findings suggest that a qualified audit opinion is a significant predictor of income-increasing earnings management practices in Türkiye. Major audit firms suppress these practices in line with the argument that they perceive them as a potential litigation threat to their reputation and assets. Firms potentially managing their earnings are observed to have more debt, less equity, and greater financial distress. This research provides comprehensive information for capital market regulators, investors, and other stakeholders to evaluate audit performance in mitigating earnings management problems. The present study contributes to the literature by providing evidence from Türkiye.

Keywords: Earnings management, audit opinion, discretionary accruals, audit quality, financial distress

Introduction

Accrual accounting allows financial statements to contain estimations, be based on optional methods and accounting policies, or reflect probable events that have not yet occurred. The accrual basis provides financial statement users with information that cannot be reported with cash flow to enable them to evaluate the firm's performance and cash forecasts (Dechow & Skinner, 2000). On the other hand, the accrual basis is the justification for discretion that allows managers to manipulate financial information. Managers may report earnings for their purposes by abusing their discretion over financial reporting (Stolowy & Breton, 2004).

Earnings items are directly observable and have a prominent effect on the perception of financial performance, particularly for outside stakeholders. Combined with the resilience

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and subjectivity in factors driving the accounting process, this fact may encourage managers to report earnings that reflect their purposes and self-interest (Bernard & Skinner, 1996). These practices, limited by accounting standards and generally accepted accounting principles, are called earnings management (hereafter, EM for short). EM poses a problem for publicly traded companies with more external stakeholders.

In the present socio-economic system, the responsibility of ensuring the reliability of financial information is delegated to auditors, who are expected to provide a professional opinion on the credibility of such information. The agency theory imposes great responsibility on auditing and is positioned as one of the instruments of corporate governance mechanisms to solve EM and such problems (El Diri et al., 2020). Auditing ensures that the information asymmetry between managers and stakeholders remains within acceptable limits. Auditors' primary responsibility is to suppress managerial practices, such as EM, and related issues that can distort stakeholders' perceptions of financial outlook. The auditors' ultimate responsibility for EM is to forewarn financial information users through their reports if EM practices still have a material impact on financial statements despite mitigating efforts in the audit process.

According to the International Standard on Auditing 240, which deals with auditors' responsibilities against fraud, auditors should provide reasonable assurance that the financial statements are free from material misstatements resulting from errors or frauds (ISA, 240). This responsibility also includes EM efforts by the management to influence financial statement users' perceptions of the firm's performance (Barghathi et al., 2018). Auditors should identify the EM efforts reported in the client's financial statements and ensure that any resulting problems are eliminated (Marinakis, 2011). At the end of the audit process, if the audit judgment indicates that material misstatements remain in the financial statements resulting from EM, the modified opinion should be included in the audit report. Audit opinions are among the most important indicators used to warn financial statement users (Imen & Anis, 2020).

The expectation from the auditors is to identify EM practices in financial statement audits and declare them in the audit report if they cannot be suppressed. The first purpose of this study is to determine the auditory sensitivity of EM detection. This sensitivity is expected to be higher, and EM practices are suppressed when a high-quality audit process is conducted. In this context, another purpose of the study is to investigate the suppressing effect on EM of a high-quality audit, proxied by the performer being a major audit firm. The model used in this research is the discretionary accruals (hereafter, DA for short) estimation model with two main predictors of concern, i.e., dichotomous variables for a firm, whether it receives a qualified opinion, and whether a major audit firm performs the audit. The model also includes control variables as DA predictors, reflecting the potential effects on earning management.

These variables are the financial distress index, return on assets, asset size, and the proxies for audit difficulty.

The impact of auditing on EM has been widely studied in different economic and institutional contexts. Studies on this relationship in emerging markets such as Türkiye are more limited. Our study provides a multi-layered analysis examining the significance of auditing variables in suppressing EM in the context of Türkiye with carefully selected control variables. This research differs from studies focusing on Türkiye using a hybrid methodology that has both qualitative and quantitative aspects. The detailed examination of audit report content from an EM perspective and comprehensive analyses guided by the qualitative context provides an original contribution to the literature.

The remainder of this paper is structured as follows: The subsequent section reviews the pertinent literature and establishes hypotheses aligned with the study objectives. The research model and the measurement of the variables are then introduced, and the scope of the sample is defined. The next section presents empirical evidence in which a post-hoc analysis follows the main findings to provide more insight. The last section emphasizes the essential aspects of the research outcome and concludes.

Literature Review and Hypotheses Development

Managers can take advantage of their reporting discretion over accruals to communicate special information about the company to users of financial information (Watts & Zimmerman, 1986). However, a significant amount of the accruals reported in the company's financial statements may be attributed to EM efforts. Managers use their discretion over accounting policies, estimates, and choices to manipulate earnings by adjusting discretionary accruals. For instance, they may inflate revenue accruals when they want to overstate revenues. Similarly, they may increase expense accruals to reduce tax liabilities or to overstate future earnings. These practices leverage flexibility within accounting standards to potentially reflect a firm's economic value more accurately; nevertheless, they can also indicate managers' opportunistic behavior (Hong et al., 2022). To address the uncertainties due to the accruals, auditors tend to declare a qualified opinion in the audit reports of companies reporting high accruals. Audit risk arising from high accruals is managed by lowering the threshold for giving a qualified opinion (Francis & Krishnan, 1999).

The relationship between audit opinion and accrual-based EM has attracted the attention of researchers for many decades. Consistent with the theoretical expectation, many studies have reported that audit opinion is related to the high levels of accruals (Hirst, 1994; Francis & Krishnan, 1999; Bartov et al., 2001; Chen et al., 2001; Karacaer & Ozek, 2010; Habbash & Alghamdi, 2017; Salehi et al., 2018; Imen & Anis, 2020). These findings indicate auditors'

sensitivity to the high level of accruals. On the other hand, in some studies, the existence of this relationship was ambiguous (Bradshaw et al., 2001; Butler et al., 2004; Garcia & Argiles, 2013; Tsipouridou & Spathis, 2014). These findings indicate that the auditor's reporting conservatism is low, or that the risks arising from the level of accruals are excluded from the scope of the audit. This indication supports the argument that auditors do not warn users about accrual-based EM. The contradictory evidence in the literature may be attributed to differences in institutional arrangements and economic conditions between the countries for the specific period of research.

Hirst (1994) tested auditors' sensitivity to management change and performance-based compensation policies that motivate EM. His research showed that audit opinion is sensitive to both positive and negative accruals. Francis and Krishnan (1999) found similar evidence in their study. They found that companies reporting high accruals are more likely to have a modified audit opinion, which is more probable for those with high negative accruals. According to the findings obtained from their analysis, companies that report high accruals are more likely to declare a modified audit opinion for going concern uncertainty problems in audit reports. Doan et al. (2021) provided confirming evidence from Vietnam corroborating the sensitivity of audit opinions to discretionary accruals.

Bartov et al. (2001) tested the strength of the five most widely used accrual models under the assumption that companies managing their earnings receive a modified opinion in their audit report. Based on this comparison, the Modified Jones Model (hereafter, MJM for short) is the most powerful model to detect EM from the standpoint of auditor's opinion. They also reported a significant positive relationship between the absolute value of DA and deviations from the unqualified opinion in the audit report. In line with Bartov et al. (2001), Karacaer and Ozek (2010) also observed a positive relationship between DA measured by the MJM and a qualified audit opinion. Chen et al. (2001) obtained similar results by examining a sample of companies listed on the China Stock Exchange. Another study on publicly traded Chinese companies reported that qualified audit opinions received in previous periods hindered current-period earnings management (Liu et al., 2023). Habbash and Alghamdi (2017), on the other hand, found evidence of a strong relationship between the level of DA and audit opinion, using the Kothari Model developed based on the MJM on a sample of Saudi Arabian companies. Imen and Anis (2020) obtained similar evidence for companies in Tunisia using an accrual model developed by adding return on assets and book value/market value ratio to the MJM. Similar findings have been reported in Indonesia. Krismiaji and Sumayyah (2023) found a positive relationship between audit opinions and earnings management. In a similar study on manufacturing companies, Susanto et al. (2021) confirmed that auditors tend to give more qualified opinions when they detect earnings management.

On the contrary, Bradshaw et al. (2001) showed no relationship between the level of accruals and the audit opinion. The results of their study indicate that earnings quality problems identified in the audit process do not affect audit opinion. Even if auditors are aware that inc-

reasing accruals will result in reduced earnings in the future, they may not feel obliged to declare this with audit opinions. Similar to Bradshaw et al. (2001), Butler et al. (2004) found no evidence that audit opinions indicated EM. For the sample of this research, companies with modified audit opinions do not report higher levels of accruals than others. However, further analysis shows that companies with negative accruals are more likely to receive qualified audit opinions for going concern uncertainty. This evidence implies that the high levels of negative accruals reported by such companies are most likely due to severe financial distress. Tsipouridou and Spathis (2014) conducted similar tests on a dataset of companies listed on the Athens Stock Exchange. Their findings do not support a significant relationship between audit opinion and accrual level for the companies with qualified audit opinions for going concern uncertainty just as for the whole data set. Garcia and Argiles (2013), Chairunnisa et al. (2022), and Juniarti et al. (2022) reported evidence parallel to the aforementioned studies.

The studies examining the relationship between audit opinions and earnings management in the Turkish academic literature are compromised regarding sample size. Karacaer and Özek (2010) found a positive relationship between discretionary accruals calculated using the Modified Jones Model and the presence of an explanation paragraph or a qualified opinion in audit reports. These findings support the effect of audit opinions on earnings management. However, Aslanoğlu et al. (2016) did not find any relationship between audit opinions and earnings management based on more recent data using the same model. On the other hand, Ocak (2016) showed in his study on a larger sample that discretionary accruals obtained by adding the profitability variable to the MJM had a positive and significant relationship with deviations from the unqualified opinion in the audit report. These results show that the effect of audit opinions on earnings management may vary depending on the financial status of the company, the audit process and the methodology used. Based on the literature presented here, the research hypothesis 1 is as follows:

$H_0$1: Receiving a qualified audit report is a statistically significant predictor of the firm's discretionary accruals.

Audit quality can be proxied by audit firm size, and Deangelo (1981) was the first to theoretically discuss this relationship between audit firm size and audit quality. She defined "audit quality as the joint probability of an auditor (1) to detect a breach in the client company's accounting system and (2) to report the breach". The probability that the auditor will detect a breach depends on several factors, such as technological capabilities, audit procedures, and the scope of the audit sample (Monroe et al., 1992). The likelihood of the auditor will report a breach discovered is a measure of the auditor's independence from the client. According to Deangelo (1981, p. 186), audit firm size is a feature that increases both possibilities. Therefore, audit firm size is a convenient indicator of audit quality.

Palmrose (1988, p. 56) defines "audit quality as the probability that the financial statements contain material omissions or misstatements". A higher level of assurance indicates

a higher quality of audit services. This definition implies that audit errors are less likely to occur in high-quality audit services. This approach is consistent with Deangelo (1981), who defined audit quality in terms of audit risk. According to Palmrose (1988, p. 57), major audit firms have more reputation and financial assets at stake, thereby increasing the risk of litigation. These factors compel larger audit firms to provide higher quality audit services.

Lennox (1999) reinterpreted Deangelo's (1981) approach to the effect of audit firm size on audit quality with the deep pocket hypothesis. According to Lennox (1999), major audit firms with more assets are more susceptible to potential threats than smaller firms. This assumption is the main rationale for using audit firm size as an indicator of audit quality. This approach has also been adopted in studies focusing on the relationship between audit quality and EM. Many of these studies provide empirical evidence that audit quality suppresses EM (Becker et al., 1998; Tendeloo & Vanstraelen, 2008; Jordan et al., 2010; Chen et al., 2011; Karacaer & Ozek, 2010; Lin & Hwang, 2010; Salehi et al., 2018; Alvarado et al., 2019; Imen & Anis, 2020). However, the relationship is ambiguous in some studies, implying that a quality audit does not seem to suppress earning management effectively (Jeong & Rho, 2004; Piot & Janin, 2007; Tsipouridou & Spathis, 2012; Habbash & Alghamdi, 2017; Almarayeh et al., 2020; Awuye, 2022).

Becker et al. (1998) reported that DA is higher for companies that are not clients of a major audit firm. The average and median of the absolute value of DA for these companies are higher than the clients of a major auditor. That is, poor audit quality leads to greater accounting flexibility. Tendeloo and Vanstraelen (2008) performed similar testing on firm-year data for numerous companies from six European countries. The outcome is consistent with the expectation that audit quality will limit the EM. Various studies have reported similar results with the samples gathered from the US (Jordan et al., 2010), China (Chen et al., 2011), Spain (Alvarado et al. 2019) and Türkiye (Karacaer & Ozek, 2010). Lin and Hwang (2010) supported the mitigating effect of audit firm size on EM in their meta-analysis on 48 studies in the audit literature. Many recent studies (Zakaria et al., 2022; Alshare et al., 2023; Thi, 2023; Verma et al., 2024) have confirmed the negative relationship between audit firm size and earnings management across samples from countries with different economic and institutional conditions.

The demand for quality audit services may vary in countries with different economic conditions and institutional arrangements. In the absence of an effective institutional mechanism other than audit to control EM practices, audit firms do not face a high risk of litigation that could discredit their reputation or threaten their assets. Under such circumstances, audit firms may intentionally choose not to provide high-quality audit services. The courts play an essential role in protecting investors in the United States and other developed countries. In addition, capital market regulators strictly rule out practices that misinform investors, inc-

luding EM. On the other hand, the responsibility of protecting investor rights and interests is predominantly on the regulatory and supervisory authorities in developing countries, and there is less emphasis on EM in audit practice. In such circumstances, auditors may ignore rather than suppress EM to attract more clients. Studies focusing on the relationship between audit quality and EM in South Korea (Jeong & Rho, 2004), France (Piot & Janin, 2007; Awuye, 2022), Greece (Tsipouridou & Spathis, 2012), and Saudi Arabia (Habbash & Alghamdi, 2017) found evidence confirming that auditors do not suppress EM. The evidence implies that the conditions mentioned above could not ensure that major audit firms provide high-quality audit services.

Audit firm size is frequently used as an indicator of audit quality, but conflicting findings are reported on the accuracy of this relationship in Türkiye, based on limited samples. Yaşar (2013) analyzed the data of manufacturing sector firms operating in Borsa Istanbul between 2003 and 2007 and found that companies audited with Big4 audit firms did not have a significant effect on earnings management. Similarly, Aslanoğlu et al. (2016) found that being a Big4 customer did not have a significant effect on discretionary accruals calculated using the MJM in their study of 60 manufacturing firms listed in Borsa Istanbul between 2010 and 2013. These results indicate that large audit firms are not always effective in limiting earnings management in Türkiye. However, Öztürkçü Akçay and Bilen (2019) determined that large audit firms limited their earnings management practices and used discretionary accruals at a lower level. Selimefendigil (2023), in his study on Borsa Istanbul companies, showed that Big4 audit firms are more effective in limiting earnings management. These findings reveal that the effect of audit firm size on earnings management may vary depending on the context and period. Based on the literature presented here, the research hypothesis 2 is as follows:

$H_0$2: Audit quality proxied by the size of the auditor firm is a statistically significant predictor of the customer firm's discretionary accruals.

Research Methodology

Estimation of Discretionary Accruals

Accrual accounting delimits management's boundaries of discretion while allowing more information to be provided to users of financial statements. In this setting, EM, a type of financial information manipulation, occurs when management exploits discretion over financial reporting, mainly through accruals. DA models are widely used to measure EM in research on this type of financial information manipulation (Beneish, 2001; McNichols, 2000). DA is defined as the deviation from the expected total accruals. This measurement is attributed to the management's overuse of discretion to manage earnings. MJM is prominent in terms of measurement performance (Dechow et al., 1995). Kasznik (1999) revised the model by adding cash flows from operations. In our study, DA was measured using Kasznik's model as follows:

$$\frac{TAC_{it}}{TA_{it-1}} = \beta_0 + \beta_{1t}\left(\frac{1}{TA_{it-1}}\right) + \beta_{2t}\left(\frac{\Delta REV_{it} - \Delta REC_{it}}{TA_{it-1}}\right) + \beta_{3t}\left(\frac{PPE_{it}}{TA_{it-1}}\right) + \beta_{4t}\left(\frac{CFO_{it}}{TA_{it-1}}\right) + \varepsilon_{it} \quad (1)$$

where for firm i year t, TAC= total accruals, REV= revenues, REC= receivables, PPE= property, plant and equipment, CFO= cash flow from operations, TA= total assets, and ϵ = error term.

Total accruals, the model's output, are assumed to be non-discretionary for a firm to operate as expected. DA is derived by subtracting the non-discretionary part from the total actual accruals.

This process requires the calculation of total accruals. Total accruals can be calculated using balance sheet items; however, this can cause significant measurement errors (Hribar & Collins, 2002). The alternative is the cash flow statement approach, in which total accruals are obtained by subtracting cash flows from operations from income before extraordinary items. In this study, net income is used for the total accruals calculation to maximize the analysis data:

$$TAC_{it} = (NI_{it} - CFO_{it}) \quad (2)$$

Research Model and Measurement of Independent Variables

From a broad perspective, EM is not limited to income-increasing practices, and such practices may intend for income-decreasing purposes, such as income smoothing and big bath accounting. According to Jones (1991), reporting fictitious high-level earnings using accruals will eventually result in lower earnings for the following periods because earnings must be equal to cash flow in the long run. Therefore, EM is two-fold: income increasing and decreasing practices. A method to measure EM with a single DA variable in a sample of income-increasing and decreasing practices is to use the absolute value of DA. The absolute value of DA is used as a broad measure of EM (Francis & Krishnan, 1999; Butler et al., 2004; Piot & Janin, 2007; Johl et al., 2007; Habbash & Alghamdi, 2017; Alzoubi, 2018; Imen & Anis, 2020). In this study, the absolute value of the DA variable is used to measure the combined effect of EM practices.

Even if the EM is two-fold, one can argue that auditors are more sensitive to income-increasing than income-decreasing practices (Dee et al., 2021). Hence, the concept of EM is mainly considered on the income-increasing side. The absolute value of DA may fail to detect this potential bias. Moreover, analyzing the combined effects of the contrasting practices on earnings may balance off the individual effects and lead to inconclusive results. Therefore, the sample of this study is subdivided into positive and negative DA firm-year data sets to capture possible contrasts. In this context, positive DA indicates potential income-increasing

practices, whereas negative DA indicates income-decreasing EM practices. Consequently, three datasets were formed to be analyzed using regression models with the same explanatory variables. These models differ in the dependent variable definitions. The model is presented below, and the explanations of the variables are explained in Table 1.

$$DA_{it} = \beta_0 + \beta_1 Big4_{it} + \beta_2 Opinion_{it} + \beta_3 ROA_{it} + \beta_4 LogTA_{it} + \beta_5 Distress_{it} + \beta_6 Inv_{it} + \beta_7 AR_{it} \quad (3)$$

Table 1
Summary of variables definitions

Variables	Acronym	Measurement	Predicted Direction
Absolute Value of DA	|DA|	The absolute value of DA calculated using the Kasznik (1999) Model	*
Positive DA	PDA	Positive signed DA calculated using the Kasznik (1999) Model	*
Negative DA	NDA	Negative signed DA calculated using Kasznik (1999) Model	*
Audit Firm Size	Big4	Dichotomous: 1, if the auditor is a Big 4 firm and 0 otherwise	–
Auditor's Opinion	Opinion	Dichotomous: 1 if the audit opinion is qualified and 0 otherwise	+
Return on Assets	ROA	Net income divided by total assets	?
Firm Size	LogTA	Natural logarithm of total assets	?
Financial Distress	Distress	Financial distress value calculated using Shumway's (2001) hazard model	+
Audit Difficulty 1	Inv	Inventories divided by total assets	+
Audit Difficulty 2	AR	Account Receivables divided by total assets	+

* Dependent Variable

Big4 and Opinion variables are audit-related variables that measure audit quality and auditors' reporting conservatism on EM. Other factors affecting the level of DA are attributed to control variables. The financial distress, return on assets, firm size, and audit difficulty proxies are selected as control variables in line with the literature (Becker et al., 1998; Jeong & Rho, 2004; Butler et al., 2004; Lin & Hwang, 2010; Tsipouridou & Spathis, 2012; Habbash & Alghamdi, 2017).

ROA was added to the model to control the relationship between EM and financial performance. This variable is expected to determine whether low or high profitability has an impact on EM trends. LogTA, as measured by the natural logarithm of total assets, is included in the research model to control for the effect of firm size on DA. Another control variable is financial distress. Financial distress can create conditions that compel managers to implement EM practices. This variable is included in the model based on the assumption that financially distressed companies can manipulate financial information. Many studies in the literature have focused on the relationship between financial distress and EM (Habib et al., 2013; Bisogno & De Luca, 2015; Kyriakou, 2020; Séverin & Veganzones, 2021).

In many studies, as in our research, financial distress is constructed as a control variable (Francis & Krishnan, 1999; Spathis et al., 2003; Butler et al., 2004; Herbohn & Ragunathan, 2008; Tsipouridou & Spathis, 2014). In these studies, well-known models, such as Altman's Z score (1983) or Zmijewski's bankruptcy scoring (1984), are used to measure financial distress, as well as more recent ones. In our research, financial distress is measured using Shumway's (2001) hazard model, as applied in Butler et al., (2004). This model is an empirically validated dynamic model that measures financial failure better than traditional static models. This measurement is presented below:

$$p = 1 - \frac{1}{(-7.811 - 6.307\,\frac{NI}{TA} + 4.068\,\frac{TL}{TA} - 0.158\,\frac{CA}{CL} + 0.307\,Ln\,(age))} \qquad (4)$$

where p =bankruptcy probability, NI =net income, TL =total liabilities, TA =total assets, CA =current assets, and CL =current liabilities. Age =number of calendar years in which the firm has been traded on Borsa Istanbul.

The effort required for every audit is not the same, and audit difficulty essentially affects the audit processes, such as confirming financial statement accounts and obtaining evidence on material misstatements. Audit procedures are more difficult to perform on some financial statement accounts. Auditors are often required to obtain information from third parties to confirm the balance in such accounts. Managers who are aware of this can shape their EM practices. They may be more audacious for EM, especially when accounts that are difficult to audit have high balances. Studies analyzing audit effort and audit qualifications include variables that measure audit difficulty (Bell & Tabor, 1991; Monroe & Teh, 1993). Audit difficulty has also been added to research models to control its impact on EM (Johl et al., 2007; Caramanis & Lennox, 2008; Karacaer & Ozek, 2010). Similarly, our model includes Inv and AR variables to control the effect of audit difficulty on EM. Inventory and accounts receivable are among the most difficult items to verify and review in the audit process and are often valued based on a large amount of estimation and managerial judgement. Therefore, auditors are likely to spend more time and resources reviewing these items. In addition, these items have flexibility that managers can manipulate in their EM practices. This is the reason why these items are selected as appropriate indicators of audit difficulty. An increase in these variables expectedly increases the level of DA.

Sample Selection and Data Collection

The sample of this research is the companies listed in Borsa Istanbul from 2013 to 2020. Companies in the financial services, real estate, and insurance sectors were excluded from the scope of the research due to the differences in the financial statement data. Analysis data is obtained from the financial statements and audit reports of the companies. The financial statement data is obtained from the Refinitiv Eikon's Datastream Database, and the audit report data is gathered from the website of the Public Disclosure Platform. The size of the collected data is 1965 firm-years.

In this study, the period from 2013 to 2020 has been selected because it encompasses a timeframe during which significant changes occurred in Türkiye's capital markets and financial reporting standards. At the beginning of this period, a new capital markets law was implemented in Türkiye, and the Turkish Financial Reporting Standards were fully aligned with the International Financial Reporting Standards (IFRS). Consequently, companies were mandated to present more transparent and comparable data in their financial reports. Starting in 2021, due to the effects of many factors, including the supply shock caused by COVID-19 and the tensions in international politics, inflation began to rise rapidly in Türkiye, creating a significant source of uncertainty in the economic environment. Inflation became a factor that directly impacted companies' financial reporting and caused unusual fictitious increases in accounting items. Therefore, selecting the 2013-2020 period as the timeframe for this study provides a meaningful framework in which neither structural changes nor external economic shocks, such as inflation, significantly affect companies' financial reporting.

Results

The analysis in this section is intended to explore the statistical explanatory power of the variables in the DA prediction model discussed previously. The data used in this analysis belong to non-financial firms listed on Borsa Istanbul for the fiscal years from 2013 to 2020. An exploration of the overall characteristics of these firms may provide background for the interpretation of the outcomes of the regression analysis. In this regard, the regression variables and the selected variables for depicting the characteristics of the firms are given in Table 2.

Table 2
Statistical means of financial variables for data groups

		Means		Welch's t-test (p-value)
Variables	**Aggregate**	**Positive DA**	**Negative DA**	**Pos. DA vs Neg. DA**
DA	-.001	.087	-.079	(.000)
TotAcc	-.009	.087	-.095	(.000)
Big4	.466	.456	.472	(.596)
Opinion	.130	.098	.159	(.000)
CFO/TA	.0433	.035	.051	(.185)
ROA	.0263	.100	-.041	(.000)
LogTA	13.033	12.98	13.078	(.271)
CR	2.133	2.732	1.590	(.000)
Inv/TA	.138	.149	.129	(.000)
AR/TA	.238	.259	.219	(.000)
Loss-binary	.302	.063	.518	(.000)
DebtRatio	.272	.210	.329	(.000)
Eq/TA	.439	.547	.341	(.000)
FirmaAge	14.99	15.28	14.72	(.069)
Distress	.029	.008	.049	(.000)
Sample size	1965	935	1030	

The means of the variables are presented as a comparison of the data grouped by the sign of the total DA. Statistical differences between the positive and negative DA firms are given as t-statistic p-value at the rightmost column. Here, the Welch t-test is used since the sample sizes of the comparison are not equal.

The average value for the cash flow from operations to total assets (CFO/TA) is approximately 4.3% for the aggregate data. The difference in the means between positive and negative DA is not statistically significant for this specific variable, CFO/TA. In the aggregate data, return on assets (ROA) is approximately 2.6% on average. The average value for this variable is +10% and −4.1% for positive and negative DA firms, respectively. This pattern is consistent with the differences in DA between groups. Similar interrelations are also observed in the binary variable indicating if a firm's bottom line is a loss (Loss-binary). The average of the Loss variable indicates the percentage of firms with negative returns in the grouped data.

Table 2 indicates that the firm size measured by the logarithm of total assets (LogTA) is not significantly different between the groups of positive and negative DA firms. Firms with positive DA have more equity proportional to their total assets (Eq/TA) and have a lower debt ratio than those with negative DA. Accordingly, the value of the Distress index that proxies the level of financial distress is higher for negative DA firms. Inventory (Inv) and accounts receivable (AR) items hold a greater amount in total assets for the firms of positive DA group.

For the aggregate data of the selected period of 2013-2020, about half of the audits (48%) were conducted by the major audit firms in the market (Big4). An unqualified opinion was expressed in 13% of the audit reports. The number of qualified audit reports is 63. Negative DA firms are more numerous among the firms having these reports. An overview of the qualified audit reports is presented in Table 3. The numbers of qualified reports are dispersed roughly equal over the years.

Table 3
Numbers of qualified reports in detail

	2013	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**Total**
Qualified	32	30	34	24	27	36	40	33	256
(by Big4)	(10)	(8)	(10)	(8)	(8)	(6)	(6)	(7)	(63)

Qualified reports by industry							
Production	**Services**	**Production (Textile)**	**Agriculture & Food**	**Raw Materials**	**Construction**	**Energy &Mining**	**Tech & IT**
58	53	52	41	17	13	11	11

The Pearson correlation coefficients of the variables of the DA prediction model are presented in Table 4. The correlation between LogTA and Big4 can be interpreted as larger firms favoring major audit firms. Another prominent finding here is a negative correlation between financial distress and return on assets: financial distress worsens when profitability is problematic. This also indicates that the proxy for financial distress used in this study is highly sensitive to profitability. The coefficients can also be used to investigate a potential mul-

ticollinearity problem in regression analysis. High correlations between variables generate multicollinearity and violate the regression analysis assumptions. Accepted threshold of high correlation is 0.8 (Gujarati, 2003). Table 4 indicates mild to moderate correlations between the regression variables.

Table 4
Correlation coefficients for data groups by positive and negative DA

Positive DA	**Big4**	**Opinion**	**ROA**	**LogTA**	**AR/TA**	**Inv/TA**	**Distress**	**Negative DA**
Big4	1	-.204*	.089*	.453*	-.023	-.030	.016	Big4
Opinion	-.132*	1	-.226*	-.205*	-.005	-.094*	.279*	Opinion
ROA	.019	.097*	1	.270*	-.012	.058	-.622*	ROA
LogTA	.469*	-.177*	-.053	1	-.114*	-.094*	-.140*	LogTA
AR/TA	-.052	-.040	-.010	-.180*	1	.032	.042	AR/TA
Inv/TA	-.074*	-.058	-.050	-.031	.033	1	-.064*	Inv/TA
Distress	-.012	.142*	-.069*	.020	.121*	-.028	1	Distress

* Correlation is significant at .05

Multicollinearity can be assessed by examining tolerance and variance inflation factor (VIF) coefficients in multivariate regression models. A value below 0.1 for the tolerance coefficient is considered as a signal for multicollinearity. For VIF, values over 4 indicate potential multicollinearity (Hair et al., 2010). The critical values of these indicators are reported at the bottom of the regression output tables. Based on these, it is evident that there is no significant problem of multicollinearity as the values are below the thresholds.

Table 5 provides the results of the regression analysis. Here, there are three outputs for models labeled with numbers. These models differ in the definition of dependent variables. In Model 1, the dependent variable is the absolute value of DA and includes all firm-year data. The dependent variable in Model 2 is positive DA and thus excludes firm-year data with negative DA values. In this regard, Model 3 is the opposite of Model 2. The dependent variables are held the same for all models.

Table 5
Regression outputs of discretionary accruals prediction models

Dependent	**Independent Variables**							
Variable	**Cons**	**Big4**	**Opinion**	**ROA**	**LogTA**	**AR/TA**	**Inv/TA**	**Distress**
(1) |DA|*								
F: 152.4	.214	-.002	.018	.264	-.011	-.025	-.042	.647
R^2: 0,353	(.000)	(.725)	(.020)	(.000)	(.000)	(.070)	(.033)	(.000)
(2) Pos. DA*								
F: 176.9	.123	-.015	.031	.456	-.006	.046	-.053	.026
R^2: 0.572	(.000)	(.037)	(.005)	(.000)	(.003)	(.017)	(.050)	(.711)
(3) Neg. DA*								
F: 129.5	-.126	-.002	-.001	.064	.005	.046	.002	-.436
R^2: 0.47	(.000)	(.718)	(.868)	(.000)	(.003)	(.002)	(.926)	(.000)

* Min. Value of Coefficients for Tolerance are .74, .73, and .58 for Model 1, 2, and 3 respectively Max. Value of Coefficients for VIF are 1.35, 1.36, and 1.74 for Model 1, 2, and 3 respectively

The F statistics indicate that all three models are significant as a whole. However, the absolute DA model (Model 1) has lower explanatory power than others. The model with the highest explanatory power is the positive DA model (Model 2). These findings support the approach of segmented analysis of positive and negative DA firm-year data. Therefore, the main discussions in this study focus on the outcomes of Models 2 and 3.

For the outputs presented in Table 5, the coefficients of the Big4 variable are negative regardless of statistical significance. For Model 2, the coefficient is statistically significant at a 5% confidence level. When the firms have more accruals than expected, an audit from Big4 reduces the level of these accruals. Therefore, audits conducted by Big4 companies suppress income-increasing practices to a degree in the sense that DA reflects EM.

Auditor's qualified opinion is a statistically significant predictor of DA for the firms that report more accruals than expected. For these firms, there is a positive relationship between DA and having a qualified audit report. On the other hand, the relationship is not statistically significant for the negative DA firms. These observations imply that the auditors focus more on income-increasing EM practices than the ones that result in a decrease in earnings.

ROA coefficients can be interpreted as the positive and significant effects of financial performance on DA. The coefficient may also reflect the direct interaction between accruals and profit. Nevertheless, the effect of profitability on DA is considerably less in Model 3 than in Model 2. Therefore, the explanation of a direct interaction falls short for this specific research model. For firms with more accruals than the expected level, higher profitability increases the level of DA more. From the EM perspective, this finding implies that income-increasing EM practices are more effective for profitable companies.

The financial distress proxy is not a statistically significant predictor for the positive DA firms. In contrast, for the firms with low accruals than the expectation, the financial distress proxy is found to have a decreasing effect on DA. It is plausible that financially distressed firms have lower accruals than financially stable ones. Thus, the financial distress variable acts as an effective control variable when investigating the effects of the other variables of concern.

The coefficients of the variable for firm size are similar in magnitude, yet their signs are opposite. This finding is interpreted as the fact that a firm's size reduces EM, based on DA measurement. The level of the receivables item has an increasing effect on DA, regardless of the firm having positive or negative DA. For the level of the inventory item, another factor that may affect the DA, the results are inconclusive for describing a pattern for EM.

In summary, the prediction model for DA was found to be acceptable from both statistical and theoretical perspectives. Profitability and financial distress prove to be the main control

variables, whereas AR and inventory items have a lesser effect on DA. Variables related to the audit process (i.e., Big4 and Opinion) are significant predictors for EM proxied by DA. The opinion variable is more significant for the firms that have positive DA. On the other hand, for the firms with negative DA, the opinion variable is insignificant in the model, whereas the financial distress variable is more pronounced.

The comparative regression outputs raised more questions about the audit process. One question is whether or not the auditors tend to report EM practices of increasing the earnings more than the ones that decrease the earnings. Another question is about the responsiveness of an audit report on reflecting the problems arising from financial distress: Do qualified audit reports inform doubts about the going concern of the firm? These will be investigated in the next section as a post hoc analysis.

Post Hoc Analysis

In this section, the post hoc analysis aims to reveal whether there is an accordance between what is addressed in the audit reports and the proxies used in this study. The post hoc analysis designed here has three steps. The first step is to conduct a contextual analysis of the qualified audit reports to determine which opinions can be related to EM and which opinions can explain the state of financial stress for a firm. The second step is to classify firm-year data into groups based on the context of auditor opinions in terms of EM and financial stress. The final step is to run the regression model in the same manner as the main analysis and to provide further insights into the EM by interpreting the output.

Table 6
Classification of qualified audit opinions

(i) Emphasis on EM	**Total**
Inadequate provision for bad debts – Trade Receivables	31
Inadequate provision for bad debts – Other Receivables	20
(Related party emphasis on inadequate provision for bad debts)	*(30)*
Overvaluation of assets	10
Inadequate provision for impairment of financial assets	9
Undervaluation of Inventories / Cost of Goods Sold	6
(ii) Emphasis on financial information manipulation other than EM	
Issues related to the income statement *	11
Issues related to liabilities and equity of the balance sheet	7
Issues related to assets of the balance sheet	4
(iii) Emphasis on Indirect Transfer Taxation Issues	
Collection procedures are not properly executed – Other Receivables	15
Collection procedures are not properly executed – Trade Receivables	3
(Related party emphasis on receivables with problems)	*(16)*
Collection procedures are not properly executed – Advances	5
Various other emphases	162

* Mainly about qualitative issues, not eligible for quantitative analysis.

When the qualified audit reports are reviewed thoroughly, the requirement of a segmented classification is needed as the context is fairly diversified. One caveat is that a report may address multiple issues classified into different categories in the following table. In Table 6, subsections (i), (ii), and (iii) are classified as means of potential manipulation of financial information. In our study, emphases in (i) and (ii) are recognized as the signals of EM. In the reports, there are various (or, miscellaneous) emphases as well, and therefore they are classified as "other" emphases. However, the size of this subsection is sufficiently large to expand the classification further.

The emphases classified as others in Table 6 are grouped into three subsections in Table 7. The emphases in the first sub-section may also affect financial information, i.e., reported earnings. Therefore, in our study, these emphases in auditors' opinions are considered as signals of EM even they are not as pronounced as those in Table 6 (i). The remaining emphases constituting the second subsection in Table 7 are irrelevant to any potential EM. The first item in subsection (ii) emphasizes on concerns over the continuity of the firm and the risk of default, i.e.,., doubts about the firm's ability to continue as a going concern. This item is expected to be related to financial distress.

Table 7
Classification of other emphases in qualified audit opinions

(i) Various other emphases with the possibility of financial information manipulation	**Total**
Uncertainties about the necessity of impairment of assets	18
Uncertainties about the valuation of financial investments at fair value	17
Uncertainties about adequacy of the provision for bad debts in receivables	13
Uncertainties about the valuation of inventories	12
Emphasis on provision for ongoing lawsuits that could result in tax penalties	10
Uncertainties about the valuation of goodwill and intangible assets	4
(ii) Various other emphases in a qualified opinion	
Going concern uncertainty (Emphasis on insolvency)	51
Issues related to the valuation of subsidiaries and affiliates	23
Insufficient audit evidence for various accounts	22
Additional explanations about ongoing lawsuits	20
Reconciliation procedures for debts are not properly executed	17
No valuation report has been received for real estate	15
(iii) Unclassified various other emphases	30

Based on the contextual analysis, if a firm has a qualified audit report with the specific emphases (i, ii in Table 6 and i in Table 7) at a specific year, the corresponding firm-year data is labeled as "earnings management". In addition, if a firm has a qualified audit opinion for going concern uncertainty at a specific year, the corresponding firm-year data are labeled as "going concern uncertainty". These labels are used to compare firm-year data groups in terms of financial characteristics (Table 8).

Table 8 has columns for the means of selected variables depicting general characteristics of firm-year data grouped and labeled based on their audit reports. In addition, there are two

columns for Welch's t-test significance values of the mean comparison between the specific conditions and the control sample. These conditions for firms include receiving an audit report with an emphasis on EM or doubts about the going concern. The corresponding control samples include firms that have a qualified audit report with a different emphasis. The mean comparison between qualified and unqualified samples is not reported because a large sample size difference disrupts statistical inferences.

Table 8
Means of financial variables for data groups by audit report context

	Means			Welch's t-test (p)	Means	Welch's t-test (p)
Variables	**Unqualified**	**Qualified**	**Earning Man.**	**E. Man. vs Other Qual.**	**Going Concern Uncertainty**	**Going Concern Uncertainty. vs Other Qual.**
DA	.004	-.030	-.045	(.471)	-.177	(.803)
TotAcc	-.006	-.026	-.056	(.317)	.012	(.416)
Big4	.449	.246	.239	(.814)	.294	(.401)
CFO	.0501	-.002	-.005	(.935)	.048	(.682)
ROA	.0356	-.038	-.069	(.440)	.0126	(.655)
LogTV	13.174	12.089	11.730	(.005)	11.617	(.051)
CR	2.084	2.461	1.602	(.001)	1.269	(.050)
Inv/TA	.142	.111	.128	(.049)	.048	(.000)
AR/TA	.240	.225	.234	(.500)	.331	(.020)
Loss	.276	.477	.513	(.298)	.706	(.000)
DebtRatio	0,261	.351	.326	(.330)	.635	(.000)
Eq/TA	.465	.267	.350	(.084)	-.082	(.001)
FirmAge	15.39	12.38	12,38	(.935)	11.39	(.075)
Distress	.018	0.106	0,074	(.063)	.259	(.000)
Sample size	1709	256	113		51	

In Table 8, mean comparisons imply that a qualified audit report is received by the firms with negative levels of cash flow, accruals, and a negative return, on average. However, emphases of neither EM nor doubts about the going concern make a statistical difference on these variables. On average, a firm with a qualified audit report has more debt, less equity, and high levels of financial distress. An emphasis on about the going concern alleviates these doubts, and it is statistically proven. Firms with doubts about the going concern also have critical levels of current ratio (CR). In summary, EM appears to be an issue for firms that financially underperform and have mild symptoms of financial distress. An audit report is likely to address the doubts about the going concern of a financially distressed firm.

The context of the auditor's opinion has been used to investigate the main characteristics of the firms thus far. However, the direct effect of an opinion can be investigated in a prediction model. Specifically, EM emphasis in an auditor's opinion is expected to affect the DA in the prediction model used in this study. The contextual analysis indicates that most of the emphases related to EM are about increasing the earnings. Therefore, the opinion variable is

expected to have a positive effect on DA, regardless of whether the accruals are positive or negative. In Table 9, the regression outputs are given for a refined sample excluding the firms other than those with audit reports emphasizing potential EM.

Table 9
Model Outputs of Sub-samples for Earnings Management

Sample Group: Potential Earning Management Related Qualified Opinions: Tab6(i, ii)+Tab7(i)								
Dependent	**Independent Variables**							
Variable	**Cons**	**Big4**	**Opinion**	**ROA**	**LogTA**	**AR/TA**	**Inv/TA**	**Distress**
(1) Pos. DA*								
F: 113.5	.058	-.028	.026	.823	-.003	.014	-.013	.118
R^2: 0.48	(.009)	(.000)	(.042)	(.000)	(.044)	(.367)	(.529)	(.062)
(2) Neg. DA*								
F: 114.9	-.093	-.001	.005	.199	.003	.023	-.004	-.319
R^2: 0.46	(.000)	(.794)	(.581)	(.000)	(.066)	(.074)	(.817)	(.000)

* Max. Value of Coefficients for Tolerance are .74, and .50 for Model 1 and 2, respectively
Max. Value of Coefficients for VIF are 1.35 and 1.99 for Model 1 and 2, respectively

In Table 9, the coefficients of the opinion variable are both positive for the firms having positive and negative DA. The coefficient is insignificant for the firms with negative DA. Nevertheless, the sign of the coefficient is now positive and the significance is improved when compared to Table 5. These results are in line with the above-mentioned theoretical expectations. In conclusion, the post hoc analysis indicates that the auditors do report EM practices and these are income-increasing. This finding is supported by the DA prediction model used in this study. Certain emphases in auditory opinions can be used as indicators of EM. In addition, the emphasis on doubts about the going concern of the firm is strongly related to financial distress.

Conclusions

The primary purpose of this study was to investigate auditors' potential to detect and suppress EM. In this regard, the effects of audit opinions and audit firm size are analyzed using a DA prediction model. The sample of this research consists of companies listed on Borsa Istanbul between 2013 and 2020, and the analysis data is 1965 firm-years of size. Subgroups of firms with negative and positive accruals are analyzed separately to observe differences in model outputs for income-increasing and decreasing EM practices. The primary analysis is followed by a further investigation of qualified audit reports to identify emphases that may be considered as a signal for EM practices. Based on the contextual analysis of the reports, firms with identified audit reports are reanalyzed to test the robustness of the main findings.

Auditors are responsible for detecting financial information manipulation, including EM practices. These practices are expected to be less effective for the clients of a major audit firm. Theoretically, EM is reflected by DA. Therefore, receiving a qualified opinion and be-

ing audited by a major firm are modeled to explain a firm's DA. These are proxied by the opinion and Big4 variables in the regression model. The empirical evidence demonstrates that a qualified audit opinion is positively related to DA, whereas the relationship is negative for an audit from Big4. The findings support the hypotheses H1 and H2. The opinion variable is more significant for the firms that have positive DA. This finding implies that the auditors are more sensitive to income-increasing EM practices. The post hoc analysis supports this implication by showing that emphases about EM on the audit reports is predominantly income-increasing practices.

Based on the empirical evidence provided in this study, auditing is effective in detecting EM practices, and major audit firms are capable of suppressing such practices. The contextual analysis of the opinion statements shows that the emphasis focuses on income-increasing practices. However, the statements cover a range of issues that can justify a qualified opinion. Therefore, these were categorized and reported in tables, which are believed to be informative for potential research. Among the categories, emphasis on going concern uncertainty is related to financial distress, a control variable of the prediction model. This variable is a significant predictor of the negative DA, meaning that the effects of financial problems are properly controlled.

The prediction model used in this study also has a broad set of variables to avoid any problems associated with omitted-variable bias. Financial performance, firm size, proxies for audit difficulty, and financial distress are the control variables that can affect the level of DA in theory. Among these, financial performance and firm size are significant predictors of positive and negative DA. However, the analysis outputs are inconsistent for the proxies of audit difficulty that are the proportions of accounts receivables and inventory to total assets. Firms with a qualified audit report also deviate in terms of financial characteristics. The mean comparison analysis indicates that these firms have negative cash flows, accrual levels, and returns. Such firms are also financially distressed with more debt and less equity.

The findings of this study should be evaluated within the framework of certain limitations. The dataset only covers firms operating in Türkiye between 2013 and 2020. This may limit the general validity of the findings and their validity under different economic conditions. On the other hand, the measures used in this study are limited to certain indicators, such as the size of the audit firm and the type of report. These indicators did not take into account many other factors in the audit process. In addition, the EM was measured using a different version of the MJM. This measure may not cover all aspects of EM. These limitations emphasize that the findings of this study should be evaluated in a specific context and highlight potential directions for future research.

The methodology in this research combines qualitative and quantitative methods for a thorough investigation of auditing effectiveness on detecting and suppressing EM. Contex-

tual analysis of the auditor's opinion is shown to be an informative classification for cross-sectional regression analysis of EM. Further research may alter the classification by adding or removing items for specific sectional analyses. The results provide important insights for predicting going concern uncertainty in firms experiencing financial distress, particularly within the context of developing economies. In such markets, firms often face challenges such as weaker regulatory frameworks, lower levels of investor protection, and greater economic volatility, all of which can exacerbate financial distress and make going concern risks more difficult to manage. Our findings suggest that firms with high financial distress are more likely to receive qualified audit opinions, which can serve as critical early indicators of going concern risks. Comparative research on different economic environments will test the generalizability of these conclusions.

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RESEARCH ARTICLE

Portfolio Optimization with Artificial Hummingbird Algorithm for Cement Industry

Murat Erhan Çimen[1]

Abstract

Portfolio optimization, which is performed while investing in any asset, is an important issue for all investors and finance researchers. In this study, the Artificial Hummingbird Optimization Algorithm (AHA), which has been proposed in recent years, was implemented for portfolio optimization by adapting it to Modern Portfolio Theory. Stocks have been selected as investment instruments in the portfolio. Stocks are classified as risky assets due to daily price fluctuations, depending on many natural or political events or decisions. In this study, since stocks are risky assets, the minimum risk criterion is preferred for a defensive investor. In addition, due to the Kahramanmaraş earthquake in Türkiye, this study aims to create a portfolio, especially within the cement sector, in a way that minimizes risk. With this objective in mind, as the originality of the study, AHA has been used to determine the optimal portfolio using stocks in the cement sector in BIST. Statistical analysis and the Wilcoxon test were conducted for the AHA results. Subsequently, several portfolios were determined based on the AHA's statistical results. Furthermore, to measure the risk and return performance for each portfolio, total normalized returns, CAPM analysis, Sharpe Ratio, and Treynor ratio were calculated, and their results were compared to each other. The results show that Portfolio 6 exhibited the best performance in terms of the minimum risk criterion among the optimized portfolios using AHA.

Keywords: Artificial Hummingbird Optimization, Portfolio Optimization, Cement industry

Introduction

The art of optimization involves using variables to maximize or minimize a specific, quantifiable, and measurable goal. For example, when planting rice fields in China, it is a learned optimization problem for people to maximize the yield from the fields they planted by adjusting the season, irrigation time, and water level in the fields (Gladwell, 2009). However, due to the geographical structure of China and its administration at that time, Chinese people had to work as they had a large amount of land. This is considered a variable of the problem. On the other hand, while the pyramids in Egypt were built, the slaves, animals, wagons, ships, the structure of the stones used in the pyramid construction, and time are the variables of the

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optimization problem. The most obvious optimization problems encountered in history were the establishment of cities and caravanserais along the Silk Road in the most suitable places that were strategically profitable and safe, and the design of weaponry equipment to be most effective in warfare (M. Çimen, 2022). However, in history, these problems have usually been solved by trial and error or by the intuition and wisdom of the people. Nowadays, these types of problems are formulated by modeling them mathematically. Once the model is established, an optimization algorithm can be employed to find the solution, typically with the assistance of a computer (Nocedal & Wright, 2006). Therefore, when looking at optimization, it is encountered in almost every field from physics (Demirdelen et al., 2022; Jin & Rahmat-Samii, 2008; Salko, Schmidt, & Avramova, 2015) to biology (Cedersund, Samuelsson, Ball, Tegnér, & Gomez-Cabrero, 2016), from health (Atteia, Abdel Samee, El-Kenawy, M., & Ibrahim, 2022; Hu et al., 2022) to logistics (Borndörfer, Grötschel, & Löbel, 1998; Z. Garip, Karayel, & Çimen, 2021), from chemistry to mechanics (Heidari et al., 2019), from medicine to tourism, from communication to energy (Abid, Apon, Morshed, & Ahmed, 2022; Ramadan, Kamel, Hassan, Ahmed, & Hasanien, 2022), from public administration to international relations, from education to finance (X.-S. Yang, 2020).

Optimization can be performed both analytically and iteratively. These methods can be developed by being inspired by physics, biology, social events, the structure of the universe, or the behavior of a swarm; thus, they are designed to imitate living and non-living beings in nature. In particular, developed algorithms of this type are called metaheuristic algorithms (Akgül et al., 2024; X.-S. Yang, 2020a). When we look at metaheuristic algorithms, they have many advantages, such as being easily applied to linear and/or nonlinear, continuous and/or discontinuous, constrained and/or unconstrained, univariate or multivariate, and differentiable or nondifferentiable problems (M. E. Çimen, Garip, & Boz, 2021; M. Çimen, Garip, M, & Boz, 2022; Xing-Shi He, Qin-Wei Fan, Mehmet Karamanoglu, 2019). One metaheuristic algorithm proposed recently is the Artificial Hummingbird Algorithm (AHA) (Ramadan et al., 2022; Zhao, Wang, & Mirjalili, 2022). Hummingbirds are remarkable creatures, recognized as the smallest birds on Earth. Hummingbirds, as shown in Figure 1, would be the most intelligent creatures on the planet, including humans, if intelligence were determined by the brain-to-body ratio (Fennelly, 2012). Hummingbirds are unique in that they have a remarkable memory of finding food. Hummingbirds' capacity to fly is another unique talent. They are the most adept flies among all bird species thanks to their small wingspan and rapid wingbeats. Hummingbirds have adaptable shoulder joints that allow them to twist their wings 180 degrees while maintaining a figure-eight motion. Hummingbirds use their distinctive flight pattern to gain energy from both the upstroke and downstroke (Tobalske et al., 2007). The hummingbird has excellent direction-finding ability. Hummingbirds can fly in several directions, including up, down, left, and right, in addition to taking flight like other birds (Leys, Reynaerts, & Vandepitte, 2016). Hummingbird flight abilities, memory capacity, and

foraging techniques are the primary sources of inspiration for the AHA (Zhao et al., 2022). The AHA algorithm has been used in fields such as energy (Ramadan, Ebeed, Kamel, Ahmed, & TostadoVeliz, 2023; Ramadan et al., 2022), parameter estimation, and engineering applications. In addition to this algorithm, Genetic Algorithm (GA) (J. Holland, 1975; J. H. Holland, 1975; Koker, 2013; Seyedali Mirjalili, 2019; X.-S. Yang, 2020), Partial Swarm Optimization (PSO) (Eberhart & Kennedy, 1995), Firefly Algorithm (FA) (X. S. Yang, 2009), Flower Pollination Algorithm (X.-S. Yang, 2020), Cuckoo Search Optimization (X. S. Yang & Deb, 2009), Sin Cos Algorithm (Seyedali Mirjalili, 2016; Rajagopal et al., 2021), Whale Optimization Algorithm (Mirjalili & Lewis, 2016), Harris Hawks Optimization (Heidari et al., 2019), Moth Flame Optimizer (Seyedali. Mirjalili, 2015), Marine Predators Algorithm (Chen et al., 2022) and more can be found in the literature.

Figure 1. Hummingbirds

In society, people like investors try to protect their savings against inflation by investing in certain investment instruments such as gold (Gök & Tiwari, 2022), foreign currency, currency-protected deposit accounts, real estate (Kiyosaki & Lechter, 2001), deposit accounts (Çelik & Tekşen, 2021), bonds, funds (Çelik & Tekşen, 2021), and stocks (Akkaya, 2021; Atik & Kovacevic, 2022; Yalcin, 2022). Under this condition, each investment instrument must be evaluated with respect to many criteria, such as tax rates, interest rates, sectorial conditions, political conditions, natural conditions, transportation, companies, countries, and states. On the other hand, it is a problem for investors to add to the portfolio and remove it from the portfolio in which weight and in what time interval among the options in the investment instrument they choose. For this purpose, they need to determine their portfolio in a way that will reduce certain risks and maximize their income. Therefore, determining the portfolio in an optimal way will maximize return. However, portfolio optimization can be expressed as the maximum return per unit of risk. In the classical portfolio management approach, risk is reduced by selecting investment instruments with high returns and increasing their variety, regardless of the correlation of each investment instrument (Ayan & Akay, 2014; Hüseyinov & Uluçay, 2019). However, when considering any investor, they expect to obtain maximum return with low risk in the portfolio they will create in the asset pool. For this reason, Markowitz proposed Modern Portfolio Theory (MPT) in the 1950s to allow investors to create a portfolio that would provide maximum return with minimum risk (G. & D., 2010; Marko-

witz, 1952, 1959; Mercangöz, 2018). A survey of the literature reveals that there are numerous approaches, such as TOPSIS, VIKOR, MOORA, or optimization, for creating a portfolio using historical data (Atukalp, 2019; Karakul & Özaydin, 2019; Karcıoğlu & Yalçın, 2022; Oh, Kim, & Min, 2005). From the literature, optimization is very suitable for MPT to form an optimal portfolio for stocks having the desired objectives. In addition, optimization has been used to form an optimal portfolio. Oh et al. created an optimal portfolio using GA on the KOSPI 200 index. However, it did not perform well when the index was flat (Oh et al., 2005). Besides KOSPI 200 index, Chang et al. performed portfolio optimization using a GA algorithm for the TAIWAN 50 index (Chang, Wang, & Min, 2010). Çankal, on the other hand, performed portfolio optimization using GA in BIST 30 in his/her thesis (Çankal, 2015). In addition to GA, Çelengi et al. created a portfolio for BIST 30 using the PSO (Çelenli, Eğrioğlu, & Çorba, 2015). Afterwards, Çelengi realized the optimal portfolio creation in his/her PhD thesis with Artificial Bee Colony Algorithm (Çelengi, 2018). Sedighi et al. applied the Strength Pareto Evolutionary Algorithm to a multi-objective portfolio optimization problem. They also attempted to use Capital Asset Pricing Model (CAPM) to allocate investments optimally to reduce risk and maximize return on a stock portfolio (Sedighi, Jahangirnia, & Gharakhani, 2018). Mustafa, in his master's thesis, examined the risk-return relationship in the Financial Asset Pricing Model. For this purpose, he randomly chose stocks in BIST 30 and BIST 50 and created several portfolios. Then, he compared portfolio performance in terms of the Sharpe and Traynor ratios (Moustafa, 2007). Similarly, Garip, in his master's thesis, created 14 different portfolios using the stocks he selected from BIST. He calculated the returns, standard deviation, coefficients of variation, and Sharpe ratios for the performances of the portfolios (O. Garip, 2014). Yücel used performance criteria, such as Sharpe, Treynor, Jensen, Sortino, and Fama criteria, to make a risk-based performance comparison of the BIST indices. Then, the relationship between index performances was evaluated using Spearman's rank correlation test (Yücel, 2016). Ramshe et al. created portfolios by applying GA, Tabu Search, Simulated Annealing, and PSO and FA methods to MPT. They tested their successes using historical data (Ramshe et al. 2021).

Cement is frequently encountered as a very important sector, as it is mainly a basic material in buildings and constructions. The first cement production in Turkey started in Darica at 20,000 tons per year through the state channel in 1911, and production capacity doubled in 1923. By 1950, the capacity increased 9 times with the establishment of different production facilities established (Arıöz & Yıldırım, 2012). According to the Activity Report published by CEMBUREAU in 2021, the Turkish Cement Industry, with a production of 72.3 million tons, was ranked 5th among the G20 countries, behind China, India, the USA, and Brasilia (Cembureau, 2021). Considering the researches, it is mostly consumed in the domestic market due to the easy availability of raw materials and the cost of transportation. In other words, cement is a local product. In addition, it has a significant place in the economy due to its contribution to Gross Domestic Product (GDP) and the benefits it provides to employment. The

cement sector provides employment to many different levels of people, such as managers, civil servants, engineers, workers, and technicians, as well as contributing to the development of other sectors, such as iron and steel, service, transportation, banking, financial leasing, insurance, and tourism.

In this study, it is aimed to create an optimal portfolio using the AHA proposed in 2021 in the cement sector between 01/31/2018 and 01/31/2023 among eleven leading companies. The main objective function was to obtain the minimum risk via MPT. To evaluate the performance of AHA, the algorithm was run 30 times independently at different swarm sizes and numbers of iterations. Obtained results have been compared statistically. The Wilxocon test was then applied to the algorithm's results to determine whether there was a significant difference or not. Moreover, the CAPM, Sharpe ratio, and Treynor ratio of each portfolio are calculated, and their performances are compared to each other. Relatively, the obtained portfolios demonstrated better performance than the CAPM. In addition, Sharpe and Treynor ratios are calculated for each portfolio, and their results are presented in tables and figures. As a result, Portfolio 6 exhibited the best performance in terms of minimum risk criteria among the optimized portfolios using AHA.

Materials and Methods

In this study, using the AHA, six portfolios with minimum risk were created from the cement sector by means of MPT. Statistical analysis and Wilxocon tests of algorihm's results have been realized and evaluated. Then, portfolio performance with respect to the CAPM, Sharpe ratio, and Treynor ratio is determined.

Artificial Hummingbird Algorithm

One of the recent nature-inspired metaheuristic algorithms is the Artificial Hummingbird Algorithm, which was developed by Zhao et al. in 2021 (Ramadan et al., 2023; Zhao et al., 2022). To choose a suitable food source among a variety of food sources, hummingbirds examine factors such as the quantity and quality of nectar produced by different flowers as well as the nectar-refilling mechanism. The proposed algorithm differs from earlier algorithms due to its broad search domain and is inspired by the distinct flying skills and accurate foraging methods of hummingbirds when searching for food. The algorithm's exploitation probability and exploration capability are both improved by the unique flight patterns. A specific part called the visit table was included to further mimic the hummingbird's memory of locating appropriate food sources. Axial, diagonal, and omnidirectional are the three flying patterns used, and territorial, migratory, and guided foraging are the search tactics used (Zhao et al., 2022). The next section presents three mathematical models that mimic the three distinct foraging habits of hummingbirds.

Initialization

The assignment of a swarm of *n* hummingbirds to *n* food sources is random in Equation 1 (Zhao et al., 2022).

$$x_i^t = LB + rand(0.0,1.0)(UB - LB) \quad i = 1, \dots, n \tag{1}$$

where LB and UB denote the upper and lower bounds of a d-dimensional problem, respectively. The location of the with the food supply that offers the answer to the specific objective is represented by x_i^t, $rand(0.0,1.0)$ is a random vector with a range of [0.0, 1.0] and *t* is iteration index. The source of food's visit table can be provided like Equation 2.

$$VT_{i,j}^t = \begin{cases} 0 & i \neq j \\ null & i = j \end{cases} \quad i,j = 1, \dots, n \tag{2}$$

If $i = j$, then $VT_{i,j}^t = null$ indicates that the hummingbird is consuming food from a specific source. If $i \neq j$, then $VT_{i,j}^t = 0$ shows that specific source has been visited by a hummingbird in the current iteration (Zhao et al., 2022).

Guided foraging

The source of the greatest nectar is visited by each hummingbird. Hummingbirds can fly in three different directions: axially, diagonally, and omnidirectionally. Equation 3 defines the axial flight.

$$D^{(i)} = \begin{cases} 1 & i = rand(1,d) \\ 0 & other \end{cases} \quad i = 1, \dots, d \tag{3}$$

Equation 4 defines the diagonal flight. In Equation 4, r_1 is a random number (0, 1) and $randperm(k)$ creates a number permutation from 1 to *k*. In addition, the function $rand(1,d)$ randomly selects a number between 1 and *d*.

$$\begin{gathered} D^{(i)} = \begin{cases} 1 & i = P(j) \\ 0 & other \end{cases} \quad \begin{matrix} i = 1, \dots, d \\ j \in [1,k] \end{matrix} \\ P = randperm(k) \quad k \in [2, r_1(d-2)+1] \end{gathered} \tag{4}$$

The definition of omnidirectional flight is expressed in Equation 5.

$$D^{(i)} = 1 \quad i = 1,2,..,d \tag{5}$$

The mathematical expression for simulating guided foraging behavior with an appropriate food supply is given as in Equation 6. $x_{i,tar}(t)$ is hummingbird's intended food source, α is guided factor at normal distribution.

$$v_i^{t+1} = x_{i,tar}^t + \alpha D\left(x_i^t - x_{i,tar}^t\right) \quad \alpha \sim N(0,1) \tag{6}$$

The latest position is updated as in Equation 7.

$$x_i^{t+1} = \begin{cases} x_i^t & f(x_i^t) \leq f(v_i^{t+1}) \\ v_i^{t+1} & other \end{cases} \tag{7}$$

Territorial foraging

The mathematical equation *x* describes the local foraging strategy of hummingbirds in terms of their territorial foraging strategy and a sufficient food source (Zhao et al., 2022). In Equation 8, *b* is a territorial factor and a directed factor with normal distribution.

$$v_i^{t+1} = x_i^t + bDx_i^t \quad b \sim N(0,1) \tag{8}$$

Migration foraging

The migration of a hummingbird from the nectar source with the slowest rate of nectar replenishment to another randomly chosen source is represented by Equation 9 (Zhao et al., 2022). In Equation 9, $x_{wor}^t = LB + rand(0.0,1.0)(UB - LB)$ represents the food source in the swarm with the lowest nectar replenishment rate.

$$x_{wor}^t = LB + rand(0.0,1.0)(UB - LB) \tag{9}$$

In the absence of replacements for food sources, a hummingbird using directed and territorial foraging strategies sequentially visited each food source with respect to visiting table at each iteration. Given a 50% probability of success when choosing between guided and territorial foraging, as well as a 50% chance of success when visiting other sources during guided foraging, it becomes essential to extend the search area and mitigate stagnation through the adoption of a migratory foraging strategy (Zhao et al., 2022). In this context, the population size specification of the migration coefficient *(M)* is provided as outlined in Equation 10. During the algorithm run, iteration number *t* increases. Meanwhile, if *mod (t, M) = 0* is met Equation 9 is used.

$$M = 2n \tag{10}$$

The pseudocode of the AHA is given in Algorithm 1.

Modern Portfolio Theory

In the first half of the 20th century, the science of investment began to develop, and although initially securities were handled and analyzed individually and focused on individual choices, a new perspective on investments was introduced in the MPT, the first building blocks of which were created by Markowitz (Akkaya, 2021; Markowitz, 1952, 1959; Mercangöz, 2018). Within the scope of portfolio management, the selection of assets that investors will add to their portfolios is called a portfolio selection problem in the finance literature (Karan, 2001). Harry Markowitz argued that traditional portfolio theory cannot reduce port-

folio risk by increasing the variety of assets in a portfolio. With the mean-variance model, the traditional portfolio theory was replaced by MPT. Investors want to know the risks they face against their expected return (Akgüç, 1998). For this reason, Markowitz used a model that would reach the minimum risk at the expected return level and the maximum return at the expected risk level by examining the relationships between the assets in the portfolio. Portfolio rate of Return is the average

Algorithm 1

Pseudocode of Artificial Hummingbird Algorithm

The objective function is determined $f(x), [x_1, x_2, \dots, x_n]^T$
Define n number Artificial Hummingbird
N_{max} *number*
LB and UB of population
The initial population values are produced by Equation (1) and
The visit table is created using Equation (2)
While $t < N_{max}$
for $i = 1: n$
If $rand(0.0,1.0) \leq 0.5$
If $rand(0.0,1.0) < 1/3$
Apply the diagonal flight using Equation (4)
Else if $rand(0.0,1.0) < 2/3$
Apply the omnidirectional flight using Equation (5)
Else
Apply the axial flight in Equation (3)
Apply guided foraging using Equation (6)
If $f(v_i^{t+1}) < f(x_i^t)$
$x_i^{t+1} = v_i^{t+1}$
for $j = 1: n(j \neq i, tar)$
$VT_{i,j}^t = VT_{i,j}^t + 1$
$VT_{i,tar}^t = 0$
for $j = 1: n(j \neq i, tar)$
$VT_{i,j}^t = \underset{k \in n, k \neq j}{max}\left(VT_{i,k}^t + 1\right)$

for $j = 1{:}\,n(j \neq i, tar)$
$VT_{i,j}^{t} = VT_{i,j}^{t} + 1$
$VT_{i,tar}^{t} = 0$
Else
Apply territorial foraging using Equation (8)
If $f(v_i^{t+1}) < f(x_i^t)$
$x_i^{t+1} = v_i^{t+1}$
for $j = 1{:}\,n(j \neq i)$
$VT_{i,j}^{t} = VT_{i,j}^{t} + 1$
for $j = 1{:}\,n$
$VT_{i,j}^{t} = \underset{k \in n, k \neq j}{max}\left(VT_{i,k}^{t} + 1\right)$
Else
for $j = 1{:}\,n(j \neq i)$
$VT_{i,j}^{t} = VT_{i,j}^{t} + 1$
If $mod(t, M) = 0$
Apply migration foraging using Equation (9)
for $j = 1{:}\,n(j \neq wor)$
$VT_{wor,j}^{t} = VT_{wor,j}^{t} + 1$
for $j = 1{:}\,n$
$VT_{j,wor}^{t} = \underset{k \in n, k \neq j}{max}\left(VT_{j,k}^{t} + 1\right)$

return rate for assets in the portfolio (Karan, 2001). When investors make an investment decision, they invest their capital in more than one investment asset to minimize risks. For this reason, since every asset with a financial nature can be a part of the portfolio, the portfolio should be evaluated in general rather than individually evaluating the assets while performing the risk-return analysis. The effect of assets on portfolio risk can be positive, negative, or neutral. The covariance of the combination values of the assets should be calculated to determine the direction in which the relationship between all assets resulting from this effect is. Covariance is the fit value of more than one variable between two or more variables at certain times.

Markowitz's mean-variance model reduces portfolio risk by creating a portfolio of assets that do not have the same relationship between returns. In MPT, a portfolio comprising a combination of low correlations and those with minimum risk has a greater impact on expected portfolio return (Ayan & Akay, 2014; Hüseyinov & Uluçay, 2019; Mercangöz, 2018). Investors want to achieve high returns; however, while creating an optimum portfolio, the relationship between return and risk should be examined. A low-risk portfolio should be selected at the same return level, while a high-risk portfolio should be selected at the same risk level (Ulucan, 2004).

The expected return of the portfolio is determined by multiplying the expected returns of each asset by the weights of those assets in the portfolio, using Equation 11. Here, *n* denotes the total number of assets in the portfolio, w_i denotes the weight assigned to each asset, and $E(r_i)$ *i* stands for the expected return on assets.

$$E(r_p) = \sum_{i=1}^{n} w_i E(r_i) \tag{11}$$

The covariance between any two data can be calculated using Equation 12:

$$Cov(r_i, r_j) = \frac{1}{n} \sum_{k=1}^{n} \left(r_{ik} - E(r_i)\right)\left(r_{jk} - E(r_j)\right) \tag{12}$$

The variance formula required to calculate the risk of a portfolio consisting of many assets using the covariance matrix is shown in Equation 13.

$$var(r_p) = \sigma_p^2 = \sum_{i=1}^{n} \sum_{j=1}^{n} w_i w_j Cov(r_i, r_j) \tag{13}$$

Markowitz examined the relationships between the returns of the securities that comprise the portfolio. He proposed the MPT, which shows that the inclusion of securities that do not have a fully positive correlation from this relationship, in other words, the correlation coefficients are less than 1, and even negative if possible, can be achieved by reducing the portfolio risk of the targeted return (Akyer, Kalaycı, & Aygören, 2018). The mathematical formula of the portfolio optimization problem to be realized using the Markowitz mean variance model is the nonlinear programing model in Equation 14. Note that in Equation 14, $var(r_p)$ to be minimized stands for objective function $J(x)$for standard optimization problem.

$$min\ \left(var(r_p)\right) = \sigma_p^2 = \sum_{i=1}^{n}\sum_{j=1}^{n} w_i w_j Cov(r_i, r_j)$$

Subject to: (14)

$$\sum_{i=1}^{n} w_i = 1 \quad i = 1,2,..,n$$

Capital Assessment Price Model

CAPM is a model that provides an indicator for investors to value risky assets and optimize their portfolios. This was suggested based on the mean-variance model and the assumption that portfolios have efficient frontiers. This model shows a linear relationship between risk and return. The CAPM model essentially gives returns that can be linearly obtained according to the risk criterion. The CAPM model is given in Equation 15. In Equation 15, $E(R_i)$ represents the expected value of the *i*-th asset, while R_f represents the risk-free interest rate in the market. β_i represents the systematic risk of the *i*-th asset, while R_m represents the expected market return (Elbannan, 2015; Moustafa, 2007).

$$E(R_i) = R_f + \beta_i\left(R_m - R_f\right) \tag{15}$$

The risk of the asset used in the CAPM model is calculated as in Equation 16. This value is also called Beta. β_i is essentially the market beta of the *i*-th asset and measures the sensitivity of the asset's return to changes in market return. $Cov(R_i, R_m)$ value is the covariance between the *i*-th asset and its market value. $\sigma^2(R_m)$ also expresses the variance in the market value.

$$\beta_i = \frac{Cov(R_i, R_m)}{\sigma^2(R_m)} \tag{16}$$

The risk of a created portfolio can be measured using Equation 17. The expected portfolio return can be calculated by substituting the calculated β_p into the β_i in equation 15.

$$\beta_p = \sum_{i=1}^{n} w_i \beta_i \tag{17}$$

Sharpe Ratio

Sharpe introduced the Sharpe ratio in Equation 18, which is used to measure performance by dividing the total return above the risk-free interest rate by the total risk (Sedighi, Jahangirnia, & Gharakhani, 2019; Yücel, 2016). In Equation 18, R_m is the return on the portfolio or stock, σ is the standard deviation of the stock or portfolio and R_f is the risk-free interest rate. If the standard deviation of a portfolio or stock is low and the return is high, then the Sharpe ratio will produce high values. Therefore, a high Sharpe ratio is desirable for a defensive investor.

$$Sharpe = \frac{R_m - R_f}{\sigma} \tag{18}$$

Treynor Ratio

Treynor assumed that a rational investor could eliminate unsystematic risk by diversifying risk. Under this assumption, Treynor introduced the Treynor ratio in Equation 19 to the literature by proportioning total return above the risk-free interest rate to systematic risk (Sedighi et al., 2019; Yücel, 2016). In Equation 19, R_m is the return of the portfolio or stock, β is systematic risk or Beta of the stock or portfolio and R_f is the risk-free interest rate. If the beta of a portfolio or stock is low and the return is high, then the Treynor ratio will produce high values. Note that when the beta of a portfolio or stock is low, an investor or finance researcher should be slow and sure. Nevertheless, a high Treynor ratio is a desirable situation for a defensive investor.

$$Treynor = \frac{R_m - R_f}{\beta} \tag{19}$$

Simulation Studies

A portfolio was created by weighting the companies in the sector to create a portfolio with the lowest risk according to the MPT technique using the AHA in the cement sector. For this, the data traded in Borsa Istanbul are discussed. In order to perform the studies, a computer with Intel(R) Core (TM) i5-9400 CPU@ 2.90 GHz, 64 Bit, 8 GB RAM was used. The study was conducted using MATLAB 2018a. Then, AHA was run to determine the appropriate portfolio selection according to the MPT technique, and analyses were carried out to determine the appropriate portfolio selection. With this objective, tests were performed on different swarm sizes and numbers of iterations to test the performance of the AHA proposed in 2021.

Datasets

This study discusses shares of companies in the cement sector traded in Borsa Istanbul. Afyon Çimento Sanayi T.A.Ş (AFYON), Akçansa Çimento Sanayi ve Ticaret A.Ş. (AKCNS), Batısöke Söke Çimento Sanayi T.A.Ş (BSOKE), Batıçim Bati Anadolu Çimento Sanayi A.Ş. (BTCIM), Bursa Çimento Fabrikasi A.Ş. (BUCIM), Çimsa Çimento Sanayi ve Ticaret A.Ş. (CIMSA), Çimbeton Hazırbeton ve Prefabrik Yapı Elemanları Sanayi ve Ticaret A.Ş. (CMBTN), Göltaş Göller Bölgesi Çimento Sanayi ve Ticaret A.Ş. (GOLTS), Konya Çimento Sanayi A.Ş. (KONYA), Niğbaş Niğde Beton Sanayi ve Ticaret A.Ş. (NIBAS) ve Oyak Çimento Fabrikaları A.Ş. (OYAKC) companies' monthly closing prices of share between 01/31/2018-01/31/2023 have been taken up. Between these dates, Boğaziçi Beton Sanayi ve Ticaret A.Ş. (BOBET) company did not have sufficient data, so this BOBET share was not taken into consideration in the analysis. In addition to these stock data, XTAST and BIST

100 were used. It is obvious that if price data for all months are given and analysis results are given, the article would take up a lot of space. Therefore, only data for a few months at the beginning and end will be given in the tables, and their analysis results will be given. A small portion of this monthly-closing price data can be seen in Table 1. These data must be normalized. Thus, to accomplish this, the formula used is given in Equation 20. When Equation 20 is examined, r_t presents t-th month price in Table 1 and R_t presents normalized proportional return. The normalized proportional return obtained when Equation 20 is applied to the monthly-closing price data of cement companies is given in Table 2.

$$R_t = \frac{r_t}{r_{t-1}} - 1 \tag{20}$$

Table 1
Monthly-closing Price Data of Companies in the Cement Sector

Month/Day/ Year	BIST 100	XTAST	AFYON	AKCNS	BSOKE	BTCIM	BUCIM
01/31/2018	1195.29	891.51	2.78	8.77	1.659	4.56	0.77
02/28/2018	1189.51	686.51	2.75	8.37	1.594	3.86	0.75
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
11/30/2022	4977.64	5077.51	8.09	61.66	4.99	38.38	5.66
12/30/2022	5.509.16	5558.75	8.45	60.63	5.69	41.70	6.19
01/31/2023	4976.55	4680.33	6.29	52.45	5.67	37.30	5.14
Month/Day/ Year	**CIMSA**	**CMBTN**	**GOLTS**	**KONYA**	**NIBAS**	**OYAKC**	
01/31/2018	1.79	45.44	26.11	253.45	1.01	3.27	
02/28/2018	1.72	40.76	23.97	241.72	0.96	3.29	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	
11/30/2022	12.66	489.50	120.50	3272.50	14.31	21.10	
12/30/2022	13.89	544.60	126.00	3430.00	16.29	21.02	
01/31/2023	11.32	414.10	110.10	2352.90	13.15	21.42	

Table 2
Normalized Proportional Returns

Month/Day/ Year	BIST 100	XTAST	AFYON	AKCNS	BSOKE	BTCIM	BUCIM
01/31/2018							
02/28/2018	-0.00483	-0.02531	-0.011	-0.046	-0.039	-0.154	-0.026
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
11/30/2022	0.25099	0.2029	0.315	0.430	0.306	-0.133	0.199
12/30/2022	0.10678	0.09477	0.045	-0.017	0.140	0.087	0.094
01/31/2023	-0.09667	-0.1580	-0.256	-0.135	-0.004	-0.106	-0.170
01/31/2018							
02/28/2018	-0.040	-0.103	-0.082	-0.082	-0.050	0.005	
⋮	⋮	⋮	⋮	⋮	⋮	⋮	
11/30/2022	0.194	0.131	0.035	0.360	0.154	0.255	
12/30/2022	0.097	0.113	0.046	0.046	0.138	-0.004	
01/31/2023	-0.185	-0.240	-0.126	-0.126	-0.193	0.019	

Table 3
Statistical Results Based on Normalized Proportional Data

	BIST 100	XTAST	AFYON	AKCNS	BSOKE	BTCIM	BUCIM
Expected Value	0.028	0.03323	0.023	0.041	0.033	0.057	0.041
Variance	0.008	0.018084	0.020	0.024	0.026	0.054	0.019
Standard Deviation	0.089	0.104155	0.140	0.154	0.160	0.233	0.138
Coefficient of variation	3.199	3.134	6.053	3.763	4.870	4.117	3.379
Beta	1.00	0.7149	0.4722	0.4170	0.2857	0.1360	0.4258
CAPM-Er	0.0280	0.0263	0.0155	0.0222	0.0157	0.0154	0.0225
Sharpe Ratio	0.2156	0.2345	0.1014	0.2090	0.1512	0.2068	0.2333
Treynor Ratio	0.0192	0.0234	0.0300	0.0772	0.0846	0.35426	0.0756
	CIMSA	**CMBTN**	**GOLTS**	**KONYA**	**NIBAS**	**OYAKC**	
Expected Value	0.039	0.060	0.037	0.057	0.102	0.039	
Variance	0.017	0.057	0.028	0.010	0.169	0.016	
Standard Deviation	0.130	0.238	0.168	0.046	0.411	0.127	
Coefficient of variation	3.300	3.981	4.547	4.547	4.048	3.265	
Beta	0.498292	0.20555	0.375531	0.229799	0.018828	0.337215	
CAPM-Er	0.0238	0.0193	0.0194	0.0199	0.0106	0.0190	
Sharpe Ratio	0.2327	0.2153	0.1682	0.2282	0.225742	0.237589	
Treynor Ratio	0.061574	0.248408	0.075029	0.21035	4.926388	0.089785	

In Table 3, the statistical and performance results for BIST 100, XTAST, and each stock, including expected value, variance, standard deviation, and coefficient of variation, Beta, CAPM-Expected return (CAPM-Er), Sharpe ratio, and Treynor ratio, are calculated. While these results were calculated, the normalized proportional results in Table 2 were used. In terms of variance, OYAKC, CIMSA, BUCIM, and AFYON exhibited better performance than BIST 100 Table 3. Regarding the expected value, most stocks, except for AFYON, exhibited a better performance than BIST 100. When the beta values of all were examined, it is observed they are lower than the one of BIST100. This indicates that each stock does not behave aggressively compared with BIST100. On the other hand, Equation 15 is used to calculate the expected return (E_r) of each asset according to CAMP. Before Equation 15 is used to calculate E_r , TCBM's annual interest rate of 10.5% in December 2023 is considered. This annual risk-free interest rate was divided by 12 to convert it into monthly risk-free interest. The monthly risk-free interest rate was calculated as R_f=0.88%. The market return is measured as R_m=2.785%, as shown in Table 3. Note that R_f and R_m are used in the CAPM analysis, the Sharpe ratios and

Treynor ratios. First, Equation 15 is used to calculate monthly expected return for each stock with respect to CAPM. When Er values are examined in Table 3, they are lower than BIST100. This indicates that the market expects lower returns from these stocks than BIST100. In addition, the Sharpe ratios are examined in Table 3, and OYAKC, CIMSA, and

BUCIM obtained the best results. Regarding the Treynor ratio, NIBAS produced the best and highest value because its Beta was low. Although its beta value, which represents its systematic risk, is close to zero, its standard deviation is the highest. Therefore, its variations or trends are not parallel to BIST100. Henceforth, both standard variation and Beta values should be considered when investigating the Treynor ratio. For instance, KONYA, BUCIM, and CMBTN have reasonable Treynor ratios. But the standard deviation of BUCIM and CMBTN are relatively higher than the standard deviation of KONYA.

Abnormal return values are used in calculating the covariance matrix. Abnormal returns are calculated by subtracting the expected values in Table 3 from the normalized proportional data of each share value in Table 2. A small proportion of these calculated abnormal returns are presented in Table 4. Afterwards, the covariance matrix calculated using Table 4 is given in Table 5. When the covariance matrix is examined, all pairs are positive or too close to zero. This means that there is nearly a correlation between most pairs for those positive values, and the others are almost not correlated. Because there is no negative value in Table 5, there are no negative correlation among pairs. Basically, these companies are in the same country, cement sector, and market; consequently, positive correlation coefficients might be close to each other and greater than zero. These data, in table 5, are prepared for use in Equation 14.

Table 4
Abnormal Returns

Month/Day/ Year	**AFYON**	**AKCNS**	**BSOKE**	**BTCIM**	**BUCIM**	**CIMSA**
01/31/2018						
02/28/2018	-0.034	-0.086	-0.072	-0.210	-0.067	-0.080
⋮	⋮	⋮	⋮	⋮	⋮	⋮
11/30/2022	0.292	0.389	0.273	-0.190	0.158	0.154
12/30/2022	0.022	-0.058	0.107	0.030	0.053	0.058
01/31/2023	-0.279	-0.176	-0.036	-0.162	-0.211	-0.224
Month/Day/ Year	**CMBTN**	**GOLTS**	**KONYA**	**NIBAS**	**OYAKC**	
01/31/2018						
02/28/2018	-0.163	-0.119	-0.119	-0.151	-0.034	
Month/Day/ Year	**CMBTN**	**GOLTS**	**KONYA**	**NIBAS**	**OYAKC**	
⋮	⋮	⋮	⋮	⋮	⋮	
11/30/2022	0.0711	-0.002	0.3029	0.0525	0.217	
12/30/2022	0.053	0.009	0.009	0.037	-0.043	
01/31/2023	-0.299	-0.163	-0.163	-0.294	-0.020	

Simulation Studies

In this study, a portfolio was created by selecting cement companies with the lowest risk. For this purpose, data between 01/31/2018 and 01/31/2023 were adapted to the MPT problem and optimal weights were determined by the AHA algorithm. In order to obtain the results for this study, a computer with Intel (R) Core (TM) i5-9400 CPU @ 2.90 GHz, 64 bits, and 8 GB RAM was used. The study was conducted using MATLAB 2018a. In the simulation studies, first, AHA was run many times, and its results statistically have been evaluated. Second, Wilxocon tests were performed to specify significant differences among the results.

Table 5
Covariance Matrix

	AFYON	AKCNS	BSOKE	BTCIM	BUCIM	CIMSA	CMBTN	GOLTS	KONYA	NIBAS	OYAKC
AFYON	0.020	0.015	0.014	0.014	0.013	0.013	0.022	0.018	0.018	0.012	0.010
AKCNS	0.015	0.024	0.013	0.013	0.011	0.015	0.016	0.016	0.016	0.004	0.010
BSOKE	0.014	0.013	0.026	0.026	0.010	0.012	0.021	0.016	0.016	0.012	0.004
BTCIM	0.014	0.013	0.026	0.054	0.010	0.015	0.026	0.022	0.022	0.002	0.002
BUCIM	0.013	0.011	0.010	0.010	0.019	0.012	0.022	0.015	0.015	0.006	0.007
CIMSA	0.013	0.015	0.012	0.015	0.012	0.017	0.020	0.016	0.016	0.004	0.008
CMBTN	0.022	0.016	0.021	0.026	0.022	0.020	0.057	0.027	0.027	0.019	0.010
GOLTS	0.018	0.016	0.016	0.022	0.015	0.016	0.027	0.028	0.028	0.007	0.011
KONYA	0.018	0.016	0.016	0.022	0.015	0.016	0.027	0.028	0.028	0.007	0.011
NIBAS	0.012	0.004	0.012	0.002	0.006	0.004	0.019	0.007	0.007	0.169	0.004
OYAKC	0.010	0.010	0.004	0.002	0.007	0.008	0.010	0.011	0.011	0.004	0.016

Third, optimal portfolios are determined that is variances and weights of portfolios by using AHA results. Fourth, the performance results of the portfolio, such as CAPM-Er, Sharpe ratio, and Treynor ratio, were calculated to be able to compare. All results were expressed in tables or graphs to ensure clear and intelligibility.

In the experiments, AHA was separately run 30 times for different swarm sizes and numbers of iterations. The minimum, maximum, average, and standard deviation results of each run were calculated. The results are presented in tables and graphs. The optimal portfolio weights in the MPT problem were determined by independently running the AHA swarm numbers 30, 50, and 100 and the iterations 100 and 500 independently times. The findings of 30 independent experiments are presented in Table 6. In addition, the maximum, minimum, and expected values of the results obtained when run 30 times are plotted in Figure 2. The minimum values are given in the graphics titles. Numerical results can be better examined in Table 6 because the numerical values cannot be seen and printed in these graphics. When the minimum values of the objective function given in Table 6 were examined, the minimum value of the objective function decreased as the swarm size and number of iterations increased. When their maximum values are checked, it is seen that the maximum value decreased as the swarm size

Table 6
Statistical Evaluation of The Results Obtained By The Optimization

Number of iterations (N_{max})	**100**	**100**	**100**
Swarm size ($_n$)	30	50	100
Minimum	0.103241317	0.1030515	0.1029558
Maximum	0.1043611	0.1040476	0.1036067
Expected Value	0.1036291	0.1033945	0.1032650
Standard deviation	3.3872e-04	2.2329e-04	1.6692e-04
Number of iterations	500	500	500
Swarm size	30	50	100
Minimum	0.1028794	0.102879426	0.10287942
Maximum	0.1028822	0.102879513	0.10287946
Expected Value	0.1028796	0.102879444	0.10287942
Standard deviation	5.1684e-07	2.1794e-08	7.0664e-09

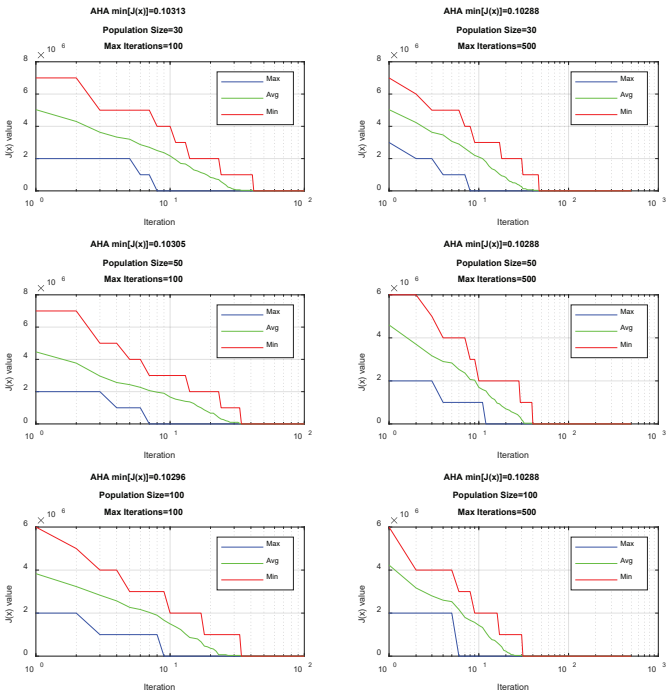

Figure 2. The convergence results of the AHA

and number of iterations increased. Similarly, when the expected values and standard deviation of the AHA results are examined, the expected values and standard deviation decrease as the number of iterations and swarm sizes increase. This means that the AHA has found close results around the global minimum; thus, the results are close to each other when the expected values and standard deviation decrease. Wilxocon tests were performed to determine whether the AHA algorithm produced significant differences in the results. The significance values of the test results are given in Table 7. When the results were examined, it was observed that

there was a significant difference between them since the values written in bold were less than 0.05. However, it was observed there is no significant difference in the results when the swarm sizes and number of iterations increased. This is because the AHA produced results that were close to the global optimum. In other words, there were significant differences between the results obtained by the AHA algorithm when the number of iterations and the swarm size increased.

Table 7
Wilxocon Test Results

	N_{max} = 100 n = 30	N_{max} = 100 n = 50	N_{max} = 100 n = 100	N_{max} = 30 n = 500	N_{max} = 50 n = 500	N_{max} = 100 n = 500
N_{max} = 100 n = 30	1.0000	**2.2531e-02**	**2.4626e-03**	**1.5805e-06**	**3.3918e-06**	**3.3918e-06**
N_{max} = 100 n = 50	**2.2531e-02**	1.0000	**3.6150e-01**	**1.5805e-06**	**3.3918e-06**	**3.3918e-06**
N_{max} = 100 n = 100	**2.4626e-03**	**3.6150e-01**	1.0000	**1.5805e-06**	**3.3918e-06**	**3.3918e-06**
N_{max} = 30 n = 500	**1.5805e-06**	**1.5805e-06**	**1.5805e-06**	1.0000	**3.4415e-04**	**9.8596e-05**
N_{max} = 30 n = 500	**3.3918e-06**	**3.3918e-06**	**3.3918e-06**	**3.4415e-04**	1.0000	7.0892E-01
N_{max} = 100 n = 500	**3.3918e-06**	**3.3918e-06**	**3.3918e-06**	**9.8596e-05**	7.0892E-01	1.0000

The optimal weights according to the minimum values obtained as a result of the analysis are given in Table 7. Eight different portfolios were constructed, including the BIST 100 and XTAST portfolios.

Total normalized proportional returns, variances, standard deviations, risk coefficients, Beta, CAMP-Er, Sharpe ratio, and Treynor ratio for each portfolio are given in Table 9. Moreover, these results were tried to be depicted in Figure 3-6. When total normalized proportional returns of portfolios are examined in Table 9, optimized portfolios that are Portfolio 1- Portfolio 6 produced close and reasonable results. If variances are investigated among the optimized portfolios, Portfolio 5 and Portfolio 6 produced minimum values. When the risk of the portfolios is observed among the optimized portfolios in Table 9, Portfolio 6 produced the minimum risk value. Standard deviations and returns are depicted are depicted in Figures 3 and 4a for each stock and portfolio. Furthermore, Figure 4b

Table 8
Percentage Weights of Portfolio Shares

	Portfolio 1	**Portfolio 2**	**Portfolio 3**	**Portfolio 4**
Number of iterations	100	100	100	500
Swarm size	30	50	100	30
Objective Values-Variances	0.01063615	0.010619613	0.010599914	0.010584182
AFYON	0.13	0.07	0.03	0.00

	Portfolio 1	**Portfolio 2**	**Portfolio 3**	**Portfolio 4**
AKCNS	0.24	0.32	0.07	0.00
BSOKE	12.71	14.66	14.63	14.78
BTCIM	3.41	2.59	4.54	3.90
BUCIM	21.68	23.24	23.36	22.49
CIMSA	12.20	9.53	8.57	9.70
CMBTN	0.06	0.06	0.03	0.00
GOLTS	0.08	0.19	0.08	0.00
KONYA	0.42	0.09	0.07	0.00
NIBAS	3.47	3.20	3.11	3.18
OYAKC	45.60	46.05	45.51	45.94
BIST 100	0	0	0	0
XTAST	0	0	0	0
	Portfolio 5	**Portfolio 6**	**Portfolio 7-BIST 100**	**Portfolio 8-XTAST**
Number of iterations	500	500	--	--
Swarm size	50	100	--	--
Objective Values-Variances	0.010584176	0.010584176	0.00792938	0.01084827
AFYON	0.00	0.00	0	0
AKCNS	0.00	0.00	0	0
BSOKE	14.80	14.80	0	0
BTCIM	3.91	3.91	0	0
BUCIM	22.52	22.53	0	0
CIMSA	9.64	9.63	0	0
CMBTN	0.00	0.00	0	0
GOLTS	0.00	0.00	0	0
KONYA	0.00	0.00	0	0
NIBAS	3.17	3.17	0	0
OYAKC	45.95	45.95	0	0
BIST 100	0	0	100	0
XTAST	0	0	0	100

depicts the standard deviations and returns of only the optimized portfolios. In Figure 3, most of the stock has higher standard deviations, implying high risk. In addition, an efficient frontier line is drawn in Figures 4a and 4b in dashed blue to obtain the optimal portfolio. Subsequently, Capital Allocation Line (CAL) is drawn in dashed magenta in Figures 4a and 4b. The CAL curve is a straight line that connects the risk-free rate of return (R_f=0.88%) to the point at which the efficient frontier intersects the y-axis (maximum return). It is assumed that this intersected point reveals the optimal portfolio shown in Figures 4a and 4b because the slope of CAL is the highest, which means that an investor can achieve the highest return per additional unit of risk. Moreover, the total normalized proportional of each portfolio to be obtained by an investor who made an investment of 1000 TL in 1.31.2018 in return for the cash to be obtained on 1.31.2023 is given in Table 9. Under this condition, Porfolio 1 returns 5414.373907 TL, but its risk is slightly higher than those of other optimized portfolios. In order to calculate the systematic risk of the portfolios, Equation 17 is used to calculate the beta values given in Table 9. These values are employed to Equation 15 to obtain the expected

market return (CAPM-Er). As shown in Table 9, CAPM-Er values of the portfolios are less than the total normalized proportional returns of the portfolio. In Figure 5a, the total normalized proportional returns and Beta values are plotted. The optimized portfolios produced higher returns than Portfolios 7-BIST 100 and 8-XTAST. Figure 5b plots the CAPM-Er and beta values. The optimized portfolios produced lower returns than Portfolios 7-BIST 100 and 8-XTAST. This implies that the market undervalued the same optimized portfolio. The reason is systematic risks or the beta of portfolios is lower level than market. That difference has caused their expected return values to decrease. To illustrate the percentage of return of optimized portfolios with respect to CAPM is calculated as to total normalized proportional returns. The results are shown in Figure 6. Consequently, CAPM results for optimized portfolios are negative compared to total normalized proportional returns. On the other hand, performances of the portfolios with respect to Sharpe ratio and Treynor ratio are measured. The results are given in Table 9 and depicted in Figure 7. When the optimized portfolios are examined in terms of Sharpe and Treynor ratios, the results are observed to be very close. However, in terms of Sharpe ratio, the result for Portfolio 1 is 0.316773, which is better than the other portfolios. That means Portfolio 1, unit return per risk is highest for portfolio 1. Regarding the Treynor ratio, the result for Portfolio 6 is 0.094180534, which is better than the other portfolios. That means Portfolio 6, unit return to systematic risk is highest for portfolio 6.

Table 9
Portfolio Results

	Portfolio 1	**Portfolio 2**	**Portfolio 3**	**Portfolio 4**
Total normalized proportional returns of Portfolio	0.0414697	0.041073894	0.041359475	0.041271351
Portfolio Variance	0.01063615	0.010619613	0.010599914	0.010584182
Risk of Portfolio	0.103131744	0.103051507	0.102955888	0.102879456
Coefficient of variation	2.486918	2.50893	2.489294	2.492757
Portfolio Return (TL)	5414.373907	5337.935954	5371.872573	5362.172354
Beta of Portfolio	0.3515066	0.350473671	0.3451784	0.3471826
CAPM-Er	0.020283615	0.02011115010	0.02003882748	0.02007348806
Sharpe Ratio	0.316773	0.313182164	0.316246872	0.31562522
Treynor Ratio	0.09294	0.0920865	0.09424	0.093528
	Portfolio 5	**Portfolio 6**	**Portfolio 7 BIST 100**	**Portfolio 8 XTAST**
Total normalized proportional returns of Portfolio	0.041265095	0.041265188	0.02783477	0.0332309
Portfolio Variance	0.010584176	0.010584176	0.00792938	0.01084827
Risk of Portfolio	0.102879426	0.102879424	0.08904706	0.10415503
Coefficient of variation	2.493134	2.493129	3.19913038	3.1342825
Portfolio Return (TL)	5361.143112	5361.120165	3163.46660	4249.8906
Beta of Portfolio	0.3471302	0.347122944	1.00	0.714986953
CAPM-Er	0.020069614	0.020069411	0.027834770	0.026267774
Sharpe Ratio	0.315564503	0.315565413	0.213760791	0.234562843
Treynor Ratio	0.093524259	0.094180534	0.01903477	0.034169714

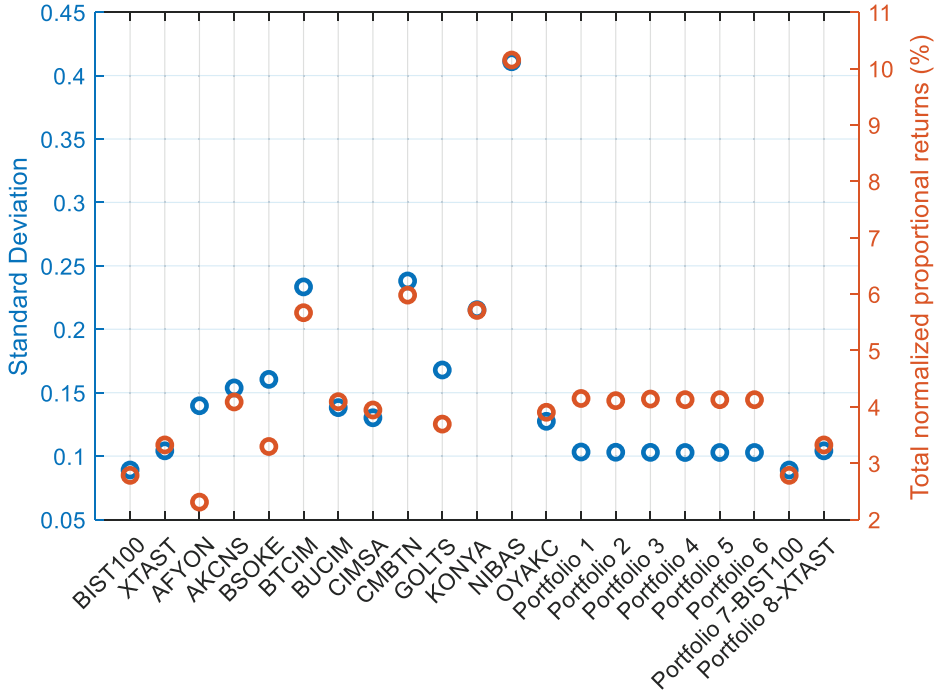

Figure 3. Standard deviations and total normalized proportional returns

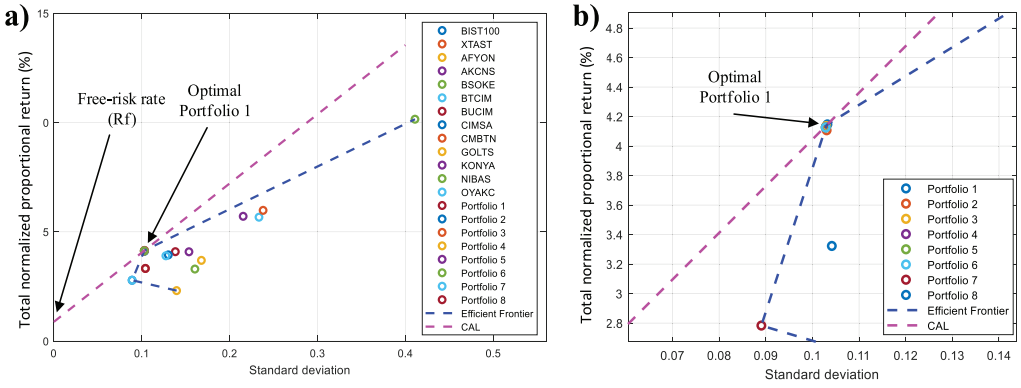

Figure 4. Efficient Frontier Line and CAL-optimal Portfolios

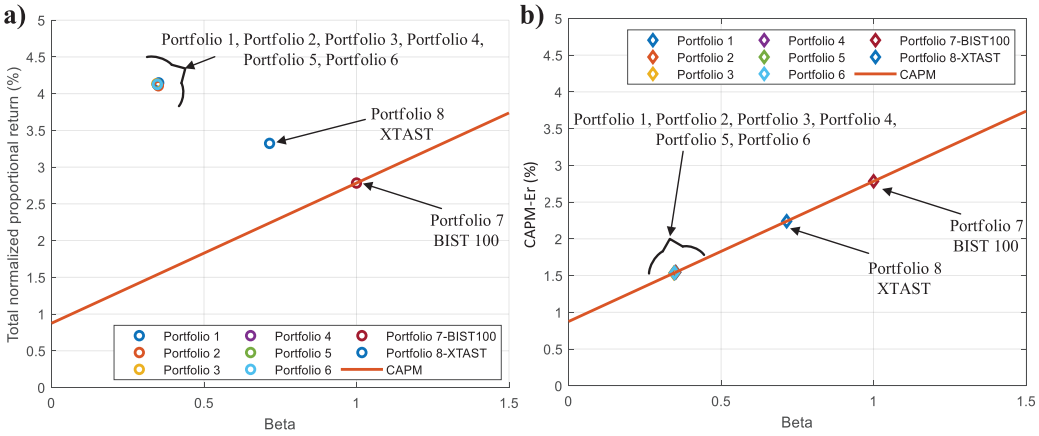

Figure 5. a) Total normalized proportional return versus beta. ***b)*** CAPM expected return versus beta

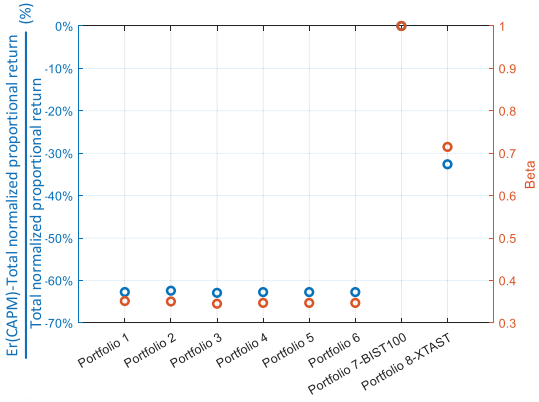

Figure 6. Percentage of return results relative to CAPM

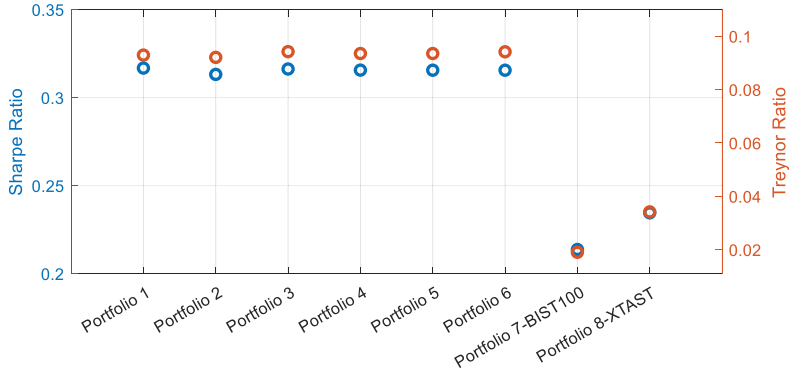

Figure 7. Sharpe and Treynor ratios of portfolios

The performance values such as Total normalized proportional return, CAPM, Sharpe ratio, and Traynor ratio, for the optimal portfolios obtained according to the minimum variance criterion for MDP with the AHA algorithm is calculated and are given in Table 9. In addition, Table 10 provides a brief demonstration of the best portfolio for the performance method. As shown in Table 10, Portfolio 1 produced the best result for the total normalized proportional return criterion. Moreover, Portfolio 1 has shown the best performance according to the CAPM, Sharpe ratio, and Traynor ratio criteria in Table 10. Apart from that, in Figure 4, Portfolio 1 also exhibited the optimal portfolio on the CAL and efficient frontier line. On the other hand, in Table 10, the best result for the minimum variance criterion was obtained by Portfolio 6. This portfolio exhibits the lowest variance, and the lowest risk compared to other portfolios. According to the CAPM analysis, the portfolio expected to produce the best return is Portfolio 7-BIST 100. The reason for this is that, as mentioned earlier, expected returns are low due to the low beta coefficients of the other portfolios.

Table 10
Comparison pf Returns And Risks For Optimal Portfolios

Performance Method	***Optimal Portfolio***	***Return***	***Variance***	***CAPM***	***Sharpe***	***Traynor***
Total normalized proportional return	*Portfolio 1*	*0.0414697*	*0.01063615*	*0.020283615*	*0.316773*	*0.09294*
Min Variance MDP	*Portfolio 6*	*0.041265188*	*0.010584176*	*0.020069411*	*0.315565413*	*0.094180534*
CAPM	Portfolio 7-BIST 100	*0.02783477*	*0.00792938*	*0.027834770*	*0.213760791*	*0.01903477*
Sharpe Ratio	*Portfolio 1*	*0.0414697*	*0.01063615*	*0.020283615*	*0.316773*	*0.09294*
Traynor Ratio	*Portfolio 1*	*0.0414697*	*0.01063615*	*0.020283615*	*0.316773*	*0.09294*
	Portfolio 3	*0.041359475*	*0.010599914*	*0.02003882748*	*0.316246872*	*0.09424*

Conclusion

This study aims to create an optimal portfolio with minimum risk in the cement sector following the Kahramanmaraş Earthquake in Turkey. The originality of this study lies in the application of the AHA within the MPT, using 11 cement sector stocks for the past 5 years. The AHA was run independently 30 times with varying iteration numbers and swarm sizes to test its performance, and the results were statistically evaluated based on minimum, maximum, average, and standard deviation values. Additionally, the Wilcoxon test was used to assess the significance of differences in results.

Several portfolios were created according to each iteration number and AHA swarm size. The performance of these portfolios was then evaluated using total normalized returns, CAPM analysis, Sharpe Ratio, and Treynor Ratio. The results indicate that, due to systematic risk, the expected return of the CAPM underestimated the optimized portfolios, except for

Portfolio 7-BIST 100, which was not optimized in this study. Notably, Portfolio 1 demonstrated the best performance in terms of total normalized returns, Sharpe Ratio, and Treynor Ratio, and was identified as the intersection point of the efficient frontier line and the Capital Market Line (CAL). However, Portfolio 6 exhibited the best performance in terms of the minimum risk criteria among the optimized portfolios using AHA.

Optimization algorithms provide speed, flexibility, and convenience to investors for determining a portfolio's performance. Thus, future studies will explore portfolio optimization using recently developed algorithms like AHA to further enhance optimization performance for other industrial sectors. In addition to minimizing risk, these studies consider other performance criteria, such as Sharpe Ratio, Treynor Ratio, Fama criteria, M^2, and T^2, to a broader range of investor preferences.

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RESEARCH ARTICLE

The Effects of Death Anxiety, Health Anxiety and Environmental Anxiety on the Intention to Purchase Eco-Friendly Product and Consumption Behavior*

İlknur Korkmaz[1], Nil Esra Dal[2]

Abstract

This study examines the effects of death anxiety, health anxiety and environmental anxiety on the intention to purchase eco-friendly products and consumption behavior. This study also aimed to determine the mediating role of health anxiety, environmental anxiety, and intention to purchase eco-friendly products. People who buy eco-friendly products were identified via an online survey, and the data of 465 participants were analyzed with Partial Least Square Structural Equation Modeling technique. A significant effect of the exposure factor of death anxiety on health anxiety was determined. The suffering factor of death anxiety influenced environmental anxiety. Environmental anxiety, on the other hand, affects the intention to purchase an eco-friendly product. The intention to purchase an eco-friendly product also impacted eco-friendly consumption behavior. Environmental anxiety plays a mediating role between death anxiety and the intention to purchase eco-friendly products. The intention to purchase eco-friendly products also mediates the relationship between environmental anxiety and eco-friendly consumption behavior. Death anxiety forms the basis of health anxiety, environmental anxiety, intention to purchase eco-friendly products, and consumption behavior.

Keywords: Death Anxiety, Health Anxiety, Environmental Anxiety, Intention to Purchase Eco-Friendly Product, Eco-Friendly Consumption Behavior

Introduction

Environmental problems such as the increase in air, water, and noise pollution, thinning ozone layer, and climate change have led to many health problems. This situation will cause health conscious people to deal with the negative consequences of the environment on the individual and society and will lead to eco-friendly behavior (Ture & Ganesh, 2012: 42). Therefore, most consumers pay attention to the health and environmental effects of a product (Amin, Manzoor, & Farid, 2020: 113).

* This study is derived from İlknur Korkmaz's doctoral thesis titled "The effects of death anxiety, health anxiety and environmental anxiety on intention to purchase eco-friendly products and consumption behavior".

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Death anxiety is the main motivation for human behavior and a fear that is the basis of many anxieties (Cicirelli, 2002: 358, as cited in Becker, 1973; Furer & Walker, 2008: 167). However, it is stated in the literature that death anxiety decreases with a good life, perceiving the world as safe and controllable (Bassett, 2007: 729). Health anxiety is the belief or excessive fear of developing a serious illness, which is often caused by the misinterpretation of physical symptoms or sensations (American Psychiatric Association, 2000; Barsky & Ahern, 2004 as cited in Alberts et al., 2013: 69). Health anxiety is the fear of developing a serious illness (Baumgartner & Hartmann, 2011: 1). In addition, health anxiety can motivate people to avoid certain harmful elements (Taylor, 2004: 113). Environmental anxiety involves worry, sadness, and fear about environmental problems, pity, and empathy for living things and objects affected by environmental problems, and an attitude toward behaviors that cause environmental problems (Takács-Sánta, 2007: 27). Environmental anxiety is also human-centered, and the environment is considered important because environmental degradation poses a threat to human health (Fransson & Gärling, 1999: 370). Considering that eco-friendly products do not pollute the environment (Shamdasani, Chon-Lin, & Richmond, 1993 as cited in Paul, Modi, & Patel, 2016: 123) and are suitable for human health (Elkington, Hailes, & Makower, 1990: 6, as cited in Moisander, 2007: 405), it is thought that eco-friendly products may be associated with death, health, and environmental anxieties. When the literature is examined, there are limited studies on purchasing eco-friendly products and death anxiety (Rahimah, Khalil, Cheng, Tran, & Panwar, 2018; Dönmez, 2020; Ülker, 2021) and health anxiety (Ecevit, Baş, & Öztek, 2022). However, no study has examined only the role of anxiety in the intention to purchase eco-friendly products and consumption behavior. In this respect, the study is considered original and is expected to contribute to the literature. Since the current study has a multidisciplinary approach in terms of the variables it deals with, it is thought that the study will contribute to other fields, including marketing.

Conceptual Framework and Hypothesis Development

Freud (1924) defined anxiety as an unpleasant emotional state and emotional response that includes fear, tension, worry, and physiological arousal. According to Becker (1973, as cited in Cicirelli, 2002: 358), death anxiety is the main motivation for behavior. People are instinctively programed to survive and are aware of death.

Eco-friendly products are products that do not pollute the environment, do not harm natural resources, can be recycled or protected (Shamdasani et al., 1993, as cited in Paul, et al., 2016: 123), are suitable for human or animal health, and do not harm the environment during production, use, or disposal (Elkington et al., 1990: 6, as cited in Moisander, 2007: 405). Ghorbanalipoor, Borjali, Sohrabi, & Falsafinejad (2010) stated that people with high death anxiety have more frequent health-promoting behaviors. Erciş, Kotan, & Türk (2016: 128)

revealed that consumers with death anxiety prefer healthy products by paying attention to the label information of the products in order to try to protect their physical health. Rahimah et al. (2018) found that death anxiety of consumers affects green purchasing intention and pro-environmental behavior. Dönmez (2020: 240) stated that death anxiety has a positive effect on purchasing environment-conscious brands. Ülker (2021) determined that the "organic consumer identity" dimension, one of the dimensions of the "organic brand attitudes" variable, is associated with death anxiety. In this regard, the first and second hypotheses of this study are as follows:

H1: Death anxiety has a statistically significant effect on the intention to purchase an eco-friendly product.

H1a: The uncertainty of death factor has a statistically significant effect on the intention to purchase an eco-friendly product.

H1b: The exposure factor has a statistically significant effect on the intention to purchase an eco-friendly product.

H1c: The suffering factor has a statistically significant effect on the intention to purchase an eco-friendly product.

H2: Death anxiety has a statistically significant effect on eco-friendly consumption behavior.

H2a: The uncertainty of death factor has a statistically significant effect on eco-friendly consumption behavior.

H2b: The exposure factor has a statistically significant effect on eco-friendly consumption behavior.

H2c: The suffering factor has a statistically significant effect on eco-friendly consumption behavior.

Becker (1973, as cited in Furer & Walker, 2008: 167) stated that death anxiety is a fundamental fear underlying many anxieties and phobias. Zilboorg (1943) stated that death anxiety is at the root of everything (as cited in Karakuş, Öztürk, & Tamam, 2012: 53). Death anxiety is a central feature of health anxiety and plays an important role in other concerns (Furer & Walker, 2008: 167). Rahimah et al. (2018) found that death anxiety affects environmental anxiety. In this regard, the third and fourth hypotheses of this study are as follows:

H3: Death anxiety has a statistically significant effect on health anxiety.

H3a: The uncertainty of death factor has a statistically significant effect on the body factor of health anxiety.

H3b: The uncertainty of death factor has a statistically significant effect on the additional factor of health anxiety.

H3c: The exposure factor has a statistically significant effect on the body factor of health anxiety.

H3d: The exposure factor has a statistically significant effect on the additional factor of health anxiety.

H3e: The suffering factor has a statistically significant effect on the body factor of health anxiety.

H3f: The suffering factor has a statistically significant effect on the additional factor of health anxiety.

H4: Death anxiety has a statistically significant effect on environmental anxiety.

H4a: The uncertainty of death factor has a statistically significant effect on environmental anxiety.

H4b: The exposure factor has a statistically significant effect on environmental anxiety.

H4c: The suffering factor has a statistically significant effect on environmental anxiety.

Experiencing mild health anxiety motivates individuals to seek appropriate health care and avoid substances harmful to health (Taylor, 2004: 113). Therefore, vigilance against threats to health is protective and promotes health-promoting behaviors (Baumgartner & Hartmann, 2011: 1). Consumers with a high level of eco-friendly product purchasing behavior see eco-friendly products as good for their health and helping to protect natural resources (Chan, 1999). Cervellon & Wernerfelt (2012: 177) stated that factors contributing to social welfare and health, such as reducing pollution, not using fur/leather, and equal approaches to employees, are the motivations for purchasing sustainable clothing in the eco-fashion sector. Ecevit et al. (2022) found that those who buy organic products have health concerns. In this regard, the fifth and sixth hypotheses of this study are as follows:

H5: Health anxiety has a statistically significant effect on the intention to purchase an eco-friendly product.

H5a: The body factor of health anxiety has a statistically significant effect on the intention to purchase an eco-friendly product.

H5b: The additional factor of health anxiety has a statistically significant effect on the intention to purchase an eco-friendly product.

H6: Health anxiety has a statistically significant effect on eco-friendly consumption behavior.

H6a: The body factor of health anxiety has a statistically significant effect on eco-friendly consumption behavior.

H6b: The additional factor of health anxiety has a statistically significant effect on eco-friendly consumption behavior.

Environmental anxiety is an attitude that directly determines intentions (Fransson & Gärling, 1999: 370). Therefore, environmental anxiety is often a direct antecedent of the intention to purchase an eco-friendly product (Newton, Tsarenko, Ferraro, & Sands, 2015). Rusyani, Lavuri, & Gunardi (2021) found that the strongest determinant of eco-friendly consumption behavior is environmental anxiety. Environmental anxiety is an important variable in the field of green marketing (Paul et al., 2016: 123). Consumers with environmental anxieties adopt a positive attitude toward organic products as eco-friendly and exhibit purchasing behavior (Cachero-Martínez, 2020: 4). For this purpose, Ahmed et al. (2021) stated that environmental anxiety positively affects the intention to purchase organic food products. Ay & Ecevit (2005: 259-260) found a significant relationship between environmental anxiety and environment-conscious consumer behavior. Studies have indicated that environmental anxiety has an impact on the intention to purchase an eco-friendly product or service (Doğan, Güngör, & Ömüriş, 2022; Hartmann & Apaolaza-Ibáñez, 2012; Hedlund, 2011; Kocagöz & İğde, 2022; Koenig-Lewis, Palmer, Dermody, & Urbye, 2014; Lee, 2008). In addition, studies have determined that environmental anxiety has an effect on eco-friendly consumption behavior (Lee, 2009; Yapraklı & Mutlu, 2021; Bulut, Nazli, Aydin, & Haque, 2021). Therefore, the seventh and eighth hypotheses of the study were formed as follows:

H7: Environmental anxiety has a statistically significant effect on the intention to purchase an eco-friendly product.

H8: Environmental anxiety has a statistically significant effect on eco-friendly consumption behavior.

Terror Management Theory, which states that the instinct of self-preservation is the basis of every motive (Solomon, Greenberg, & Pyszczynski, 1991), argues that people shape their behavior according to this instinct. In addition, Mikulincer, Florian, & Hirschberger (2003) mention that cultural worldview and self-esteem are two psychological defenses that reduce death anxiety. Therefore, people try to increase their self-esteem and reduce their death anxiety by paying attention to what they eat and drink (Erciş et al., 2016). Because the way to survive is to be physically healthy. This condition sometimes causes health anxiety in many people (Looper & Kirmayer, 2001, as cited in Abramowitz, Olatunji, & Deacon, 2007:

86). Death anxiety plays an important role in other forms of anxiety and is at the center of health anxiety (Furer & Walker, 2008: 167). At the same time, death anxiety is a basic fear underlying many anxieties (Becker, 1973, as cited in Furer & Walker, 2008: 167). For this reason, people with death anxiety prefer healthy products by placing importance on product label information to protect their health (Erciş et al., 2016). Since eco-friendly products and services do not pose a danger to human health (Elkington et al., 1990: 6, as cited in Moisander, 2007: 405), it is thought that people's death and health anxieties may effect the intention and consumption of these products. Based on the literature, people prefer healthy products to protect their physical health (Erciş et al., 2016) because the way to survive is through physical well-being (Looper & Kirmayer, 2001, as cited in Abramowitz, et al., 2007: 86). Since eco-friendly products do not harm health (Elkington et al., 1990: 6, as cited in Moisander, 2007: 405), health anxiety may have a mediating role between death anxiety and the intention to purchase eco-friendly products. In this regard, the ninth hypothesis of this study is as follows:

H9: Health anxiety has a mediating role in the effect of death anxiety on the intention to purchase eco-friendly product.

H9a: The effect of the uncertainty of death factor on the intention to purchase an eco-friendly product is mediated by the body factor of health anxiety.

H9b: The effect of the uncertainty of death factor on the intention to purchase an eco-friendly product is mediated by the additional factor of health anxiety.

H9c: The effect of the exposure factor on the intention to purchase an eco-friendly product is mediated by the body factor of health anxiety.

H9d: The effect of the exposure factor on the intention to purchase an eco-friendly product is mediated by the additional factor of health anxiety.

H9e: The effect of the suffering factor on the intention to purchase an eco-friendly product is mediated by the body factor of health anxiety.

H9f: The effect of the suffering factor on the intention to purchase an eco-friendly product is mediated by the additional factor of health anxiety.

Death anxiety is at the root of many anxieties (Becker, 1973, as cited in Furer & Walker, 2008: 167), and death anxiety may also be the basis of environmental anxiety. As a matter of fact, a study in the literature (Rahimah et al., 2018) has determined that death anxiety affects environmental anxiety. It is thought that death anxiety will affect environmental anxiety, and environmental anxiety will affect the intention to purchase an eco-friendly product. Environmental anxiety is suggested to play a mediating role in this impact process.

An important indirect determinant of certain environmental behaviors is environmental anxiety (Bamberg, 2003: 23). Leblebici Koçer & Delice (2016: 112) revealed that environ-

mental anxiety plays a mediating role in the relationship between green advertising attitude and environmental sensitivity. Rahimah et al. (2018) found that environmental anxiety plays a mediating role between death anxiety and the intention to purchase an eco-friendly product. Ahmed et al. (2021) stated that environmental anxiety has a mediating effect between attitude and intention to purchase organic food. Thus, the tenth hypothesis of this study is as follows:

H10: Environmental anxiety has a mediating role in the effect of death anxiety on the intention to purchase an eco-friendly product.

H10a: Environmental anxiety has a mediating effect on the effect of the uncertainty of death factor on the intention to purchase an eco-friendly product.

H10b: Environmental anxiety has a mediating effect on the effect of the exposure of death factor on the intention to purchase an eco-friendly product.

H10c: Environmental anxiety has a mediating effect on the effect of the suffering of death factor on the intention to purchase an eco-friendly product.

Intention is the motivation factor that affects a behavior and the desire to perform it (Ajzen, 1991: 181). In this respect, intention leads to the occurrence of behavior (Ali, Khan, Ahmed, & Shahzad, 2011: 218). Intention is widely used to predict eco-friendly behavior (Mahardika, Thomas, Ewing, & Japutra, 2020: 1). Therefore, the eleventh hypothesis of this study is as follows:

H11: The intention to purchase eco-friendly products has a statistically significant effect on eco-friendly consumption behavior.

As consumers become more anxious about the environment day by day, their intention to buy eco-friendly products has increased (do Paço, Raposo, & Filho, 2009: 17). Eco-friendly consumption behavior is a voluntary behavior that reflects a conscious effort to solve some environmental problems, such as global warming, environmental degradation, and climate change. Thus, consumers voluntarily try to minimize the negative effects on the environment by purchasing organic and eco-friendly products (Mainieri, Barnett, Valdero, Unipan, & Oskamp, 1997, as cited in Wang, Wang, & Gao, 2020: 1). Ali et al. (2011: 218) stated that consumers who see environmental pollution as a problem are more likely to buy eco-friendly products. In this respect, the authors explained that when consumers pay attention to environmental problems, their attitudes and their intention to buy eco-friendly products also change. Based on the literature, it is believed that environmental anxiety may affect the intention to purchase an eco-friendly product, and the intention may affect eco-friendly consumption behavior. It is argued that the intention to purchase eco-friendly products mediates this effect. Because intention is widely used to predict eco-friendly consumption behavior (Mahardika, et al., 2020: 1). Therefore, the twelfth hypothesis of this study is as follows:

H12: The effect of environmental anxiety on eco-friendly consumption behavior is mediated by the intention to purchase an eco-friendly product.

Method

The aim of this research is to examine the effects of death anxiety, health anxiety and environmental anxiety on the intention to purchase eco-friendly products and consumption behavior. In addition, determining the mediating role of health anxiety, environmental anxiety, and the intention to purchase an eco-friendly product constitutes the other purpose of the research.

Descriptive and relational analysis methods were adopted in the research design of this study. Descriptive research describes the characteristics of a population, such as age, education, and occupation (Gegez, 2019: 33-37).

Research Model and Variables

The model used in this study is shown in Figure 1. In the research model, the factors of each scale are also included.

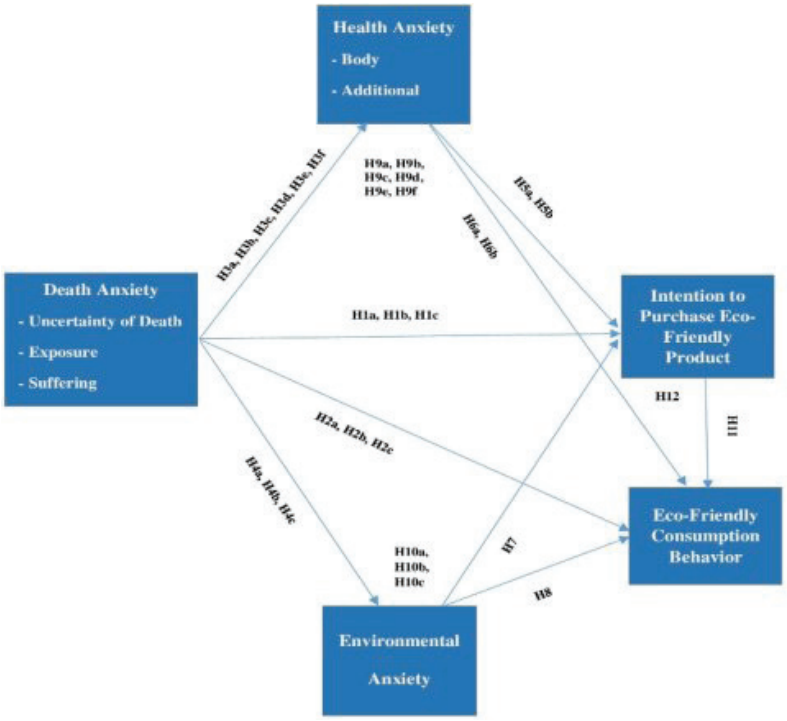

Figure 1. Model of the Study

Population of the Research and Sampling Method

The population of the research is people living in Türkiye and purchasing eco-friendly products. To reach people who buy eco-friendly products, a question such as "Have you purchased an eco-friendly product before?" was added to the survey form. People who answered "no" were excluded from the sample. To reach people who easily and quickly buy eco-friendly products, the convenience sampling method was applied due to cost and time constraints. Convenience sampling is the method of obtaining data from the most easily accessible participants until the targeted sample size is achieved (Gürbüz & Şahin, 2016: 132-134).

There is no information on the number and geographical distribution of people who buy eco-friendly product in Türkiye. However, in the case of a population size of 1,000,000, a sample size to be 384 people (Sekaran & Bougie, 2016: 264). In this regard, a sample size of 384 was considered sufficient for the current study.

Data Collection Method and Tool

A quantitative method was adopted in the research, and the browsing method was used for data collection. A survey is a method of applying a prepared and structured survey to sampling to obtain information from people on a particular subject (Malhotra, 2023: 167).

The scales used in this study are listed in Table 1. Both the original and Turkish translations of the scales were checked by two academicians who have English proficiency and are experts in the field of marketing, and necessary translation corrections were made. There are 66 questions in all.

Table 1
Scales Used in the Research

SCALE NAME	SPECIALITY	DEVELOPER	TRANSLATE TO TURKISH
Death Anxiety	5-point Likert scale, 20 items and 3 factors: The Uncertainty of Death, Exposure, and Suffering Reliability: 0.83	Sarıkaya & Baloğlu, 2016	
Health Anxiety	4-point sequential response, 18 items and 2 factors: Body and Additional Reliability (in Turkish Translation): 0.91	Salkovskis, et al., 2002	Aydemir, et al., 2013
Environmental Anxiety	5-point Likert scale, 12 items, and single factor Reliability (in Turkish Translation): 0.78	Straughan & Roberts, 1999	Ay & Ecevit, 2005
Intention to Purchase Eco-Friendly Product	5-point Likert, 4 items and Single factor Reliability (in Turkish Translation): 0.81	Song et al., 2012	Erciş & Türk, 2019
Eco-Friendly Consumption Behavior	5-point Likert, 4 items and Single factor Reliability (in Turkish Translation): 0.82	Lee, 2008	Uyar, 2019

Health Anxiety 4-point Likert (0=Never, 1=Sometimes, 2=Mostly, 3=Always),
Death Anxiety, Environmental Anxiety, Intention to Purchase an Eco-Friendly Product, and Eco-Friendly Consumption Behavior scales are 5-point Likert scales (1=Strongly Disagree, 2=Disagree, 3=Neither Agree or Disagree, 4=Agree, 5=Strongly Agree)

Ethics Committee Approval

In this study, ethics committee approval was obtained from the decision of Burdur Mehmet Akif Ersoy University, meeting dated 01.12.2021, meeting number 2021/12, numbered GO 2021/417.

Analysis of Data and Findings

In this research, the Statistical Package for the Social Sciences (SPSS) 20 was used for descriptive statistics and pre-test reliability analysis; SmartPLS 4.0.9.2 program was used for validity and reliability analysis, structural equation modeling, and hypothesis testing.

Two pretest studies were conducted to test the intelligibility of the scale items and questions in the survey form. The pre-test is the application of the survey to a small sample to improve the survey by eliminating possible problems (Malhotra, 2023: 312). For the first pretest, 89 people were reached online, and 73 people who had previously purchased eco-friendly products were included in the sample. Data collected from the 73 participants were analyzed. Because of the pretest, corrections were made to make the items and questions in the survey form more understandable. The survey form was revised based on the results obtained from the first pretest. Then, with the second pretest, the new survey form was applied face-to-face to 150 participants. After determining the reliability of the scales in the survey form, an online survey was conducted with 484 respondents. The reliability results of the scales because of the pretest were also examined. Reliability analysis defines the degree to which the research scale consistently measures the conceptual structure. In the reliability analysis, the reliability coefficient was measured using Cronbach's alpha (Gürbüz & Şahin, 2016: 309-325). Saruhan & Özdemirci (2016: 196) stated that a Cronbach's alpha value less than 0.60 indicates low reliability and greater than 0.80 indicates good reliability. The Cronbach's alpha value of the death anxiety scale was 0.95, the health anxiety scale was 0.93, the environmental anxiety scale was 0.81, the intention to purchase eco-friendly product scale to be 0.87, and the eco-friendly consumption behavior scale to be 0.90. Since the reliability results were high and the comprehensibility of the survey form was determined, the survey form was applied online between December 2021 and June 2022.

Descriptive Statistics

Within the scope of the research, 484 people were reached. 19 survey forms were excluded from the scope of the study because they were filled out incompletely and incorrectly. Analyses were performed on the remaining 465 survey forms. When the demographic findings are examined; 52% of the participants are women, 34% are between the ages of 35-44, 44.1% are high school graduates, 30.1% are private sector employees, 37.2% have an income of 3000-5000 TL and 84.1% do not have a chronic disease. 21.9% of the participants always, 35.3% often, 40.4% occasionally and 2.4% very rarely purchase eco-friendly products.

Partial Least Squares Structural Equation Modeling (PLS-SEM)

PLS-SEM can model more than one independent variable and more than one dependent variable, make stronger predictions (Garson, 2016), and work with smaller sample sizes (Avkiran & Ringle, 2018; Sarstedt, Ringle, & Hair, 2021: 13). In this study, the reliability and validity of the measurement model were determined, the structural model was evaluated, and the hypotheses were tested.

Evaluation of the Measurement Model

Hair et al. (2021) explained that measurement models should be evaluated in four steps according to indicator reliability, internal consistency reliability, convergent validity, and discriminant validity.

Indicator reliability is the square of the factor loadings, and indicator loadings below 0.40 should be deleted (Avkiran, 2018: 8; Hair, Ringle, & Sarstedt, 2011; Hair, Hult, Ringle, & Sarstedt, 2017). For internal consistency reliability, Hair et al. (2011: 145-146; 2017) stated that Cronbach's Alpha and Composite Reliability (CR) should be at least 0.70. Dijkstra-Henseler's rho_A value functions as a compromise between Cronbach's Alpha and composite reliability and should be above 0.70 (Hair et al., 2017; 2021). Items with an indicator reliability of less than 0.40 were excluded from the measurement model. To meet the Fornell-Larcker and Heterotrait-Monotrait (HTMT) conditions, the overlapping items of the scales that did not meet the criteria were deleted. After deleting the items, the reliability and convergent validity results of the measurement model are shown in Table 2.

Table 2
Reliability and Convergent Validity

Variable	Factor	Item Code	Factor Loadings	Indicator Reliability	Cronbach's Alpha	rho_A	CR	AVE
Critical Value			**≥0,40**	**≥0,40**	**≥0,70**	**≥0,70**	**≥0,70**	**≥0,50**
OK	OK_MK	MK1	0.805	0,648	0.940	0.940	0.939	0.688
		MK2	0.851	0,724				
		MK3	0.860	0,739				
		MK4	0.792	0,627				
		MK5	0.811	0,657				
		MK6	0.805	0,648				
		MK7	0.877	0,769				
	OK_AC	AC1	0.879	0,772	0.722	0.771	0.740	0.593
		AC3	0.642	0,412				

Variable	Factor	Item Code	Factor Loadings	Indicator Reliability	Cronbach's Alpha	rho_A	CR	AVE
Critical Value			**≥0,40**	**≥0,40**	**≥0,70**	**≥0,70**	**≥0,70**	**≥0,50**
SK	SK_Govde	GSK1	0.791	0,625	0.940	0.942	0.939	0.585
		GSK2	0.747	0,558				
		GSK4	0.847	0,717				
		GSK5	0.750	0,562				
		GSK7	0.731	0,534				
		GSK8	0.691	0,477				
		GSK9	0.736	0,541				
		GSK11	0.822	0,675				
		GSK12	0.653	0,426				
		GSK13	0.687	0,471				
		GSK14	0.916	0,839				
CK		CK7	0.744	0,553	0.849	0.849	0.848	0.583
		CK8	0.781	0,609				
		CK9	0.761	0,579				
		CK10	0.769	0,591				
CN		CN1	0.883	0,779	0.851	0.853	0.852	0.742
		CN2	0.839	0,703				
CT		CT1	0.961	0,923	0.915	0.921	0.917	0.847
		CT3	0.877	0,769				

Note: Death Anxiety (*OK*), Death Anxiety Exposure factor (*OK_MK*), Death Anxiety Suffering factor (*OK_AC*), Health Anxiety (*SK*), Health Anxiety Body factor (*SK_Govde*), Environmental Anxiety (*CK*), Intention to Purchase an Eco-Friendly Product (*CN*), Eco-Friendly Consumption Behavior (*CT*), Exposure (*MK*), Suffering (*AC*), Health Anxiety Body (*GSK*)

When Table 2 is examined, the reliability and convergent validity of the measurement model are ensured as it meets the specified threshold values.

For discriminant validity, cross-loadings, Fornell-Larcker criterion, and HTMT coefficients were examined in Table 3.

According to cross-loadings, the factor loadings of each indicator should have the highest value in their respective structures. The Fornell-Larcker criterion states that the square root of the AVE values of each latent structure should be greater than the correlation coefficients between other latent structures (Hair et al., 2011; 2017). Henseler, Ringle, & Sarstedt (2015 as cited in Hair et al., 2017) stated that if the structures are similar to each other in the path model, the threshold value for the HTMT coefficients should be 0.90, and if the structures are different, the threshold value should be 0.85. Discriminant validity was ensured according to the cross-loadings, Fornell-Larcker Criterion, and HTMT coefficients shown in Table 3.

Table 3
Discriminant Validity Results

Cross-Loadings

	OK_AC	CK	CN	CT	SK	OK_MK
AC1	0.879	0.317	0.462	0.348	0.203	0.491
AC3	0.642	0.325	0.327	0.183	0.127	0.465
CK10	0.210	0.769	0.556	0.494	0.060	0.189
CK7	0.396	0.744	0.512	0.357	0.116	0.256
CK8	0.313	0.781	0.504	0.504	0.086	0.204
CK9	0.342	0.761	0.494	0.441	0.117	0.246
CN1	0.390	0.638	0.883	0.758	0.136	0.226
CN2	0.509	0.525	0.839	0.677	0.151	0.290
CT1	0.351	0.567	0.796	0.961	0.091	0.197
CT3	0.304	0.516	0.738	0.877	0.058	0.180
GSK1	0.182	0.097	0.108	0.084	0.791	0.486
GSK11	0.160	0.134	0.175	0.107	0.822	0.495
GSK12	0.101	0.108	0.113	0.002	0.653	0.418
GSK13	0.107	0.055	0.119	0.067	0.687	0.431
GSK14	0.256	0.142	0.151	0.117	0.916	0.540
GSK2	0.203	0.123	0.145	0.100	0.747	0.436
GSK4	0.177	0.029	0.076	0.002	0.847	0.547
GSK5	0.179	0.119	0.163	0.073	0.750	0.444
GSK7	0.188	0.072	0.109	0.059	0.731	0.443
GSK8	0.130	0.010	0.116	0.009	0.691	0.436
GSK9	0.133	0.143	0.121	0.051	0.736	0.461
MK1	0.448	0.175	0.223	0.194	0.517	0.805
MK2	0.626	0.299	0.292	0.182	0.480	0.851
MK3	0.483	0.258	0.247	0.178	0.527	0.860
MK4	0.483	0.252	0.217	0.163	0.485	0.792
MK5	0.487	0.246	0.237	0.155	0.499	0.811
MK6	0.551	0.220	0.250	0.153	0.499	0.805
MK7	0.498	0.242	0.261	0.165	0.549	0.877

Fornell-Larcker Criterion

	CK	CN	CT	OK_AC	OK_MK	SK
CK	0.764					
CN	0.676	0.862				
CT	0.589	0.834	0.920			
OK_AC	0.411	0.520	0.357	0.770		
OK_MK	0.292	0.298	0.205	0.616	0.829	
SK	0.124	0.166	0.082	0.219	0.613	0.765

HTMT Coefficients

	CK	CN	CT	OK_AC	OK_MK	SK
CK						
CN	0.675					
CT	0.588	0.835				
OK_AC	0.428	0.527	0.353			
OK_MK	0.291	0.298	0.205	0.635		
SK	0.127	0.166	0.083	0.216	0.608	

Evaluation of the Structural Model

Hair et al. (2017) proposed evaluating a structural model in six steps according to collinearity issues, significance, and relevance of structural model relationships, R^2 values, f^2 effect size, predictive relevance Q^2, and q^2 effect size, respectively.

Tablo 4
Structural Model Evaluation Results

Exogenous Variable	Endogenous Variable	VIF	R^2	f^2	Q^2	q^2
OK_AC	**SK**	1.379	0.351	**0.029**	**0.215**	**0,015**
OK_MK		1.379		**0.488**		**0,248**
OK_AC	**CK**	1.379	0.120	**0.060**	**0.075**	**0,034**
OK_MK		1.379		0.012		

Exogenous Variable	Endogenous Variable	VIF	R^2	f^2	Q^2	q^2
OK_AC		1.500		**0.078**		**0,047**
OK_MK	**CN**	2.071	0.395	0.001	**0.323**	
SK		1.541		0.005		
CK		1.137		**0.352**		**0,257**
OK_AC		1.617		0.001		
OK_MK		2.074		0.000		
SK	**CT**	1.549	0.563	0.003	**0.483**	
CK		1.537		**0.031**		
CN		1.652		**0.623**		**0,452**

Omission distance for Q^2: 7
f^2 and q^2 formula (Henseler, Ringle, & Sinkovics, 2009; Hair et al., 2017):
$f^2 = (R^2 \text{ included} - R^2 \text{excluded}) / (1 - R^2 \text{ included})$
$q^2 = (Q^2 \text{ included} - Q^2 \text{ excluded})/(1- Q^2 \text{ included})$
VIF ≤3 (Hair, Risher, Sarstedt, & Ringle, 2019); <4 (Garson, 2016); <5 (Diamantopoulos, Riefler, & Roth, 2008); <10 (Henseler et al., 2009; Kline, 2016)

According to Table 4, the VIF values of the variables are lower than all the threshold values stated in the literature, and there is no linearity problem.

The relationships of the structural model should be evaluated by the significance of the t-values, p-values, and confidence intervals. If there is no zero value in the confidence interval, the path coefficient is significant at the 5% level (Hair et al., 2017). For the suitability of significant relationships in the structural model, path coefficients are interpreted relative to each other, and their dimensions are evaluated (Hair et al., 2017). Table 5 presents the hypothesis results, including the direct effects in the research model.

Table 5
Hypothesis Result Related to Direct Effects

Hypotheses				Standardized Beta	Standard Deviation	t value	p value	%95 Confidence Intervals
H1b	OK_MK	*à*	CN	-0.041	0.062	0.656	0.512	-0.169; 0.076
H1c	OK_AC	*à*	CN	0.266	0.098	2.708	0.007	0.071; 0.444
H2b	OK_MK	*à*	CT	0.014	0.056	0.252	0.801	-0.091; 0.126
H2c	OK_AC	*à*	CT	-0.029	0.092	0.315	0.753	-0.208; 0.154
H3c	OK_MK	*à*	SK	0.661	0.039	17.001	0.000	0.581; 0.733
H3e	OK_AC	*à*	SK	-0.161	0.047	3.466	0.001	-0.256; -0.074
H4b	OK_MK	*à*	CK	0.119	0.043	2.800	0.005	0.036; 0.202
H4c	OK_AC	*à*	CK	0.269	0.105	2.563	0.010	0.040; 0.451
H5a	SK	*à*	CN	0.069	0.053	1.302	0.193	-0.034; 0.173
H6a	SK	*à*	CT	-0.043	0.050	0.860	0.390	-0.140; 0.056
H7	CK	*à*	CN	0.492	0.082	6.012	0.000	0.308; 0.635
H8	CK	*à*	CT	0.145	0.093	1.565	0.118	-0.039; 0.321
H11	CN	*à*	CT	0.671	0.128	5.228	0.000	0.368; 0.873

* Bootstrap samples: 5,000 samples were selected at a significance level of 0.05. (Hair et al., 2011; 2017; Henseler et al., 2009)
T-values for two-tailed tests: * 1.65 (significance = 10%); ** 1.96 (significance = 5%); *** 2.57 (significance = 1%)
*p<0.1, **p<0.05, ***p<0.01 (Hair et al., 2017)

At the stage of ensuring the reliability and validity of the structural model of the research, the uncertainty of the death factor of death anxiety and the additional factor of health anxiety were excluded from the model on the grounds that it did not provide critical values. Because relevant factors were removed from the model, the hypothesis analyzes were made on the existing variables. Therefore, the direct effect hypotheses (H1a, H2a, H3a, H3b, H3d, H3f, H4a, H5b, H6b) regarding these factors are not included in Table 5. The hypotheses supported in Table 5 are as follows:

The suffering factor of death anxiety (*β=0.266, t=2.708, p=0.007, confidence interval=0.071;0.444*) and environmental anxiety (*β=0.492, t=6.012, p=0.000, confidence interval=0.308;0.635*) have a significant effect on intention to purchase an eco-friendly product. H1c and H7 hypotheses were supported. Exposure factor of death anxiety (*β=0.661, t=17.001, p=0.000; confidence interval=0.581;0.733*) and suffering factor (*β=-0.161, t=3.466, p=0.001; confidence interval=-0.256; -0.074*) have a significant effect on the body factor of health anxiety. H3c and H3e hypotheses were supported. Exposure factor of death anxiety (*β=0.119, t=2.800, p=0.005; confidence interval=0.036; 0.202*) and suffering factor (*β=0.269, t=2.563, p=0.010; confidence interval=0.040; 0.451*) had a significant effect on environmental anxiety. H4b and H4c hypotheses were supported. The intention to purchase an eco-friendly product (*β=0.671, t=5.228, p=0.004; confidence interval=0.368; 0.873*) has a significant effect on eco-friendly consumption behavior. The H11 hypothesis is supported. According to Table 5, the hypotheses H1b, H2b, H2c, H5a, H6a, and H8 were not supported (*p>0.05, t<1.96, the confidence intervals contain zero values*).

R^2 value of 0.20 is considered high in consumer behavior research (Hair et al., 2011; 2017). According to Table 4, exogenous variables explain endogenous variables at a rate of 0.120–0.563.

The f^2 effect size, the change in R^2 value when a certain external structure is removed from the model, evaluates whether the removed structure has a significant effect on internal structures (Hair et al., 2017). The f^2 coefficient at values of 0.02, 0.15, and 0.35 represent small, medium, and large effects, respectively (Cohen, 1988). If the f^2 value is less than 0.02, then there is no effect (Sarstedt et al., 2021). The effect of the exposure factor of death anxiety (f^2=0.001<0.02) and the body factor of health anxiety (f^2=0.005<0.02) was not determined. In Table 5, the direct effect of the exposure factor of death anxiety on environmental anxiety was found to be significant (p=0.005<0.05). However, Table 4 shows that the effect size of the exposure factor of death anxiety on environmental anxiety (f^2=0.012) is less than 0.02 and has no effect. Therefore, the H4b hypothesis, which was supported according to Table 5, was not supported when the f^2 value was examined. Moreover, in Table 5, no effect of environmental anxiety on eco-friendly consumption behavior was found (p=0.118>0.05) and the H8 hypothesis was not supported. In this regard, the f^2 value (f^2=0.031>0.02) is not significant.

The fact that the predictive relevance coefficients (Q^2) of the endogenous variables in the research model are higher than zero indicates that the model has the predictive relevance of the endogenous variables (Hair et al., 2011: 145-147). Table 4 shows that the Q^2 value exceeded zero (0.215; 0.075; 0.323 and 0.483). Therefore, the research model has predictive relevance for health anxiety, environmental anxiety, intention to purchase eco-friendly products, and eco-friendly consumption behavior.

The q^2 effect size represents the contribution of the extrinsic structure to the Q^2 value of the endogenous latent variable. The q^2 effect sizes of 0.02, 0.15, and 0.35 indicate that an exogenous structure has a small, medium, or large estimated relevance for a particular internal structure, respectively (Hair et al., 2017; Henseler et al., 2009). When Table 4 is examined, it is seen that the suffering factor of death anxiety has no effect on the body factor of health anxiety (q^2=0.015<0.02). In this context, the previously supported hypothesis H3e is not supported. The structural model of the research is presented in Appendix-1, and it shows the factor loadings, path coefficients, and R^2 values.

Mediation Effect Analysis

Zhao, Lynch, & Chen (2010) stated that the only condition for a mediation effect is that the indirect effect (a x b) must be significant. Hypothesis results were tested for the significance of indirect effects using the resampling method in the SmartPLS program and the findings are presented in Table 6.

Table 6
Hypothesis Result Related to Indirect Effects

Hypotheses		Standardized Beta	Standard Deviation	t value	p value	%95 Confidence Intervals
H9c	OK_MK -> SK -> CN	0.045	0.035	1.312	**0.189**	-0.022; 0.114
H9e	OK_AC-> SK -> CN	-0.011	0.010	1.166	**0.244**	-0.035; 0.003
H10b	OK_MK -> CK-> CN	0.059	0.023	2.530	**0.011**	0.018; 0.109
H10c	OK_AC -> CK -> CN	0.132	0.063	2.098	**0.036**	0.016; 0.263
H12	CK -> CN -> CT	0.330	0.080	4.145	**0.000**	0.179; 0.488

T-values for two-tailed tests: * 1.65 (significance = 10%); ** 1.96 (significance = 5%); *** 2.57 (significance = 1%)
*p<0.1, **p<0.05, ***p<0.01

According to Table 6, environmental anxiety has a mediating effect on the effect of the suffering factor of death anxiety on the intention to purchase an eco-friendly product (*β=0.132, t=2.098, p=0.036; confidence interval=0.016;0.263*). It was determined that the effect of environmental anxiety on eco-friendly consumption behavior was mediated by the intention to purchase an eco-friendly product *(β=0.330, t=4.145, p=0.000; confidence interval=0.179;0.488*). The H10c and H12 hypotheses were supported.

When Table 6 is examined; H9c and H9e hypotheses were not supported. The p-values of the hypotheses are greater than 0.05, the t-values are less than 1.96, and the confidence

intervals contain zero values. In addition, according to Table 6, environmental anxiety had a mediating effect on the effect of exposure factor of death anxiety on the intention to purchase an eco-friendly product (*β=0.059, t=2.530, p=0.011; confidence interval=0.018; 0.109*). However, according to the f^2 values in Table 4, the H4b hypothesis was not supported because the effect size of the exposure factor of death anxiety on environmental anxiety was smaller than 0.02 (f^2=0.012). Therefore, the exposure factor did not significantly affect environmental anxiety. In this regard, the indirect effect of the H10b hypothesis is not significant and the H10b hypothesis is not supported.

The effect of the suffering factor of death anxiety on environmental anxiety (*β=0.269; p=0.010, R^2=0.120*), the effect of environmental anxiety on the intention to purchase eco-friendly product (*β=0.492; p=0.000, R^2=0.395*), and the effect of the suffering factor of death anxiety on the intention to purchase eco-friendly products are significant and positive (*β=0.266; p=0.007, R^2=0.395*). According to the decision tree of Zhao et al. (2010), the partial mediation (complementary) effect of environmental anxiety was determined. The effect of environmental anxiety on the intention to purchase an eco-friendly product (*β=0.492; p=0.000, R^2=0.395*) and the effect of intention to purchase an eco-friendly product on eco-friendly consumption behavior (*β=0.671; p=0.000, R^2=0.563*) are significant and positive. Environmental anxiety had no effect on eco-friendly consumption behavior (*β=0.145; p=0.118>0.05*). The full mediation effect of intention to purchase an eco-friendly product was determined.

When the hypothesis results of the research were examined in general, hypotheses H1c, H3c, H4c, H7, H10c, H11, and H12 were supported. The H1a, H1b, H2a, H2b, H2c, H3a, H3b, H3d, H3e, H3f, H4a, H4b, H5a, H5b, H6a, H6b, H8, H9a, H9b, H9c, H9d, H9e, H9f, H10a, and H10b hypotheses are not supported.

Conclusion and Discussion

In this study, the hypotheses were tested with Partial Least Squares Structural Equation Modeling. The results of the hypothesis test were examined, it was revealed that the exposure factors of death anxiety had a significant effect on the body factor of health anxiety. This effect is positive. Death anxiety can be said to lie at the root of health anxiety. Exposure to death-related events and situations that remind people of death (for example, seeing a coffin, seeing a funeral, reading an article about death or watching a program, talking about death) increase people's health anxieties. Because remembering death causes people to worry about their health by examining their health, thinking about the disease, and being aware of the changes in their bodies. Studies in the literature indicate that death anxiety is the main motivation for fear and behavior that underlies many anxieties and phobias (Becker, 1973; Cicirelli, 2002: 358; Furer & Walker, 2008: 167). It is stated in the literature that the necessity

of being physically well to continue life causes health anxiety (Looper & Kirmayer, 2001, as cited in Abramowitz et al., 2007: 86). Thus, the relationship between death, life, and health anxiety is discussed. In addition, the literature has stated that death anxiety is a central feature of health anxiety (Furer & Walker, 2008: 167). Therefore, the result of the study that death anxiety affects health anxiety is similar to the literature.

A significant effect of the suffering factor of death anxiety was found on environmental anxiety. The suffering factor had a positive effect on environmental anxiety. It can be said that death anxiety is the basis of environmental anxiety. Anxiety caused by a deadly disease, thinking about the pain to be experienced at the time of death also affects environmental anxiety. The environment also affects human health. Therefore, in order to avoid a deadly disease and from dying from the suffering caused by this disease, a life without environmental pollution and without disturbing the balance of nature is important. Because people have to adapt to the environment in order to live. In the literature, some studies have stated that death anxiety affects environmental anxiety. The results of this study are similar to those of Rahimah et al. (2018).

The study revealed that the suffering factor of death anxiety had a significant effect on the intention to purchase an eco-friendly product. The suffering factor of death anxiety has a positive effect on intention. Death anxiety can be said to have an effect on the formation of purchase intention for eco-friendly products in consumers. Consumers may turn to eco-friendly products because of death anxieties. Catching a deadly disease and dying slowly increases consumers' death anxiety, and this increase in death anxiety increases consumers' intention to purchase eco-friendly products. Consumers develop a purchase intention towards eco-friendly products to relieve the anxiety caused by the possibility of catching a deadly disease and dying slowly. This result was similar to Rahimah et al. (2018).

This study revealed that environmental anxiety has a significant effect on the intention to purchase an eco-friendly product. This effect is positive. As consumers' environmental anxiety increase, their intention to purchase eco-friendly products also increases. Environmental anxieties make consumers more sensitive to eco-friendly products. It is seen that they intend to purchase eco-friendly products in order not to harm the environment and to protect the balance of nature. Kim (2019, as cited in Cachero-Martínez, 2020: 4) stated that consumers with environmental anxieties have developed an attitude toward organic products as eco-friendly. Studies have found that environmental anxiety has an impact on the intention to purchase eco-friendly products (Ahmed et al., 2021; Doğan et al., 2022; Hartmann & Apaolaza-Ibáñez, 2012; Hedlund, 2011; Kocagöz & İğde, 2022; Koenig-Lewis et al., 2014; Lee, 2008). Therefore, the results of the study are compatible with the literature.

In this study, the intention to purchase an eco-friendly product affects eco-friendly consumption behavior. This effect is positive. As consumers' intention to purchase eco-friendly

products increases, their eco-friendly consumption behaviors also increase. In other words, the higher the intention to purchase an eco-friendly product, the more eco-friendly their consumption. Intention affects behavior (Ajzen, 1991: 181) and ensures the formation of behavior (Ali et al., 2011: 218). In addition, the literature has found that intention is frequently used as a factor predicting eco-friendly consumption behavior (Mahardika et al., 2020: 1). This study, similar to the literature, revealed that the intention to purchase an eco-friendly product affects eco-friendly consumption behavior.

When the mediating effect hypotheses of the research were examined, it was determined that environmental anxiety had a mediating effect on the effect of the suffering factor of death anxiety on the intention to purchase an eco-friendly product. The mediation effect is positive. The suffering factor of death anxiety affects the intention to purchase eco-friendly products through environmental anxiety. In this effect, environmental anxiety plays a mediating role and conveys the effect of the suffering factor of death anxiety on eco-friendly consumption behavior. Therefore, the increase in death anxiety increases environmental anxiety by positively affecting it, and the increase in environmental anxiety creates the intention to purchase eco-friendly product in consumers. It has been stated in the literature that environmental anxiety acts as an important indirect determinant of environmental behavior (Bamberg, 2003: 23). There are studies in the literature stating that environmental anxiety plays a mediating role (Ahmed et al., 2021; Leblebici Koçer & Delice, 2016: 112; Rahimah et al., 2018). Rahimah et al. (2018) found the mediating effect of environmental anxiety on the effect of death anxiety on the intention to purchase an eco-friendly product. In this respect, the results of the study are similar to those of Rahimah et al. (2018).

The study revealed that the intention to purchase an eco-friendly product has a mediating effect on the effect of environmental anxiety on eco-friendly consumption behavior. The mediation effect is positive. Environmental anxiety impacts eco-friendly consumption behavior through consumers' intention to purchase eco-friendly products. In this effect, the intention to purchase an eco-friendly product assumes the role of a mediator and conveys the effect of environmental anxiety on eco-friendly consumption behavior. Therefore, the increase in environmental anxiety increases the intention to purchase eco-friendly products by positively affecting consumers, and the increase in the intention to purchase eco-friendly products creates eco-friendly consumption behavior. Environmental anxieties of consumers increase their intention to purchase eco-friendly products (do Paço et al., 2009: 17). It is stated that consumers purchase eco-friendly products because of environmental anxieties, and thus, they cause less damage to the environment by purchasing eco-friendly products (Mainieri et al., 1997, as cited in Wang et al., 2020: 1). Therefore, consumers who view environmental pollution as a problem are more likely to purchase eco-friendly products (Ali et al., 2011: 218). In addition, since intention is widely used in predicting eco-friendly consumption behavior (Mahardika et al., 2020: 1), it can be said based on the literature that intention acts as a mediator between

environmental anxiety and consumption behavior. In this respect, the results of this study are similar to those of previous studies.

In this study, the absence of effect of health anxiety on eco-friendly consumption behavior differed from the study of Ecevit et al. (2022), the absence of effect of death anxiety differed from the study of Rahimah et al. (2018), and the absence of effect of environmental anxiety differed from the studies of Lee (2009), Yapraklı & Mutlu (2021), Bulut et al. (2021).

Based on the results of this research, it can be concluded that death anxiety is the basis of health anxiety and environmental anxiety. In addition, death anxiety is the basis of consumers' intention to purchase eco-friendly products and their consumption behaviors. Death anxiety has a direct effect on the intention to purchase an eco-friendly product. This result shows that death anxiety is effective in forming consumers' purchase intentions related to eco-friendly products. In addition, death anxiety affects the intention to purchase eco-friendly products through environmental anxiety. In this effect, environmental anxiety plays a mediating role and conveys the effect of death anxiety on the intention to purchase an eco-friendly product. Therefore, the increase in death anxiety increases environmental anxiety by positively affecting it, and the increase in environmental anxiety leads to consumers' intention to purchase eco-friendly products.

Implications

Theoretical Implications

In the literature, it has been stated that death anxiety varies according to culture (Lehto & Stein, 2009: 25-32), and there are studies examining culture and death anxiety (Schumaker, Warren, & Groth-Marnat, 1991; Suhail & Akram, 2002). There are also studies examining death anxiety according to demographic characteristics such as age (Hall, 1897; İnci & Öz, 2009; Schumaker et al., 1991; Suhail & Akram, 2002; Thorson & Powell, 1988) and gender (Harding, Flannelly, Weaver, & Costa, 2005; Suhail & Akram, 2002; Thorson & Powell, 1988). Future studies should explore the impact of anxiety on the intention to purchase eco-friendly products and consumption behavior in the context of different cultures, demographics, product categories, and brands. In addition, research can be conducted according to various variables, including personality traits, psychological disorders, psychological factors, and different types of anxiety.

It has been stated in the literature that death anxiety has many dimensions (Karakuş et al., 2012: 50). Research can also be conducted on different death topics, such as death anxiety, mortality salience, meaning given to death, and death threat. Studies in which death anxiety has been studied using religion and religiosity variables (Hall, 1897; Harding et al., 2005;

Maglio & Robinson, 1993; Suhail & Akram, 2002; Wen, 2010) are also included in the literature. The intention to purchase an eco-friendly product and consumption behavior can be investigated according to the variables of religion, religiosity, and belief.

Since environmental anxiety expresses a relationship with environmental problems (Schultz et al., 2005: 458), environmental problems such as pollution, waste, climate change, global warming, the intention to purchase eco-friendly products, and consumption behavior can be examined. In this study, it was determined that there is no effect of health anxiety on the intention to purchase an eco-friendly product and consumption behavior. Future studies may use a shorter health anxiety scale that is not pathological. Other research can examine the intention to purchase eco-friendly products and consumption behavior using qualitative, mixed, and experimental methods. Consumers who do not purchase eco-friendly products were not included in the study. By including people who have not previously purchased eco-friendly products, their attitudes toward eco-friendly products, and the reasons for not purchasing these products can be investigated. The amygdala and hippocampus are brain systems where death anxiety occurs (Lehto & Stein, 2009: 25-32). Future studies should examine the effects of death anxiety on brain systems within the scope of neuromarketing. In addition, research can be conducted on the effectiveness of marketing communication studies in which death anxiety and fear appeal in eco-friendly consumption behavior are used.

Managerial Implications

This study offers suggestions for marketing strategies related to eco-friendly products. The study revealed that the intention to purchase an eco-friendly product and consumption behavior depend on death anxiety and environmental anxiety. Therefore, marketing practitioners should focus on death and environmental anxieties in their strategies to encourage consumers to purchase eco-friendly products and direct these intentions toward consumption. Therefore, the effects of environmental problems on human life and the continuation of life can be included in marketing communication strategies. The role of eco-friendly products can be transferred to consumers to eliminate these environmental problems and their threatening effects on human life. Because humans are creatures established to live healthy and to continue their life for many years.

In marketing strategies, the benefits of eco-friendly products to human life and the environment can be kept in the foreground. In addition, businesses can use consumers with death and environmental anxieties as a psychographic market segmentation measure. Thus, by better understanding the consumption behaviors of this market segment, more appropriate strategies can be developed for these consumers. Businesses should present awareness-raising and informative messages about eco-friendly products in their marketing communication efforts. The message content should be convincing and provide confidence that the

product is suitable for human and environmental health and does not threaten human life. In addition, the element of convincingness and confidence should be included in the product design, label, logo, and packaging. Consumers with death and environmental anxieties may show purchasing behavior to relieve their anxieties if they believe that the product is eco-friendly. Businesses should transparently share with consumers the importance they attach to the environment and their social responsibility activities for the environment. Accordingly, businesses can increase their environmental activities. It should convince consumers that they use environmental resources correctly in product development, do not harm the environment, and do not threaten human life. It should also develop its brand positioning on this axis. In situations such as disasters and epidemics that may exacerbate consumers' death anxiety, businesses should increase the content of reliable and convincing messages that eco-friendly products are suitable for human life and environmental health. Because in situations that threaten human life, consumers can avoid risky purchases and turn to reliable products because of their anxieties.

In the literature, studies (Chen & Lin, 2018; Miller, 2021; Temeloğlu, Taşpınar, & Soylu, 2017) have investigated the effect of positive and negative emotions on consumers' purchasing behavior. It has been stated that death anxiety is also an emotion (Karakuş et al., 2012: 42). Therefore, in addition to positive emotions, negative emotions such as death anxiety and environmental anxiety can impact consumers' purchasing behavior. In this regard, businesses should perform marketing communication efforts that take into account-negative emotions. In addition, fear appeal, which is frequently used in health campaigns, includes messages that aim to deliver threats to consumers (Leshner, Bolls, & Wise, 2011: 77). The persuasive feature of fear appeal is strong (Rotfeld, 1988; Witte, 1994). There are also studies (Laroche, Toffoli, Zhang, & Pons, 2001; Tannenbaum et al., 2015; Witte & Allen, 2000) that have demonstrated that fear appeal can influence and change human behavior. In addition to being convincing, the messages used in the fear appeal should offer a solution to alleviating the fear (Fırat, 2013). Therefore, businesses should benefit from the emotional and fear appeal of death anxiety and environmental anxiety in directing consumers' intention to purchase eco-friendly products toward consumption behavior. It should also convince consumers that the solution to relieving fear and anxiety is eco-friendly products.

When the income levels in the demographic information of the participants were examined, it was determined that they had lower and middle income levels. In recent years, high inflation in the Turkish economy has affected the purchase of eco-friendly products by low and middle income consumers. Although they suffer death and environmental anxieties, some consumers experience difficulties in seeking eco-friendly products due to economic anxieties. Therefore, income may also affect the purchase of these products. Businesses should develop their price strategies and conduct marketing efforts in this direction, considering income and economic anxieties.

Limitations of the Study

The population of the research is people living in Türkiye and purchasing eco-friendly products. It is not possible to reach the research population in terms of time and cost. In this respect, the convenience sampling method was chosen with time and cost limitations to reach people who purchased eco-friendly products. In convenience sampling, it is not fully known whether the sample represents the population or not, since the sample selection consists of accessible people and the personal judgments of the interviewer or the researcher are effective in the selection of the sample (Gegez, 2019: 200). Therefore, it is thought that there is a generalization limitation in the study. In addition, since the study adopted cross-sectional analysis, data were obtained from the participants at one time and at a certain time. Therefore, the application of cross-sectional analysis may also constitute a limitation because consumers' perceptions may change over time.

This research was not conducted for any product and a brand categories. Therefore, the results cannot be generalized to product and brand categories. This situation constitutes another limitation of this study. Anxiety is a common psychological condition in modern society (Levitt, 2016: 1-2) and can be disturbing (Colasanti, Rabiner, Lingford-Hughes, & Nutt, 2011). Death anxiety is also a valid condition (Gonen et al., 2012: 348). There is death avoidance in human existence (Thorson & Powell, 1988: 691). At the same time, death is perceived as a disturbing phenomenon that should be addressed (Karakuş et al., 2012: 42-45). Obtaining data for research on anxiety, especially death anxiety, which is a phenomenon that people run away from, are afraid to face, and disturb when the subject is brought up, can be a difficult, effort and time-consuming issue. It is believed that this situation may affect the response speed and willingness of the survey. Therefore, the difficulty in obtaining anxiety-related data is another limitation of this study. In addition, social desirability may affect answering the survey. However, it was assumed that the participants were sincere in answering the survey and would mark the most appropriate options for them. However, it was assumed that the participants were sincere in answering the survey and would mark the most appropriate options for them.

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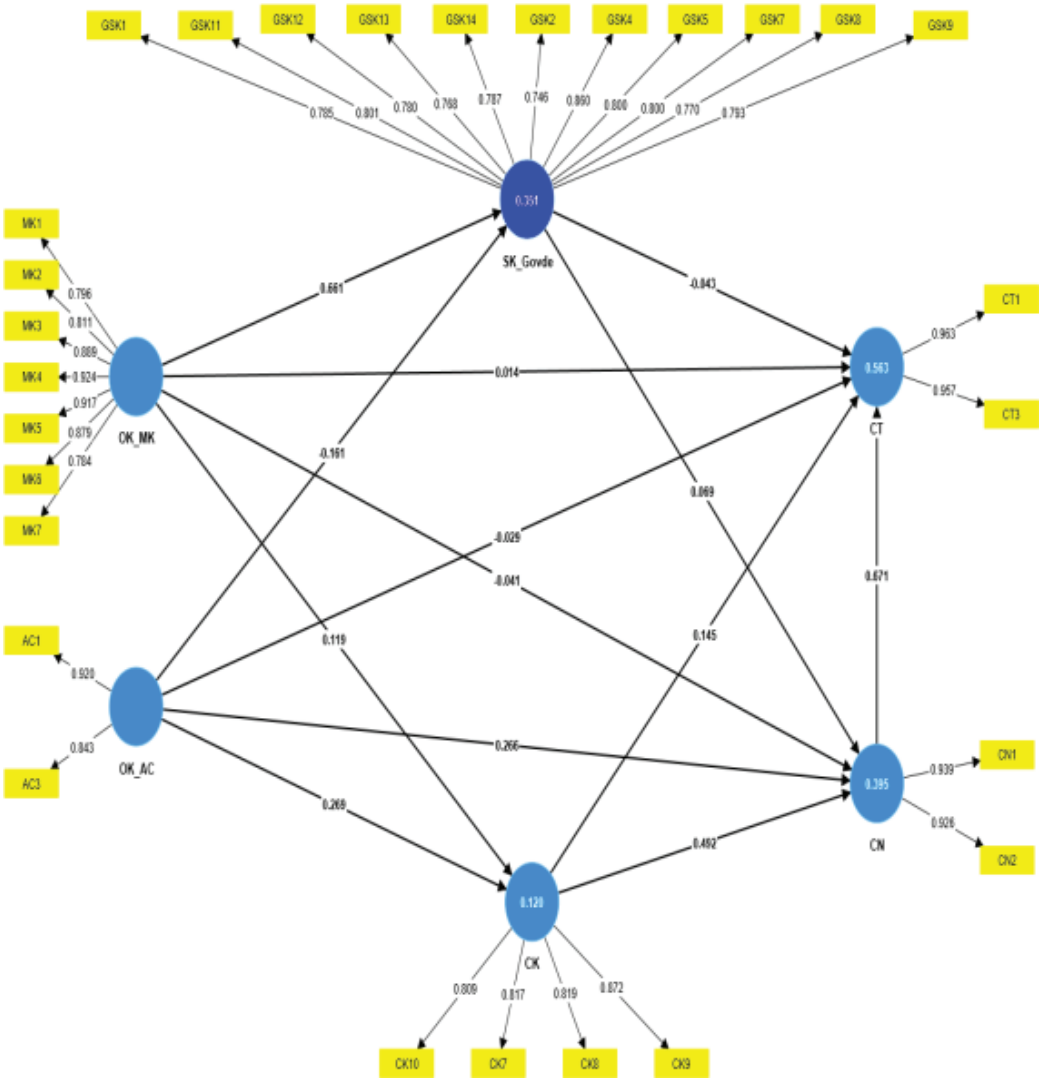
APPENDIX-1: Structural Model of the Research



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RESEARCH ARTICLE

Does ESG Investment Influence Firm Risk During the COVID-19 Pandemic? Evidence from European Markets*

Seyfullah Selimefendigil[1]

Abstract
Corporate social performance (CSP) has gained in importance in recent decades. To satisfy the concerns raised by consumers, investors, fund providers, and governmental organizations about sustainability, businesses stick to working for a more sustainable environment. This paper examines the nexus between environmental, social, and governance factors (ESG) and various risk types, including market and accounting-based risk, using a data set consisting of 175 firms from European countries which covers the period from 2015 to 2022. In this study, we examine both aggregated and disaggregated ESG scores and their associations with accounting-based default risk, measured by Altman's Z'' and Zmijewski's ZM-scores, as well as market risk proxied by beta. To explore the nexus between ESG and risk factors, panel data analysis with both time and unit effects was used and considered with cluster robust standard errors. We find that economic cycles have an impact on the relationship between CSP and risk. While ESG factors demonstrate a risk-mitigating effect during the COVID-19 pandemic, it has no impact before the COVID-19 pandemic. We also find that market-based risk assessment is more informative than accounting-based risk assessment.

Keywords: Corporate Social Performance, COVID-19, Firm risk, Stakeholder Theory, Agency Theory

Introduction

The COVID-19 pandemic outbreak in China's Wuhan province has triggered a challenging economic recession since World War II and, emerged as a key milestone for sustainable investment (Morgan, 2020). The pandemic destroyed commodity and equity markets, as documented by several studies (Phan & Narayan, 2020; Padhan & Prabheesh, 2021; Harjoto et al., 2021; Hu & Zhang, 2021; Li et al., 2022). As COVID-19 spreads, investors began placing greater emphasis on environmental, social, and governance stocks. As an example, stock markets emphasizing ESG factors generally outperform their counterparts (Rubbaniy et al., 2022). Investors have recognized that it is reasonable to invest in ESG- led funds during the COVID-19 pandemic (Mooney, 2020). In light of this HSBC (2020) indicated that investments in sustainable portfolios have been rising and that the majority of investors (49%)

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prefer sustainable portfolios because they believe the returns will be higher and risks will decrease. During the COVID-19 pandemic the environment was severely impacted by the usage of pesticides, soaps ,detergents, and disposable masks (Ankit et al., 2021). Furthermore, the plastic demand has increased because of the packaging and medical uses (Patrício Silva et al., 2021). Therefore, during this time, investors began to demand funds with low ESG risk, especially those with low environmental risk rather than governance and social risks (Ferriani & Natoli, 2020;2).

The potential of ESG investments as a risk-mitigating factor is a topic of debate in the academic literature. A good ESG performance can be attributed as a sign of transparency and risk mitigation, but it can also be used as a disguise measure to deflect shareholders' attention (Lueg et al., 2019).

According to the literature, two distinct perspectives exist regarding the nexus between ESG performance and firm risk: the risk mitigation perspective and the overinvestment perspective. The risk mitigation perspective asserts that ESG investments act as a protective measure for firms during crises, enhance their cash flows, and serve as a risk management tool (Bouslah et al., 2018: 644). Based on stakeholder theory, this view posits that ESG is inversely related to firm risk (Lueg et al., 2019). Investing in ESG reduces reduced risks, according to stakeholder theory.Specifically, lower ESG scores correlate with a higher likelihood of encountering lawsuits and incurring legal fines, whereas substantial ESG investments can cultivate more favorable relationships with government entities and broader financial institutions (McGuire et al., 1988).

Conversely, the overinvestment view suggests that allocating resources to ESG activities is an inefficient use of resources, which can undermine the firm's stability and result in poorer cash flow performance (Goss & Roberts, 2011). Notably, this perspective aligns with shareholder and agency theories, where excessive corporate social performance investments may serve as a smokescreen for opportunistic behavior and divert attention away from shareholders' interests.

In this research, we investigate how ESG investments affect accounting-related risks, as assessed using Altman's Z''-score and Zmijewski's ZM-score, as well as systematic risk (beta). Our investigation spans 2015 to 2022 and encompasses a sample of 172 non-financial companies operating across European countries, including Austria, Belgium, Germany, Denmark, Luxembourg, the Netherlands, and Switzerland. We selected these countries because of their strong commitment to ESG reporting and the availability of relevant data. Europe, in particular, has been at the forefront of addressing environmental concerns within industries, and companies in this region began disclosing their ESG-related practices earlier than in other parts of the world, as noted by (Zahid et al., 2022; 201). Moreover, several European Union directives have been enacted to promote Corporate Social Performance (CSP)

among European companies (European Commission, 2013). To explore the moderating role of COVID-19 on the relationship between company risk and ESG investment, we divided our sample into two sections: the years between 2015-2019 and 2020-2022 constitute pre -and during the COVID-19 periods, respectively. The ESG–firm risk link will be further explored by taking a closer look at the three components; the environmental, social, and governance performance. Following this, we incorporated both account-based default risk and systematic risk into the model.

The first contribution of this study is its examination of both account-based and market-based risk indicators. Most previous studies have neglected to include account-based risk indicators and instead have focused on market-based risk indicators (Oikonomou et al., 2012; Albuquerque et al., 2019; Shahrour et al., 2021; Aevoae et al., 2023). In accordance with Orlitzky and Benjamin (2001), CSP and financial risk are mutually causal, with CSP having a stronger correlation with systematic risk than accounting-based risk. To compare account-based and market-based risk indicators, we included both indicators.

Second, this study uses multiple countries as a sample and focuses on the total and different sub- components of ESG investment. A number of previous studies have examined the relationship between CSP and risk using a single country (Broadstock et al., 2021; Korinth & Lueg, 2022; Zhou & Zhou, 2022; Habermann & Fischer, 2023; Zhang et al., 2023). Other studies that focused on multiple countries (Bitencourt et al., 2020; Hizarci-Payne et al., 2021; Saidane & Abdallah, 2021) did not consider general CSP measures and their subcomponents together.

Third, this study contributes to the literature by demonstrating the moderating effects of the COVID-19 pandemic. Firms may face greater challenges during periods of economic turbulence than during economic upswings. Therefore, it is important to examine the moderating role of crises, such as COVID-19, in assessing firm risk and CSP performance. Moreover, adverse macroeconomic conditions serve as a natural laboratory to investigate the relationship between firm risk and CSP, as noted by (Bouslah et al., 2018). In this way, the main motivation of CSP investments can be better revealed by considering both the risk mitigation and overinvestment perspectives.

Related Literature

There has been a large amount of literature examining the nexus between corporate financial performance (CFP) and ESG, and the results have been diverse (Singal, 2014; Velte, 2017; Taliento et al., 2019; Duque-Grisales & Aguilera-Caracuel, 2021; Shaikh, 2021; Al Amosh et al., 2022; Saygili et al., 2022). While there is a great amount of empirical studies that explore the ESG and Corporate Financial Performance (CFP) link, there is limited rese-

arch that focuses on the link between ESG factors and firm risk (Meles et al., 2023). In this context, findings obtained from different studies vary since they have used different loci of research, measures of CSP, and the yardstick of risk.

Habermann and Fischer (2023) stated that the economic cycle of the selected timeline significantly influences the ESG and firm risk link. They examined the nexus between corporate social performance and bankruptcy likelihood, which was measured using Eikon ESG scores and Altman Z scores, respectively. The 6696 firm-year observations from US firms between 2007 and 2019 constitute the study sample. This study subdivided the sample into two sections covering 2007-2009 and 2010-2019 and the results have been compared with one another. ESG performance decreases firm risk during economic crises but, not during economic upswings. Considering the stock price fluctuations and ESG performance in the context of the COVID-19 pandemic, Zhou and Zhou (2022) found that good ESG performance can mitigate risk associated with the COVID-19 period to a certain extent. Consistent with these findings based on 10 different countries, Lööf et al. (2022) revealed that ESG investment decreases firms' tail risk but it also decrease their return potential during the pandemic period. Chinese based evidence obtained by Broadstock et al. (2021) showed that ESG performance helps reduce financial risk during the COVID-19 pandemic, but its impact is less noticeable before then. To build on this, Korinth and Lueg (2022) explored the same relation for German firms between 2012 and 2019. They found an U-shaped relation between ESG performance and firm risk which indicated benefit of ESG investment up to a certain level. In contrast, Zhang et al. (2023) discovered that ESG performance lead firm risk. Yet, this relationship exhibited some weakening in the middle of the COVID-19 pandemic.. Additionally, the locus of research plays a crucial role in shaping how this relationship is seen. Since more sustainable countries have already explored many opportunities, ESG investment is not helpful to decrease firm risk as much as it does in other countries. Considering that, executives should invest in ESG activities only up to a certain point and terminate them at the appropriate level. Investment in CSP initially decreases firm risk, but overinvestment in these activities lead firm risk again. Sweden based findings by Engström and Martinsson (2020) conclude that there is a positive link between ESG performance and firm risk. The study explored the bidirectional relationship between firm risk and ESG investment for the South African companies provided further insights (Lueg et al., 2019). They discovered that, South African firms tend to increase their investments in ESG activities to obscure firm risk. For African firms, Corporate Social Responsibility (CSR) could be linked to insolvency risk, as suggested by (Saidane & Abdallah, 2021). They demonstrate that better environmental performance leads to a less stable firm. To extend this line of thinking, Bitencourt et al. (2020) analyzed 71 studies and revealed that the eco-innovation and corporate performance association is more potent in countries with a lower human development index. Consistent with these findings, Do (2022) discover that the influence of CSR is more prominent in countries with weak capital markets

and legal systems by investigating this identical association using an extensive dataset of companies spanning 36 countries model. Additionally, Hizarci-Payne et al. (2021) conducted a comprehensive review covering 70 studies and concluded that environmental innovation can contribute to firms' performance, with an even greater contribution observed in developing countries than in developed countries.

Because of the different calculation methodologies for ESG ratings, the outcomes of the studies may differ, as noted by (Korinth and Lueg, 2022). In this way, the Eikon ESG ratings (Thomson Reuters) database (e.g., Habermann & Fischer, 2023; Barth et al., 2022; Korinth & Lueg, 2022; Engström and Martinsson 2020; Sassen et al., 2016) and Kinder, Lydenberg, and Domini (KLD) database (see also, Bouslah et al., 2013; Oikonomou et al. 2012; Jo & Na, 2012; Goss & Roberts, 2011) are widely used sources. Despite the fact that many studies have demonstrated a negative relationship between aggregated ESG and firm risk, the individual ESG measure has been less clear. A recent study published by Cohen (2022) utilizing S&P500 stock data spanning the period from 2019 to 2021 showed that corporate risk, as assessed by Altman's Z-score, is inversely impacted by E and S factors but, not by G factors. Using the sample of same capital market Bouslah et al. (2013) found that different domains of CSP determine associations in distinct ways. The findings obtained by Assous (2022) indicated that E scores exhibit a noteworthy positive impact on the stock return fluctuation of Saudi banks, whereas the S score exerts a negative influence on this volatility. In another study, Eratalay & Ángel (2022) investigated the association between ESG and firm systematic risk over the period January 2016–September 2020 for firms listed on the S&P Europe 350. Based on their research outcomes, companies with elevated ESG ratings tend to have reduced exposure to systematic risk. Specifically, during the COVID-19 period, only the S and G scores have a notable and significant influence on systematic risk.

Turning our attention to risk measurement, it becomes evident that various risk metrics are employed. Systematic risk is commonly employed as the primary indicator of risk among market-based risk measures (Sassen et al., 2016). An analysis of a panel of S&P 500 companies was concluded between 1992 and 2009 by Oikonomou et al. (2012). They find that social responsibility exhibits a weak negative association with systematic risk, whereas irresponsibility had a strong positive association with systematic risk. Albuquerque et al.(2019) introduced an industry equilibrium model, along with empirical findings, by analysing a dataset consisting of U.S. companies from 2003 to 2015. They documented that firms with a long year of CSP experience reduced systematic risk. A recent study using data from 47 publicly listed banks across various countries during 2007–2020, conducted by Aevoae et al. (2023) demonstrated that the combined ESG and G scores have a favorable effect on the systematic risk of banks. Additionally, Merton's (1974) model, which is based on the credit risk of a firm, has served as a standard yardstick for market risk in numerous studies. For instance, regarding this model and accounting-related risk indicators represented by the Z score, Shahrour et

al. (2021) found that ESG scores help mitigate firms' default risk particularly during financial crises. Meles et al. (2023) used Bharath and Shumway's (2008) model as a market-based risk indicator derived from Merton's (1974) model also documented comparable results. They found that green innovation has a stronger effect in mitigating default risk in countries with market-oriented financial systems, than in those bank-oriented financial systems.. In their extensive study, Lin and Dong (2018) measured firms' distress level using Altman Z-scores and explored the same relation for the US sample. They discovered that firms with a history of CSR engagement had a lower likelihood of bankruptcy. In a similar vein, Boubaker et al. (2020) examined the same relation for US- listed firms from 1991 to 2012. They use Altman's (1968) Z-score, Ohlson's (1980) O-score, and Zmijewski's (1984) ZM-score to assess firm risk. They reach the same conclusion: CSR engagement reduces firm risk. Unlike other studies, Cooper and Uzun (2019) included defaulted and non-defaulted US companies in their study for the years between 2007 and 2014. As a result, their study concluded that firms with elevated CSR levels exhibit reduced susceptibility to bankruptcy, assuming all other factors remain constant.

Theoretical Framework and Hypothesis Development

Firm risk includes various risks, including systematic, idiosyncratic, legal, and credit risks. Firms can reduce their various risks by improving financing conditions through ESG/ CSR ratings (Meles et al., 2023). Investment in ESG activities reduces firm risk because they increase social awareness and managers' motivation. Moreover, motivated employees act more loyal and innovative when dealing with firm risk (Vishwanathan et al., 2020). The main source of firm risk might be either internal factors (i.e.,bad management) or economic factors such as the worldwide economic downturn or COVID-19 pandemic. Regarding economic circumstances or cycles, fewer firms face risk during periods of economic prosperity. It is common, however, for firms to experience problems associated with external factors during economic crises (Habermann & Fischer, 2023). Although a firm cannot prevent external factors, it can reduce the possibility of being in a distress position at an early stage with sound management mechanisms (Whitaker, 1999). Thus, from the risk mitigation perspective, ESG investments provide firms with a greater level of capital and relational wealth, which improves their transparency and reduces doubt about their future cash flow. On the basis of the risk mitigation view, it can be said that ESG investments function as a type of insurance for a company (Bouslah et al., 2018). Furthermore, a socially responsible investor makes decisions in light of both financial and non-financial factors. When examining theoretical models depicting the relationship between ESG factors and expected returns, it is crucial to highlight that socially responsible assets are highly valued and typically associated with lower risk, irrespective of their return potential. Conversely, assets linked to irresponsibility are often undervalued and tend to entail higher levels of risk (Fama & French, 2007).

In contrast to the aforementioned view, the overinvestment view assumes that firm risk and ESG are positively related. Investment in ESG activities is considered a waste of scarce resources, resulting in more volatile cash flow for the firm (Goss & Roberts, 2011). Moreover, more investment in ESG activities requires permanent maintenance with stakeholders and thus leads to an increase in fixed costs (Perez-Batres et al., 2012). Overall, value-destroying ESG investment activities lead to firm risk. Although philanthropic activities on behalf of shareholders may seem beneficial at first glance for firms, in reality, these activities are more costly than beneficial (Porter & Kramer, 2006). In addition, this view posits (based on agency theory) that managers may invest more in social performance than the potential cost of shareholders to enhance their personal reputation (Barnea & Rubin, 2010) or to attract environmental and climate activists to enhance their existing position in a firm (Cespa & Cestone, 2007).

As a third alternative approach to understanding ESG and firm risk associations, the lens of institutional theory is considered. Several studies of the CSP-CFP relationship have indicated that CSP reduces risk, however, institutional theory suggests that its effect varies based on the length of institutionalization (Brower & Dacin, 2020). In particular, innovative firms lack mature administrations or accounts for their operations and, therefore appear unnecessary or unreliable to acquire resources from other interest groups, increasing their risk exposure (Bansal & Clelland, 2004). Hence, numerous studies have provided evidence that as CSP becomes more deeply ingrained within organizations, it tends to operate in a manner akin to an insurance mechanism (Godfrey et al., 2009; Doh et al., 2010; Mishra & Modi, 2013).

However, regardless of a firm's degree of institutionalization or market structure, they are reluctant to invest in ESG activities during periods of unfavorable business cycles. Hence, during adverse macroeconomic conditions, firms may opt to reduce their investment in ESG activities to utilize resources more efficiently to utilize their resources effectively, or they may decide to invest in these activities to set themselves apart and enhance their differentiation in the market (Branca et al., 2012). As a result, examining ESG and risk associations before and during the COVID-19 period is relevant because adverse macroeconomic conditions provide a natural laboratory for testing the main theories argued in the literature, e.g., the risk mitigation perspective and the overinvestment perspective (Bouslah et al., 2018). As a result, we contend that firms during economic upswings do not depend on stakeholders to assist them in overcoming financial difficulties, as firms in such periods tend to avoid insolvency irrespective of their CSP level. However, those firms benefit from their stakeholders during economic downturn periods to overcome financial difficulties. Consequently, the first hypothesis is developed as follows;

H1: ESG is negatively related to firm risk, particularly during the COVID-19 pandemic

Second we argue in this study that market-based risk measurement reflects firms' actual status more precisely; therefore, systematic risk is more informative than accounting-based

risk measurement regarding CSP. There is a greater impact at the firm's image on measures of market risk than on measures of accounting risk. CSP results in risk mitigation primarily through the mediation of factors such as reputation, market risk, and the infusion of fresh capital resources (Orlitzky & Benjamin, 2001). Additionally, as market prices reflect information instantly and unbiasedly, we assume the same is true for firm risk, leading us to propose the following hypothesis.

H2: ESG is more related to systematic risk than accounting-based risk.

Data and Methodology

Sample Selection

The social performance data for European firms from TR Eikon database is widely used by many scholars (e.g.,Habermann & Fischer, 2023; Barth et al., 2022; Korinth & Lueg, 2022; Engström and Martinsson 2020; Sassen et al., 2016). The CSP scores extracted from this database are trained by analysts at 900 evaluation points per firm-year. By doing so, the collected data regarding the dimensions of environment, social, and governance are, verified at multiple levels (Desender & Epure, 2015). Regarding data variability and distribution, this database is considered more anti-biased and relevant than comparable ESG ratings (Habermann & Fischer, 2023). This database gathers information from different sources, including stock exchange filings from firms, CSR and annual reports, and websites managed by non-governmental organizations. After collection, these qualitative variables will be transformed into quantitative variables (Ioannou & Serafeim, 2012)..

We chose firms from seven European countries as the sample for this study because these countries have stable economic conditions and a strong focus on environmental, social, and governmental factors. Because we access relevant data from the TR Eikon database, we refrain from including the financial sector because of its unique capital characteristics and reporting methods. After this elimination, 565 firms remained, and following that, we removed some firms due to missing values. After winsorizing the Z and ZM scores at the 1st and 99th percentiles, 172 firms remained. We chose the starting period of 2015 because there were not enough data on firms' beta values before this year. Further, this timeline does not include any financial crisis or external shocks until 2020, when the COVID-19 pandemic had a widespread impact on both financial and equity markets.

Methodology

Measurement of CSP

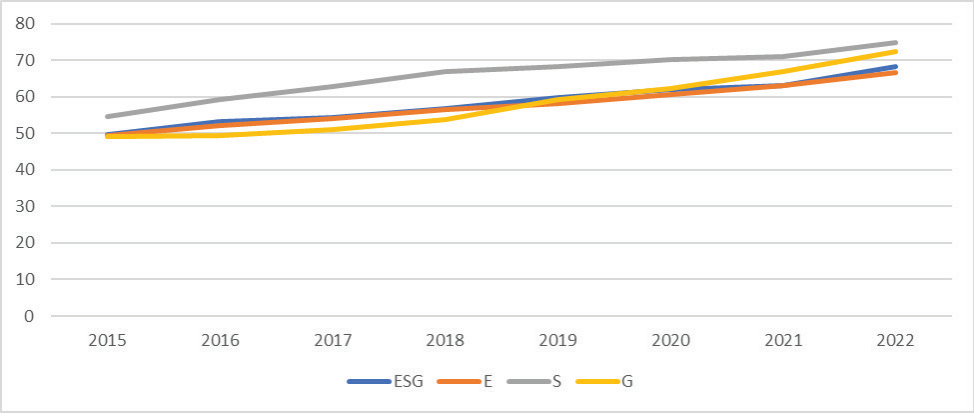
Our study measures firms'CSP performance using Refinitiv ESG scores as an independent variable. By doing so, we use four different CSP metrics namely; overall ESG combined

score and its subcategories. The values range from 0 to 100, where 100 represents the highest related score and 0 represents the lowest related score. As indicated, environmental factors include data pertaining to firms' impacts on energy consumption, greenhouse gas emissions, land use, and waste management, while social factors include the percentage of women in the workforce, a company's reputation, customer and society loyalty, and governance factors provide an evaluation of the firm's capability to sustain long-term relationships with shareholders and corporate sustainability strategy performance (Habermann & Fischer, 2023; Lueg et al., 2019; Ioannou & Serafeim, 2012).

Table 1 illustrates the mean values of the ESG combined score, and its subcategory scores across the selected countries from 2015 to 2022.

According to the development of the ESG combined score and, its component scores, the highest improvement was seen in governance performance, followed by the second highest increase in social performance, and the lowest increase was observed in environmental performance among its counterparts. When focusing only on the pandemic period (2020-2022), the highest improvement was again identified in governance performance, followed by environmental performance, and, finally, social performance.

Table 1
Avarage of ESG, E, S, and G scores between 2015 and 2022



Year	ESG Score	Environmental Score	Social Score	Governance Score
2015	49.68179	49.31531	54.77384	49.12334
2016	53.35665	52.22982	59.37203	49.29981
2017	54.44768	54.13355	62.79126	51.19006
2018	56.70036	56.45466	66.93289	53.68624
2019	59.86666	58.29202	68.20227	59.22280
2020	61.91702	60.62448	70.24734	62.28956
2021	63.00271	63.17126	71.08700	67.04291
2022	68.43536	66.78820	74.83673	72.38629

Measuring Firm Risk

Firm risk is defined as the nature of a firm's operations due to any internal or external resources that, in turn, impact firms' rentability. In other words, firm risk represents the combination of business and financial risk. The first category refers to equity risk associated with firms' operating activities, while the latter category refers to an extra risk associated with debt financing (Jo & Na, 2012). To measure firm risk, this study uses both default risk based on accounting measurements and systematic risk (beta) as a dependent variable. In accounting-based models, default risk is predicted using financial statements; however, in market-based models, default risk is predicted using bond market data and option pricing theory.

Accounting Risk

Accounting-based firm risk measurement methods are used in a growing body of literature (Habermann & Fischer, 2023; Meles et al., 2023; Cohen, 2022; Boubaker et al., 2020; Lin & Dong, 2018). To include only accounting-based information, we measure accounting-based risk using the Z''-score (Altman et al., 1998) and ZM-score (Zmijewski, 1984).

The first risk measurement model Z''-score is computed as follows;

$$Z''\text{-score} = 6.56(WC/TA) + 3.26(RE/TA) + 6.72(EBIT/TA) + 1.05(EQ/TL),$$

where WC refers to working capital, TA to total assets, RE to retained earnings, EBIT to earnings before interest and tax; EQ to equity book value; TL to liabilities book value.

The Z″-score is computed by considering four factors: liquidity, overall profitability, current operational effectiveness, and capital structure stability. Typically, a decrease in the Z″-score indicates a decrease in the risk of financial distress. An alternative to accounting-based risk measurement is the ZM-score, which is calculated as follows;

$$ZM\text{-score} = -4.336 - 4.513(NI/TA) + 5.679(TL/TA) + 0.004(CA/CL),$$

where net income is denoted as NI, total assets as TA, total liabilities as TL, current assets as CA, and current liabilities as CL. The ZM-score is assessed using three indicators: profitability, leverage, and liquidity. Moreover, it's important to note that an increase in the ZM-score is linked to a higher risk of financial distress.

Market Risk

In contrast to accounting-based risk measurement methods, systematic or market-based risk (beta) is included in this study to evaluate a firm's risk and its CSP. Systematic risk is macroeconomic by nature. Systematic risks include shocks to economic growth, interest rates, oil prices, and inflation rates (Gregory et al., 2014). Since the COVID-19 pandemic devastated most finan-

cial and equity markets, it can be considered systematic risk; thus we anticipate a strong association between firms' systematic risk and their CSP, especially during the COVID-19 pandemic.

We use "beta" value to measure systematic risk retrieved from the TR Eikon database. A least squares linear regression line is employed to calculate how each firm's stock price fluctuation aligns with its market price fluctuation for a given year.

Empirical Strategy

This study uses panel regression to analyze the relationship between firm risk and CSP. Panel regression is preferred for this research because it allows us to control changes between firms and intra-firm variations across years.

The fixed-effect model was applied to conclude the empirical analysis because it imposes fewer restrictions than the random-effects model. In addition, the *Hausman* test also confirmed the preferences of the fixed-effect model. To control for any changes within a specific firm across years, we include the firm-fixed effect. This approach allows us to account for all time-invariant effects among firms, such as management, sector, location, and capital market (Meles et al., 2023; Barth et al., 2022; Do, 2022). Similarly, to control for any changes in a given year across firms, we employ the year-fixed effect. This enables us to also account for variations in economic conditions that may affect firm risk. The Breusch–Pagan test was used to determine the presence of heteroskedasticity. Clustered standard errors were then employed, and the tested relationship was represented as follows;

$$firmrisk_{it} = \beta 0 + \beta 1\ ESG_{it} + \beta 2\ ROA_{it} + \beta 3\ LEV_{it} + \beta 4\ SIZE_{it} + \beta 5\ MTB_{it} + \beta 6\ LIQ_{it} + FE_i + FE_t + \varepsilon_{it} \quad (1)$$

Furthermore, several firm characteristics are added, consistent with previous studies (Meles et al., 2023; Habermann & Fischer, 2023; Korinth & Lueg, 2022). The data for these firms characteristics were obtained from the TR Eikon database. The firm characteristics used in this study are comprehensively outlined in Table 2. European firms were chosen as a locus of research and their distribution and percentage are presented in Table 3.

Table 2
Definition of variables

Variables	Definition
BETA	market risk of a firm where, value indicates a higher level of risk, where lower value indicates a reduced risk level
Z''-Score	the business risk of a firm, where a higher value indicates a reduced risk level and a lower value indicates a higher risk level
ZM-Score	the business risk of a firm, where a higher value indicates a higher risk level, whereas a lower value indicates a reduced risk level
ESG-Score	combined environmental, social, and governance pillar scores ranging between 0 and 100, and high values represent high commitment to these activities.

Variables	Definition
E-Score	environmental pillar scores ranging between 0 and 100, and high values represent high commitment to environmental activities.
S-Score	social pillar scores ranging between 0 and 100, and high values represent high commitment to social activities.
G-Score	governance pillar scores ranging between 0 and 100, and high values represent high commitment to governance activities.
ROA	profitability ratio computed as net income deflated by total assets
SIZE	natural log of total assets
LEV	net leverage ratio is determined by subtracting cash and marketable securities from long-term liabilities and deflating by the market value of equity
MTB	Market-to-book ratio is calculated by dividing the market value of a firm by its book value
LIQ	cash and short-term assets are deflated by total assets

Table 3
Sample Composition

Country	Number	Percentage
Austria	10	5.7
Belgium	16	9.1
Denmark	16	9.1
Germany	52	29.7
Luxembourg	8	4.5
Netherlands	28	16
Switzerland	45	25.7
Total	175	100

Results

Correlations and Descriptive Statistics

Table 4 provides descriptive statistics for social performance metrics, firm risk measures, and firm characteristics. Using beta as a market risk indicator, the average firm in this study has a beta of 0.926, ranging from -0.9 to 2.8. The Z''-score, a measure of business risk, has a mean value of 4 and ranges from -7.5 to 135 points. The ZM-score, another business risk indicator, has a mean value of -1.23 and ranges from -5 to 16. The combined ESG scores, representing social performance, have a mean value of 58, with, a range of 18 to 94. Among the ESG components, the environmental pillar has the lowest mean value at 57.4, ranging from 0 to 98. The social performance score has the highest mean value of 66, ranging from 0.6 to 98, while the governance performance score has a mean value of 58, ranging from 6 to 98. The standard values of firm characteristics are reasonable. For instance, the average ROA was 0.37, ranging from -3 to 0.4. The SIZE ranged from 6 to 18, with an average value of 10. The

LEV has an average value of 0.50, ranging from -0.45 to 21.6. The mean MTB value was 3.5, ranging from -158 to 168. Finally, LIQ had a mean value of 0.47, ranging from -0.7 to 1.2.

Table 4
Descriptive Statistics

Variables	Mean	Standard Deviation	Minimum	Maximum
BETA	.9262857	.4590124	-.9075083	2.804779
Z''-Score	4.079628	8.814808	-7.5063	135.4045
ZM -Score	-1.236404	1.386678	-5.288278	16.02722
ESG-Score	58.26158	18.35178	3.909928	94.25075
E-Score	57.46171	25.08903	0	98.20076
S-Score	65.91089	22.05926	.6271777	98.20207
G -Score	57.71435	22.37887	6.088693	97.76803
ROA	.0379326	.1497221	-3.292467	.3994034
SIZE	9.902354	.6821107	6.218404	11.78328
LEV	.5046848	1.030138	-.4592628	21.60505
MTB	3.520607	9.216814	-158.5088	168.3729
LIQ	.4773746	.2144396	-.7188494	1.193019

Additionally, Table 5 presents the average values of social performance and firm risk both after and during the crisis. Throughout the COVID-19 period, social performance and firm risk have increased. In terms of social performance, the greatest increase is observed with governance activities, followed by social activities, and the smallest increase is observed with environmental activities. Based on firms' risk performance both market and business risks, have increased. The beta and ZM-scores have shown differ significantly before and during the pandemic. However, it is worth noting that the increase in business risk, as measured by the Z''-Score, did not demonstrate a statistically significant difference between these two periods.

Table 5
Risk And Social Performance Before And During COVID-19

	Social Performance			
	ESG-Score	**E-Score**	**S-Score**	**G-Score**
Pre-crisis	54.80229	54.06282	62.43278	52.48293
Amid-crisis	64.39881	63.49179	72.0815	66.99555
p value (difference)	0.0000	0.0000	0.0000	0.0000
	Risk Performance			
	BETA	**Z"-Score**	**ZM -Score**	
Pre-crisis	.8485577	4.138135	-1.283948	
Amid-crisis	1.064185	3.975454	-1.152056	
p value (difference)	0.0000	0.6272	0.0466	

Table 6
Correlation Matrix

Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(1)ESG	1											
(2)E	0.73*	1										
(3)S	0.80*	0.68*	1									
(4)G	0.67*	0.43*	0.51*	1								
(5)BETA	0.13*	0.13*	0.15*	0.22*	1							
(6)Z"-Score	-0.25*	-0.24*	-0.24*	-0.16*	0.09*	1						
(7)ZM -Score	0.14*	0.16*	0.14*	0.15*	0.08*	-0.45*	1					
(8)SIZE	0.30*	0.54*	0.39*	0.33*	0.07*	-0.05*	0.12*	1				
(9)MTB	0.12*	0.06*	0.12*	0.04	0.02	0.01	-0.07*	-0.02	1			
Variables	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
(10)ROA	0.05*	0.05*	0.06*	-0.01	-0.02	0.12*	-0.54*	0.11*	0.09*	1		
(11)LEV	-0.02	0.04	0.01	0.04	0.03	-0.15*	0.45 *	0.16*	-0.11*	-0.38*	1	
(12)LIQ	0.04	-0.04	0.04	0.01	0.20*	0.06*	-0.08*	-0.27*	0.16*	0.11*	-0.18*	1

** statistical significance at the %5 level*

To address the computational problems associated with multicollinearity, Pearson correlation coefficients were computed and are demonstrated. The correlations among all variables were computed and demonstrated in Table 6. In general, no correlation exists between variables that exceed 0.54 (correlation between SIZE and E and between ROA and ZM scores) that would preclude the regression analysis, except for the correlation between ESG components, which is why it is not possible to combine any ESG component with the combined ESG variables. In view of the correlation between SIZE and ESG components, it should be noted that larger organizations strive to achieve high social performance scores, particularly regarding environmental activities. These firms are prone to investing in these activities because they receive more attention and have more resources to allocate. The same negative correlation between ROA and ZM-score suggests that firms with a high profitability ratio are less likely to be in an endangered position in terms of business risk.

Regression Results

The link between CSP and firm risk is examined using model (1), as discussed in the section on "Empirical Strategy". Based on this model, Table 7 illustrates an overview of the association between market risk (beta) and ESG both before and during the COVID-19 pandemic. Considering that, ESG does not have a positive influence on market risk during economic upswings. However, the ESG and E scores have a negative impact on the market risk during the COVID-19 pandemic. Altough the coefficients of S and G scores are also negative, they do not have a significant effect on market risk during this period. In terms of risk mitigation, the E score exhibits a more pronounced role than its counterparts. This emphasize that firms with stronger environmental performance are better prepared for the changing conditions and regulations, which enable them to manage market risk during a economic downturn.

Due to the size of firms, there is a difference between large and small firms during the pandemic period. A large firm's market risk is higher during a pandemic than a small firm's. However, during periods of economic prosperity, size does not affect bearing market risk. With a more complex structure, large firms may have a more difficult time regulating their supply chains during crisis periods, which may lead to greater market risk. In addition, small firms respond quicker to market crises than large firms (Zhang & Fang, 2022). It appears that before COVID-19, firms' profitability ratio had a negative effect on market risk, whereas during COVID-19, its impact was deemed insignificant. Although highly profitable firms seem far from being to be exposed to market risk before the pandemic, all firms are exposed to market risk during the pandemic regardless of their rentability level. We also included firm financial ratios following Bouslah et al. (2018). It appears to expose firms to market risks during economic upswings; however, its impact seems insignificant during economic downturn. Firm liquidity seems to serve as insurance-like protection against market risk before the pandemic, but it has an insignificant impact during the pandemic. Furthermore, it should be highlighted that firms' liquity is deteriorated during adverse economic states. A firm's liquidity appears to act as a form of protection against market risk before a pandemic, but it becomes insignificant during a pandemic. Furthermore, it should be noted that during periods of economic hardship, all firms' liquidity is adversely affected (Baig et al., 2021).

Table 7
ESG And Market Risk

Dependent Variable: BETA								
Panel A: before COVID-19					**Panel B: COVID-19**			
	ESG	**E**	**S**	**G**	**ESG**	**E**	**S**	**G**
ESG	.0015 (.0010)				-.0016* (.0008)			
E		.0019 (.0012)				-.0049* (.0025)		
S			.0009 (.0011)				-.0001 (.0019)	
G				.00165 (.0010)				-.0007 (.0010)
SIZE	.0808 (.1107)	.0846 (.1106)	.0918 (.1110)	.0666 (.1095)	.7095*** (.1735)	.7079*** (.1747)	.7220*** (.1750)	.7212*** (.1706)
MTB	.0002 (.0009)	.0002 (.0008)	.0003 (.0009)	.0004 (.0008)	-.0025 (.0017)	-.0025 (.0017)	-.0026 (.0016)	-.0026 .0016
ROA	-.0927* (.0504)	-.0944* (.0495)	-.0951* (.0501)	-.0899* (.0498)	-.1903 (.2384)	-.1992 (.2425)	-.1943 (.2417)	-.1937 (.2374)
LEV	.0227** (.0106)	.0222** (.0101)	.0229** (.0105)	.0220** (.0103)	-.0039 (.0186)	-.0042 (.0184)	-.0037 (.0179)	-.0037 (.0182)
LIQ	-.1902* (.1097)	-.1833* (.1091)	-.1966* (.1107)	-.1757 (.1120)	.0379 (.1762)	.0354 (.1767)	.0454 (.1753)	.0393 (.1769)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	875	875	875	875	525	525	525	525

Dependent Variable: BETA								
Panel A: before COVID-19					**Panel B: COVID-19**			
	ESG	**E**	**S**	**G**	**ESG**	**E**	**S**	**G**
R-squared	0.1990	0.1935	0.2963	0.1646	0.1063	0.1108	0.1130	0.2851
Number of Firms	175	175	175	175	175	175	175	175

*Standard errors of clustered and heteroscedasticity robust models are provided in parentheses. ***, **, and * indicate statistical significance at the 1, 5, and 10% levels, respectively.*

As with market risk, business risk is calculated using both the Z'' and ZM scores, and its relationship with CSP is illustrated in Tables 8 and 9. As can be seen, ESG has no impact of on business risk before and during the pandemic period. Altough the findings from the market risk analysis support H1's hypothesis that ESG is negatively correlated with firm risk, this hypothesis cannot hold true when considering business risk. Therefore, H1 is partially supported based on these analysis results. On the other hand, the H2 hypothesis can be accepted because, it holds that ESG is more closely related to market risks than to business risks derived from accounting data.

Based on firm size, it can be concluded that large firms are more exposed to business risk before and during the pandemic. Because of large firms' greater susceptibility to recessionary risk, they are more susceptible to default risk (Denis & Denis, 1995; Lang & Stulz, 1992). Similar patterns are observed in terms of profitability ratios when comparing these two periods. During both periods profitable firms are not exposed to going bankrupt. The book-to-market ratio is aimed at detecting differences between value and growth companies (Sassen et al., 2016). Although the market-to-book ratio has no impact on market risk, its impact is observed on business risk during economic prosperity. This implies that value companies were less vulnerable to business risk before the pandemic. Additionally, financial leverage negatively impacts market risk during periods of economic upswing and negatively impacts, business risk during COVID-19.

Table 8
ESG And Business Risk (Based On Z''-Score)

Dependent Variable: Z'' Score								
Panel A: before COVID-19					**Panel B: COVID-19**			
	ESG	**E**	**S**	**G**	**ESG**	**E**	**S**	**G**
ESG	-.0190 (.0162)				-.0139 (.0126)			
E		-.0338 (.0338)				.0330 (.0224)		
S			-.01542 (.0168)				.0588 (.0454)	
G				-.0013 (.0077)				-.1237 (.0920)
SIZE	-4.3241* (2.496)	-4.339* (2.438)	-4.4631* (2.447)	-4.4242* (2.476)	-13.214 (15.630)	-12.931 (15.551)	-12.917 (15.447)	-13.319 (15.505)

Dependent Variable: Z" Score								
Panel A: before COVID-19					**Panel B: COVID-19**			
	ESG	**E**	**S**	**G**	**ESG**	**E**	**S**	**G**
MTB	-.0032 (.0059)	-.0017 (.0060)	-.0036 (.0059)	-.0042 (.0061)	-.0166 (.01824)	-.0166 (.01840)	-.0200 (.0196)	-.0168 (.0187)
ROA	5.5019** (2.2873)	5.5296** (2.2974)	5.5397** (2.2936)	5.5036** (2.2931)	26.633* (13.844)	26.777* (13.890)	26.566* (13.800)	26.725* (13.384)
LEV	.0285 (.04018)	.0378 (.0420)	.0254 (.0407)	.0285 (.0418)	.2997 (.2757)	.2985 (.2827)	.2625 (.2783)	.3070 (.2449)
LIQ	-.4075 (2.4024)	-.5574 (2.4249)	-.3081 (2.3620)	-.3530 (2.3768)	.2208 (4.4340)	.4651 (4.4233)	-.0112 (4.3853)	-.6439 (4.228)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	875	875	875	875	525	525	525	525
R-squared	0.1975	0.1942	0.2960	0.1577	0.2688	0.2683	0.2686	0.2765
Number of Firms	175	175	175	175	175	175	175	175

*Standard errors of clustered and heteroscedasticity robust models are provided in parentheses. ***, **, and * indicate statistical significance at the 1, 5, and 10% levels, respectively.*

Table 9
ESG and business risk (based on ZM -Score)

Dependent Variable: ZM score								
Panel A: before COVID-19					**Panel B: COVID-19**			
	ESG	**E**	**S**	**G**	**ESG**	**E**	**S**	**G**
ESG	.0002 (.0016)				-.00015 (.0013)			
E		-.0033 (.0021)				.00043 (.0017)		
S			-.0009 (.0018)				-.00004 (.0028)	
G				.0010 (.0011)				-.0019 (.0019)
SIZE	1.3175*** (.3403)	1.3292*** (.3410)	1.3178*** (.3415)	1.3043*** (.3409)	1.8694*** (.3854)	1.8728*** (.3835)	1.8704*** (.3854)	1.8671*** (.3865)
MTB	-.0067*** (.0020)	-.0064*** (.0020)	-.0066*** (.0020)	-.0066*** (.0021)	.0098 (.0060)	.0098 (.0060)	.0098 (.0060)	.0098 (.0060)
ROA	-5.222*** (.1224)	-5.222*** (.1225)	-5.220*** (.1230)	-5.220*** (.1225)	-6.169*** (.4292)	-6.1671*** (.42871)	-6.1694*** (.4294)	-6.1674*** (.4266)
LEV	.0448 (.0338)	.0449 (.0335)	.0447 (.0336)	.0443 (.0337)	.0967** (.0384)	.0967** (.0385)	.0967** .0390	.0968** .0381
LIQ	.2507 (.3591)	.2435 (.3580)	.2504 (.3593)	.2623 (.3582)	-.3478 (.2650)	-.3448 (.2651)	-.3470 (.2688)	-.3620 (.2631)
Firm FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Observations	875	875	875	875	525	525	525	525
R-squared	0.1954	0.1930	0.2951	0.1582	0.2047	0.2056	0.2047	0.2069
Number of Firms	175	175	175	175	175	175	175	175

*Standard errors of clustered and heteroscedasticity robust models are provided in parentheses. ***, **, and * indicate statistical significance at the 1, 5, and 10% levels, respectively.*

Conclusion

In this study, we examine whether and how ESG and its components impact firm risk during the COVID-19 pandemic. The empirical strategy used fixed-effect regression with a sample of 1400 firm-year observations from European countries. To avoid multicollinearity and potential endogeneity problems, each ESG component and risk measurements were separately analyzed. In contrast to other studies (Habermann & Fischer 2023; Zhang et al., 2023; Lueg et al., 2019), we use both business and market risk to determine their association with firms' ESG performance. In addition, many studies used a sample that included financial crises, which does not provide a true reflection of the impact of CSP on firm risk. Due to this problem, the samples before and during COVID-19 is separated and compared. According to the findings of this study, CSP is more strongly associated with market risk than with business risk. Furthermore, it is concluded that CSP mitigates market risk during the COVID-19 economic downturn period. It is difficult to observe the potential contribution of ESG to risk elimination during the economic upswing because, each firm is capable of overcoming potential risks through credit or ensuring greater demand for goods and services. Consequently, it can be concluded that investment in CSP during periods of economic upswing aligns with agency theory because investment under these conditions wastes resources and disburses firms' cash. However, during at financial crisis, investments in CSP activities will prove beneficial, as can be seen from the viewpoint of stakeholder theory. Based on prior research (Habermann & Fischer 2023; Broadstock et al., 2021; Bouslah et al., 2018) and the results of this study it can be inferred that there exists a positive influence of CSP particularly during periods of economic adversity. Thus, the main conclusions of this study support the risk mitigation view.

As provided in the "Data and Methodology" section , since 2015, the most increase was observed in the governance pillar score and the least increase was observed in the enviromental pillar score. Considering the pandemic period, the improvement order has changed, and environmental performance is ranked second. Further combined ESG and each of its components showed improvement before and during the pandemic period. Business and market risk also increased during the same period. Accordingly, when considering ESG components, environmental performance is the main driver of risk mitigation during the pandemic. As a result, firms with high environmental pillar scores are perceived as offering investors refuge during the COVID-19 pandemic. Due to the increasing importance of resource use and environmental stability during the COVID-19 pandemic, firms began investing more in eco-friendly technologies; therefore, the environment was more prominent for investors than social and governance issues. Because each economic crisis has different reasons and consequences, the importance of the ESG subcategories may vary depending on the type of crisis. Furthermore, the locus of research plays an important role in determining CSP and firm risk relationship. Considering this, we recommend that further studies investigate how ESG and its components impact firm risk, with gross domestic product (GDP) as a moderating factor.

The findings of this study also show that market risk is closely related to CSP whereas there is no association between business risk and CSP. The COVID-19 pandemic directly affects both the economy and financial markets; thus, its effect on market risk is more significant than its impact on business risk. Therefore, other studies are also recommended to focus more on market-based risk measurement models (i.e, Bharath and Shumway, 2008; Merton, 1974) or actual financial failure (Cooper and Uzun, 2019) to provide more accurate results.

Nevertheless, some caveats should be considered when interpreting the results of this study. The first limitation of this study is that, it is based solely on one market risk indicator. However, beta is also widely used in the literature as a market risk indicator, apart from idiosyncratic and tail risks. This study also included firms from countries with higher GDP per capita and a higher human development index. These countries already have developed capital markets and legal systems; thus, it is difficult to observe the positive effects of CSP on firm risk, particularly during economic growth periods. Consequently, the conclusions drawn from this study may not be readily applicable to emerging economies or to markets characterized by less robust capital markets and legal systems, where localized financial crises are more likely to occur and have a more significant adverse impact. Finally, this study measured firms' CSP performance using firms' ESG performance obtained from the TR Eikon database. Although this database is widely used in the literature and involves numerous ESG metrics, it is doubtful to consider it as a fully CSP performance reflective mechanism.

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RESEARCH ARTICLE

Effect of Festival Satisfaction on Destination Loyalty through Destination Overall Image: The Case of Alaçatı Herb Festival

Ayşe Arslan Özkan[1], Erkan Yıldız[2]

Abstract
This study examines the relationships among festival success factors, festival satisfaction, destination image and destination loyalty. Based on the literature review, festival success factors were identified and a model was developed to measure the direct impact of these factors on destination loyalty and the impact of these factors through the overall image of the destination. Data were collected during the 11th Alaçatı Herb Festival held between March 24-27, 2022. The data obtained were analyzed with the structural equation modeling. According to the results of the study, the program, festival area, staff, souvenirs, and information dimensions of festival success factors affect festival satisfaction. The effects of convenience and food dimensions on festival satisfaction were statistically insignificant. The festival satisfaction and destination overall image variables have positive effects on destination loyalty, and the festival satisfaction variable has positive effects on the destination overall image. The destination overall images an integral partial mediating role in the relationship between festival satisfaction and destination loyalty.

Keywords: Festival Success Factors, Festival Satisfaction, Destination Image, Destination Loyalty

Introduction

The tourism sector is recognized worldwide as a driving force for national and global development (www.unwto.org). Therefore, considering the dynamism of tourism, destinations are looking for ways to be successful, and the image of the destinations is very important at this point. A destination with a positive image has a stronger competitive power compared to other destinations (Şahin & Baloğlu, 2011). The destination image affects the destination selection process and the general behavior of consumers (Bigne et al., 2001). Accordingly, destinations resort to some activities to improve their image and increase their destination loyalty. Festivals are used extensively to create uniqueness among competing destinations.

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Events are among the driving forces that encourage people to travel. In recent years, planned events have been used as an alternative to the tourism product to attract visitors to the region, make them stay longer and spend more (Osti et al., 2012). Following this trend, local governments organize festivals to increase destination attractiveness for both international and local visitors. Festivals are tools that provide opportunities to improve the destination image, revitalize the economy, culture and traditions; they bring economic, social and cultural benefits to the communities they are in and contribute to destination marketing (Tanford & Jung, 2017). They also offer tourists the opportunity to experience the local culture and lifestyle of the destination in a very limited time (Deng & Li, 2014). In destinations like Alaçatı with limited space and a short season, planned events have strategic implications for destination image building and destination loyalty.

Many elements such as culture, art and shopping are used as themes for festivals to attract tourists to destinations. Food is an important part of cultural tourism and is increasingly seen as an important area of interest, especially in rural areas (Hall & Mitchell, 2001). This can be explained by the fact that local foods or food products have the potential to increase sustainability in tourism, contribute to the authenticity of the destination, strengthen the local economy and provide an environmentally friendly infrastructure (Handszuh, 2000). Food helps tourists have authentic experiences (Sims, 2009). Tasting delicious food and experiencing food-related culture are among the travel motivations of modern tourists (Horng & Tsai, 2012). From this perspective, food as an important part of the travel process can be used as an attraction (Boyne & Hall, 2004; Stone et al., 2018). Indeed, this is supported by the fact that tourists typically spend around 40% of their budget on food while traveling (Boyne et al., 2002). In parallel with the growing interest of tourists in food and food-related culture, a number of food festivals have emerged around the world. In these festivals, local cuisine is emphasized and the theme is food. The festival contributes both to the destination economy (Rand et al., 2003) and to the added value of existing tourism products (Quan & Wang, 2004). Furthermore, the festival is seen as an element that attracts tourists to the region and encourages them to spend money while promoting the destination (Cudny, 2014). Thus, it is important for destination marketers and experts to understand the relationship between the perceived service quality and visitor satisfaction of festival participants and their intention to participate in the event again, in terms of creating a destination image and building destination loyalty (Carse et al., 2018). For this reason, it is crucial to examine the effects of festival satisfaction of visitors on the destination image and destination loyalty. The current study examines the relationships between festival success factors, festival satisfaction, destination image and destination loyalty through structural equation modeling.

Literature Review

Having been a part of human life since ancient times, festivals are now regarded as one of the rapidly developing popular activities (Zhou, 2010). Festivals vary from culture, art, sports, business and food and beverage festivals. For people to escape from everyday life and experience new experiences, each festival should present many factors together in its own unique way. Bringing these factors together in the planning and organization processes of festivals is the key to festival success.

Festivals are essential both for the promotion and marketing of local products and for the destination's sustainability. Additionally, festivals can help the destination attract more tourists by impacting the destination image, differentiate and gain superiority over competing destinations, and enhance long-term destination loyalty. Therefore festivals have been the subject of many studies, both local and abroad, recently. In a recent review of 423 festival studies, Getz (2010) identified three main discourses in this body of work—namely, (1) the roles, meanings and impacts of festivals in society and culture; (2) festival tourism; and (3) festival management. Other important aspects considered in previous research on festivals include festival antecedents (e.g. participation motivations), planning and management, and outcomes (e.g. economic).

When the relevant literature is evaluated, it is seen that some studies focus on festival participation motivations (Crompton & McKay, 1997; Nicholson & Pearce, 2000; Lee et al., 2004; Wamwara & Bettina Cornwell 2009; Maeng et al., 2016; Nongsiej & Mothila 2019); some of them focus on factors of festival success (Khuong & Khanh Uyen 2018; Carse et al., 2018); main success factors that affect the loyalty of festival visitors (Dalgiç & Birdir, 2020); attributes of festival service quality perceived (Markovic et al, 2015); the impact of festivals on destination image formation (Hernández-Mogollón, 2018; Al-Dweik, 2020; Thongrom, 2019; Leal Londoño et al., 2022); the effects of festivals on visitor satisfaction and loyalty (Yoon et al., 2010; Anil, 2012, Çatır & Şimşek, 2019); and the relations between the experiential value of food festival, destination image and loyalty (Deng & Tang 2020). Furthermore, Alaçatı Herb Festival has become the subject of research by many local academicians in recent years (Özkan, et al., 2015; Ön Esen & Yılmaz, 2016; Saatcı & Yalçınkaya, 2018; Çoban & Süer, 2018, Yavuz, 2019; Kızılcalıoğlu et al., 2019). However, to the best of our knowledge, none of the previous studies focused specifically on the relationship between festival success factors, festival satisfaction, destination image, and destination loyalty. Seeking to fill this gap in the literature, this paper studies this relationship using the case of Alaçatı Herb Festival. The research model used is shown in Figure 1.

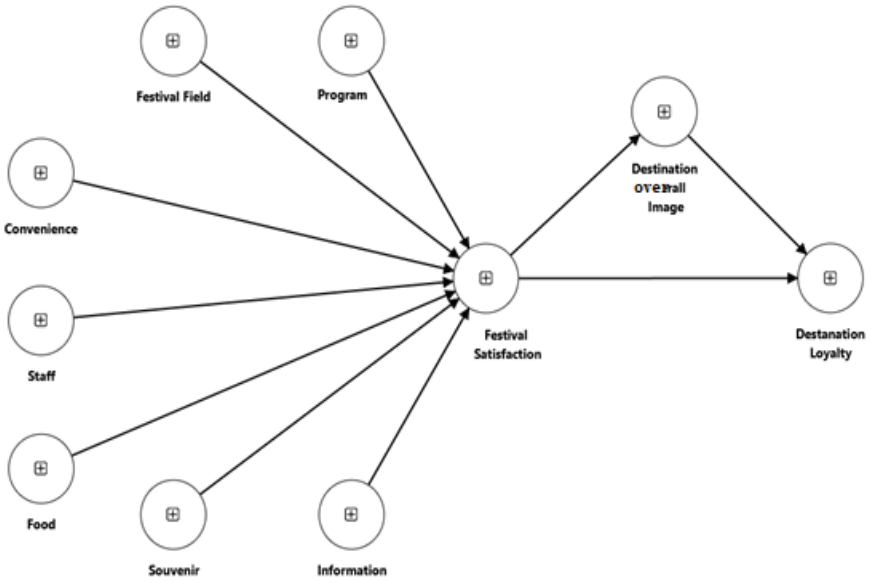

Figure 1. Research Model

Festival Success Factors: Festival success factors are those that can change the perceptions and behaviors of participants and provide them with unique experiences. When the related literature is examined, it is seen that similar criteria are mentioned in many studies as festival success factors. To realize a successful event, these factors need to be provided both before and during the event (Baker, 1986; Lee et al., 2008; Özdemir & Çulha, 2009; Yoon et al., 2010; Saayman et al., 2012; Anil, 2012; Mason & Paggiaro, 2012; Wan & Chan, 2013; Marković et al., 2015; Çatır & Şimşek, 2019; Dalgıç & Birdir, 2020). The festival success factors discussed in the research are as follows:

The program dimension represents the plan of the festival (beginning and end) and the organization of the activities that will take place during the festival.

The festival area dimension represents the width of the indoor and outdoor areas where the festival takes place, the cleanliness of these areas, the location of the festival, the décor and lighting of the festival area and the quality of the materials used there.

The convenience dimension measures the adequacy of the facilities in the festival area. The number of toilets, the cleanliness of the toilets, the size of the parking lot, the proximity to the festival area, and the number and adequacy of the rest areas were evaluated with this dimension.

The staff dimension refers to the attitudes of the staff working at the festival toward the

visitors and whether they have information about the festival.

The food dimension evaluates the variety of food at the festival, the traditional nature of the food, and the price and quality of the food.

The souvenir dimension evaluates the variety of souvenirs, the tradition of souvenirs, and the price and quality of souvenirs.

The information dimension represents information about the details of the festival, billboard advertisements and brochures, and directional signs in the festival area.

To assess the festival's success, it is essential to measure the visitors' satisfaction (Lee & Beeler, 2007). When festival success factors are assessed positively, the satisfaction of visitors positively affects festival satisfaction (Yoon et al., 2010; Mason & Paggiaro 2012; Anil, 2012, Markovic et al., 2015). The following hypotheses were developed in accordance with this scope:

H_1: The program dimension of festival success factors has a positive effect on festival satisfaction.

H_2: The festival area dimension of festival success factors has a positive effect on festival satisfaction.

H_3: The convenience dimension of festival success factors has a positive effect on festival satisfaction.

H_4: The staff dimension of festival success factors has a positive effect on festival satisfaction.

H_5: The food dimension of festival success factors has a positive effect on festival satisfaction.

H_6: The souvenir dimension of festival success factors has a positive effect on festival satisfaction.

H_7: The information dimension of festival success factors has a positive effect on festival satisfaction.

Festival Satisfaction

According to Tian-Cole et al. (2002), "*satisfaction is a summary of identified psychological results that visitors experience over time*", whereas Babin & Griffin (1998) defined it as a "*positive, emotional reaction arising from a favorable assessment of a shopping or consumption experience*". Satisfaction is dependent on both the quality of the service and

the information under the control of the provider. However, festival satisfaction is "*the overall festival value assessed by a combination of quality dimensions*" (Yoon et al., 2010). In the study, satisfaction with the festival is a summary of the experience of the visitors at the festival (McDowall, 2011; Wu & Ai, 2016). According to Folgado-Fernández et al. (2017), gastronomic experiences like food festivals in two specific regions of Spain and Portugal have a positive impact on destination image and loyalty. High satisfaction has a positive impact on visitors' behavioral intentions (Severt et al., 2007; Gautam, 2022). Furthermore, event quality plays an important role in the development of the destination image (Kusumah & Wahyudin, 2023). From this viewpoint, the following hypotheses were developed:

H_8: Festival satisfaction has a positive effect on destination loyalty.

H_9: Festival satisfaction has a positive effect on the overall destination image.

Destination Image: The destination image has long been the focus of attention of many researchers in the field of tourism (Gartner, 1989; Crompton & Ankomah, 1993; Stepchenkova & Mills, 2010). Destination image is defined as "*the expression of an individual's knowledge, impressions, prejudices, imagination and emotional thoughts about a particular place*" (Lawson & Baud Bovy, 1977). It is widely accepted that the destination image influences tourists' subjective perceptions, outcome behaviors, and destination choice (Milman & Pizam, 1995; Baloglu & McCleary, 1999). The destination image, which is integrated with tourists' beliefs, values and destination impressions, plays a critical role in tourism marketing (Crompton, 1979). Destination image is recognized as a tourism experience that combines different natural routes, material resources, natural environment, cultural heritage, activities and other resources with traditional culture (Kolb, 2006). Local food and culture are believed to increase the value of a destination, and local cuisine can shape tourists' destination image (Telfer & Wall, 1996; Hammitt et al., 2006). Many studies have proven that gastronomic activities are part of the tourism strategy by creating and enhancing the destination image (Kivela, 2006; Fox, 2007). Therefore, food festivals are believed to be beneficial for enhancing the destination image (Lee & Arcodia, 2011). Destinations with a positive image are more likely to be considered in tourists' decision-making process. Therefore, a more positive image leads to higher tourist satisfaction. Moreover, the destination image is influenced and can change because of tourists' destination experiences (Fakeye & Crompton, 1991). In other words, the destination image significantly influences tourists' behavior by affecting future destination choices (Bigne et al., 2001; Chen & Tsai, 2007). Accordingly;

H_{10}: Destination overall image has a positive effect on destination loyalty.

Destination Loyalty:

Destination loyalty, seen as an extension of customer loyalty (Zhang et al., 2014), is a

key issue in destination marketing success (Oppermann, 2000). Newman and Werbel (1973) defined loyal customers as "*people who repurchase a brand, pay attention only to that brand and do not seek information about the brand*". Hawkins et al., (1995) defined loyalty as "*consumers' intentions or actual behavior to repeatedly purchase specific products or services*". According to Lee & Cunningham (2001), customer loyalty is the tendency of consumers to become customers of existing suppliers again based on their previous experiences and expectations for the future. In other words, it is an indicator of consumers' attitudes in terms of product categories, brands, stores and services (Uncles et al., 2003).

According to Zeithaml et al., (1996), positive behavioral intentions are related to the ability of a service provider. This relationship is realized by consumers 1) saying positive things about the company, 2) recommending it to other consumers, 3) being loyal to it (i.e. buying back), 4) spending more with the company, and 5) buying the same product/service at a higher price. On the other hand, tourist loyalty depends on tourist satisfaction and fulfillment of expectations (Chi & Qu, 2008). Facilities, security and infrastructure, cultural and shopping attractions, sights and ambience, diversity and accessibility affect tourist loyalty (Prayag, 2008). In addition to basic services; service quality, social value, entertainment, esthetics, perceived monetary cost, perceived risk, time and effort spent and perceived value (Gallarza & Saura, 2006); cognitive image of natural resources, cognitive image of service quality, cognitive image of entertainment and emotional image are also considered as antecedents of tourist loyalty (Hernandez et al., 2006).

Tourists' loyalty to a particular destination is expressed by their intention to revisit the destination and their intention to recommend the destination to others (Oppermann, 2000). Satisfaction with the festival is strongly associated with loyalty (Tanford & Jung, 2017). Satisfaction with a festival has a direct impact on destination loyalty (Molina-Gómez et al., 2021). The festival and destination image have a positive impact on visitor satisfaction (Deng et al., 2015; Carse et al., 2018) and contribute to both behavioral intention and visit frequency (Kaplanidou & Gibson, 2012). Based on this literature, the following hypothesis is proposed:

H_{11}: Destination overall image mediates the relationship between festival satisfaction and destination loyalty.

Research Methodology

Data Collection Method

The questionnaire technique was used as a data collection method in the study. The questionnaire was applied to the participants in the festival area, parking lot and tour busses. In the first part of the questionnaire, which consists of two parts, there are 4 questions to determine

the demographic characteristics of the participants and 2 questions questioning the status of visiting Alaçatı and the Herb Festival. In the second part, four different scales were used to measure the dependent variable of the research, festival success factors, and the independent variables festival satisfaction, destination image and destination loyalty. Festival success factors consist of 21 statements and 7 dimensions (program, festival area, convenience, staff, food, souvenirs, information) taking into account the scales used by Özdemir & Çulha (2009); Anıl (2012); Dalgıç & Birdir (2019). The second part consisted of 30 statements, including festival satisfaction (3 statements and 1 dimension previously proposed by Lee et al., 2008); destination overall image (4 statements and 1 dimension as previously proposed by Chi & Qu 2008), and destination loyalty (3 statements and 1 dimension previously proposed by Deng and Tang, 2020). The statements in the scale were scored on a 5-point Likert scale (from 1 = "strongly disagree" to 5 = "strongly agree").

Sampling Process

The population of the study consists of domestic tourists who participated in the 11th Alaçatı Herb Festival organized in Alaçatı in 2022. Since the Çeşme Municipality festival officials could not provide a reliable estimate of the number of tourists attending the festival, we relied on the minimum sample size at 95% confidence interval, which amounted to 384 (Baştürk & Taştepe, 2013:150). Between March 24-27, 2022, 480 questionnaires were collected by the convenience sampling method. 30 questionnaires were not included in the analysis because they were incomplete and not filled in sincerely, and 450 questionnaires were evaluated.

Results

Demographic Characteristics of Participants

The SPSS Statistics statistical package program was used to evaluate the demographic profile of the sample. According to the results of the frequency analysis, the demographic characteristics of the participants are shown in Table 1.

Table 1

Findings on the Demographic Characteristics of Tourists

Demographic Characteristics		Number of Participants (n)	Percentage (%)	Demographic Characteristics		Number of Participants (n)	Percentage (%)
Gender	Female	325	72,2	Age	18-24	75	16,7
	Male	125	27,8		25-34	71	15,8
Education Status	Middle School	20	4,4		35-44	104	23,1
	High School	165	36,7		45-54	148	32,9
	Undergraduate	195	43,3		55-64	40	8,9
	Postgraduate	70	15,6		65 and over	12	2,7
Marital Status	Married	265	58,9	Alaçatı Visit	Yes	311	69,1
	Single	171	38,0		No	139	30,9
	Other	14	3,1	Herb Festival Visit	Yes	416	92,4
					No	34	7,6

As can be seen in Table 1, in terms of gender distribution, 325 (72.2%) were female, and 125 (27.8%) were male. With regard to the educational status, most of the participants had undergraduate education (43.3%), were married (58.9%), and aged 45-54 years old (32.9%). In addition, most of the respondents visited Alaçatı (69.1%) and Herb Festival (92.4%) for the first time.

3.1. Validity and Reliability Analyses of the Scales

The validity and reliability results of the constructs used in the study were tested with the measurement model. Confirmatory factor analysis was conducted for validity and reliability. Convergent and discriminant validity and internal consistency reliability of the constructs were investigated through factor analysis. For convergent validity, factor loadings and average variance explained (AVE=Average Variance Extracted) coefficients of the statements measuring the constructs were calculated. Composite reliability (CR=Composite Reliability) values were checked for internal consistency reliability. According to Hair et al., (2006; 2022), the factor loadings of the statements should reach ≥0.70, the CR coefficients of the variables should reach ≥0.70 and the AVE value should reach ≥0.50 thresholds. The results of the measurement model are presented in Table 2.

Table 2

Measurement Model Results

Structure/Dimension		Code Given to the Statement	Factor Load	Composite Reliability (CR)	Average Variance Explained (AVE)
Festival Success Factors	Program	fbf1	0,845	0,879	0,785
		fbf2	0,925		
	Festival Area	fbf3	0,825	0,842	0,573
		fbf4	0,653		
		fbf5	0,769		
		fbf6	0,769		
	Convenience	fbf7	0,689	0,789	0,557
		fbf8	0,708		
		fbf9	0,834		
	Staff	fbf10	0,732	0,923	0,750
		fbf11	0,915		
		fbf12	0,908		
		fbf13	0,896		
	Food	fbf14	0,910	0,894	0,808
		fbf15	0,888		
	Souvenirs	fbf17	0,860	0,844	0,648
		fbf18	0,905		
		fbf19	0,621		
	Information	fbf20	0,952	0,939	0,885
		fbf21	0,929		
Festival Satisfaction		fm1	0,923	0,958	0,885
		fm2	0,961		
		fm3	0,937		
Destination Loyalty		ds1	0,917	0,960	0,888
		ds2	0,959		
		ds3	0,951		
Destination Overall Image		dgi1	0,906	0,933	0,823
		dgi2	0,918		
		dgi3	0,897		

According to Hair et al. (2022), the factor loadings should be ≥0.708. The authors suggest that statements with factor loadings below 0.40 should be removed from the measurement model, and statements with factor loadings between 0.40 and 0.70 should be removed from the measurement model if their AVE or CR values are below the threshold value. Statement number three (fbf16) of the food dimension with a factor loading below 0.40 was removed from the measurement model. The factor loadings of the number two (fbf4), number one

(fbf7) and number three (fbf19) statements of the festival area dimension, convenience dimension and souvenir dimension were calculated as 0.653, 0.689 and 0.621, respectively. Although the factor loadings of these statements were below the threshold value, the AVE and CR coefficients of the festival area, convenience, and souvenir dimensions were within the desired limits, so the statements were not removed from the measurement model.

It is seen from the results in Table 2 that the CR coefficients were calculated between 0.789 and 0.960. Therefore, it was determined that the internal consistency reliability of the variables used in the study was ensured (Hair et al., 2022). The factor loadings of the statements measuring the variables were observed between 0.621 and 0.961, and the AVE coefficients were observed between 0.557 and 0.888. Considering these findings, it was understood that the convergent validity of the variables used in the study was ensured (Hair et al., 2022).

HTMT coefficients were calculated to investigate the discriminant validity of the variables. According to Henseler et al. (2015), the HTMT coefficients should theoretically be below 0.90 for close structures and below 0.85 for distant structures. The calculated HTMT coefficients are shown in Table 3. According to the calculated HTMT coefficients, discriminant validity was achieved.

Table 3

HTMT Coefficients

	Information	**Destination Overall Image**	**Destination Loyalty**	**Festival Area**	**Festival Satisfaction**	**Souvenirs**	**Staff**	**Program**	**Convenience**	**Food**
Information										
Destination Overall Image	0,506									
Destination Loyalty	0,434	0,704								
Festival Area	0,496	0,546	0,613							
Festival Satisfaction	0,554	0,676	0,540	0,426						
Souvenirs	0,490	0,378	0,430	0,373	0,511					
Staff	0,375	0,445	0,317	0,351	0,367	0,263				
Program	0,555	0,494	0,460	0,756	0,499	0,393	0,417			
Convenience	0,478	0,361	0,382	0,711	0,347	0,377	0,521	0,563		
Food	0,298	0,383	0,408	0,377	0,289	0,363	0,739	0,416	0,461	

Testing the Research Model and the Results

The structural equation model created to test the hypotheses of the study is shown in Figure 2.

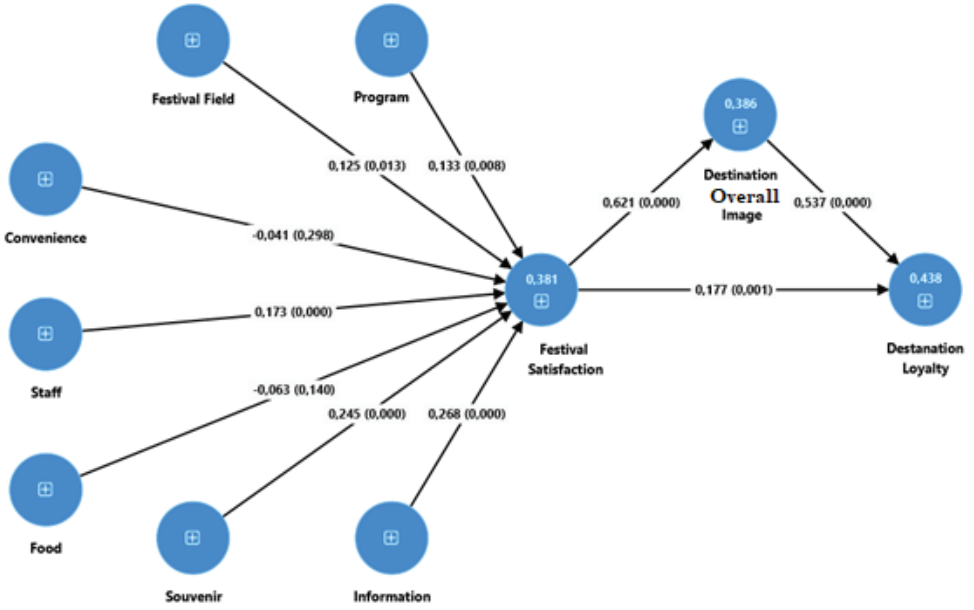

Figure 2. Structural Equation Model

Partial least squares path analysis (PLS-SEM) was used to analyze the research model. Data were analyzed using the SmartPLS 4 statistical program (Ringle et al., 2022; Yıldız, 2021). The PLS algorithm was run to calculate linearity, path coefficients, R^2 and effect size (f^2). To assess the significance of the PLS path coefficients, t values were calculated by taking 10000 subsamples from the sample by resampling (bootstrapping). The VIF, R^2, and f^2 values for the research results are presented in Table 4.

Table 4

Research Model Coefficients

Path		**VIF**	**R^2**	**f^2**
Program	Festival Satisfaction	1,765	0,381	0,016
Festival Area		1,823		0,014
Convenience		1,515		0,002
Staff		1,817		0,027
Food		1,725		0,004
Souvenirs		1,278		0,076
Information		1,515		0,077
Festival Satisfaction	Destination Loyalty	1,628	0,438	0,034
Destination Overall Image		1,628		0,316
Festival Satisfaction	Destination Overall Image	1,000	0,386	0,628

Hair et al., (2022) argued that there is no linearity problem if the VIF (Variance Inflation Factor) coefficients between variables are less than 5. Since the VIF coefficients in Table 4 are

less than 5, it can be stated that there is no linearity problem between the research variables.

When the R^2 values in the table are analyzed, it is determined that festival satisfaction is explained by 38%, destination loyalty by 44% and destination overall image by 39%.

According to Hair et al. (2022), if the coefficient of predictive power (Q^2) is greater than zero, the exogenous variables in the research model have the power to predict the endogenous variables. The exogenous variables of the research have predictive power over the endogenous variables since the Q^2 coefficients in Table 4 are greater than zero.

An effect size coefficient (f^2) of 0.02 and above is considered low; 0.15 and above is considered medium; and 0.35 and above is considered high (Cohen, 1988). According to Sarstedt et al. (2017), it is not possible to talk about an effect when the coefficient is below 0.02. When the effect size coefficients (f^2) are analyzed,

· It has been observed that the staff, souvenir and information dimensions have small effect sizes on festival satisfaction,

· Festival satisfaction has small effect sizes on destination loyalty,

· Furthermore, festival satisfaction has high effect sizes on the destination's overall image.

Direct impact coefficients calculated by the resampling method are presented in Table 5 and the indirect impact coefficients are presented in Table 6.

Table 5

Research Model Direct Effect Coefficients

Path		Standardize β	Standard Deviation	t value	p value
Program	Festival Satisfaction	0,133	0,050	2,649	0,008
Festival Area		0,125	0,050	2,482	0,013
Convenience		-0,041	0,039	1,058	0,298
Staff		0,173	0,045	3,829	0,000
Food		-0,063	0,042	1,490	0,140
Souvenirs		0,245	0,046	5,346	0,000
Information		0,268	0,043	6,274	0,000
Festival Satisfaction	Destination Loyalty	0,177	0,051	3,465	0,001
Destination Overall Image		0,537	0,045	11,863	0,000
Festival Satisfaction	Destination Overall Image	0,621	0,037	16,634	0,000

When the results in Table 5 are analyzed,

· The positive effects of program ($\beta=0.133$; $p<0.01$), festival area ($\beta=0.125$; $p<0.05$), staff ($\beta=0.173$; $p<0.01$), souvenirs ($\beta=0.245$; $p<0.01$) and information ($\beta=0.268$; $p<0.01$) on festival satisfaction were found to be statistically significant.

· The positive effects of festival satisfaction (β=0.177; p<0.01) and destination overall image (β=0.537; p<0.01) on destination loyalty were statistically significant.

· The positive effects of festival satisfaction (β=0.621; p<0.01) on the overall image of the destination were found to be statistically significant.

The effects of convenience and food dimensions on festival satisfaction were found to be statistically insignificant (p>0.05). Within the framework of these results, hypotheses 1, 2, 4, 6, 7, 8, 9, and 10 were supported, while hypotheses 3 and 5 had to be rejected.

Table 6

Research Model Indirect Effect Coefficients

Path			Standardize β	Standard Deviation	t value	p value
Festival Satisfaction	Destination Overall Image	Destination Loyalty	0,334	0,042	7,929	0,000

When the values in Table 6 are analyzed, it is seen that the indirect effect of festival satisfaction (β=0.334; p<0.01) on destination loyalty through the overall destination image is significant.

According to Zhao et al., (2010), when independent variables have significant effects on mediating variables and mediating variables have significant effects (indirect effects) on dependent variables, the presence of a mediating effect is considered. Therefore, since the effects of festival satisfaction on the overall destination image and the destination image on destination loyalty are significant, we can talk about the mediating effect.

Since the mediating effects were identified, the type of mediating effect was examined in line with the Zhao et al., (2021) mediating effect decision tree. Since the indirect effect on the path of Festival Satisfaction → Destination Overall Image → Destination Loyalty is significant, the direct effect on the path of Festival Satisfaction → Destination Loyalty is significant, and the path coefficients are positive, it is determined that the destination overall image has an integral partial mediating role in the relationship between festival satisfaction and destination loyalty. Based on this finding, hypothesis 11 of the study is supported.

Conclusion and Discussion

A festival with social and cultural meaning is a powerful source of attraction for tourists and is of great importance in creating or strengthening a destination's image. Therefore, festival planning should maximize the benefits of a destination through appropriate image enhancement and economic development. Positive behavioral intentions toward a destination can provide important support for the development of new destinations, especially those with growth potential. According to Ritchie (1984), short-term festivals have a positive impact

on a destination's level of recognition, attractiveness and profitability. The study identified seven dimensions representing festival success factors and examined how these factors affect tourist satisfaction and, in turn, destination image and loyalty.

Alaçatı Herb Festival is a local festival that brings together various herbs of the Aegean with travel lovers since 2010. The festival, which was organized as a single day in the first year, was increased to 2 days in the following years and to 3 days in 2022 with very intense and diverse activities. According to the results of the research, among the festival success factors, the program, festival area, staff, souvenirs and information dimensions affect visitors' festival satisfaction. However, the food and convenience dimension did not affect festival satisfaction. Destination loyalty is affected by festival satisfaction and overall destination image. In addition, festival satisfaction has a positive effect on the destination image. In addition, the overall destination image plays an integrative partial mediating role in the relationship between festival satisfaction and destination loyalty.

According to the results of the research, the program dimension affects festival satisfaction; this result is similar to the results of Lee et al., 2006; Yoon et al. (2010). It can be concluded that the festival is better planned with the enrichment of the festival program content every year and 10 years of experience. The 11th Alaçatı Herb Festival has prepared a very rich program including painting exhibition, sculpture exhibition, olive oil tasting, herbal tea brewing techniques, talks on Aegean herbs and health, races and concerts.

The festival area dimension positively affects festival satisfaction. It supports the results of Lee et al., (2006), Özdemir and Çulha (2012), Mason and Paggiaro (2012), Anıl (2012), Çatır and Şimşek (2019). The festival area has been expanded because of the increasing interest from year to year, and in 2022, the area where herbs were exhibited was separated from the bazaar area to disperse the density.

The staff dimension positively affects festival satisfaction. This supports the result of Çatır and Şimşek (2019). However, in some studies such as Lee et al., (2006), it has been observed that the staff has no effect on festival satisfaction.

The souvenir dimension positively affects festival satisfaction. It is possible to say that tourists find souvenirs sufficient in terms of variety, quality and price. This result is the same as that of Yoon et al., (2010) and Çatır and Şimşek (2019).

The information dimension positively affects festival satisfaction. Lee et al., 2008, Çatır and Şimşek (2019) also reached a similar conclusion.

While five of the seven dimensions have a positive impact on festival satisfaction, the food and convenience dimension needs to be emphasized. The result that the food dimension does not affect festival satisfaction supports the result of Markovic et al. (2015) KuşKonmaz

festival research. It also differs from the results of Lee et al., (2008); Anıl (2012); Yoon et al., (2010) Polat et al., (2018). The festival, which takes a different herb as a theme every year, chose Labada in 2022. While programing the next festival, food diversity, availability of local products, and reviewing and controlling food prices are seen as necessary practices to increase festival satisfaction, destination image, and destination loyalty.

It can be said that there are some problems in the dimension of convenience (rest areas, toilets, parking area), that is, facilitating services. This result is similar to the results of Lee et al., (2006) and Polat et al., (2018). Since the time of the festival is spring, organizing indoor and outdoor recreation areas by taking into account the air temperature, increasing the number of toilets and closely controlling hygiene, and expanding the parking area can increase festival satisfaction. Based on these results, it can be concluded that festival planners and organizers should focus on details related to food and convenience in organizing a successful festival event. Efforts should be made to improve these dimensions. Each component of the festival success factors should be carefully planned and implemented for a successful festival.

Destination loyalty is affected by festival satisfaction and the destination image. This is similar to the results of Chi & Qu (2008), Çatır & Şimşek (2019), Deng & Tang (2020), Dalgıç & Birdir (2020). For Alaçatı Herb Festival tourists, festival satisfaction and destination image are considered to be important factors in encouraging tourists to visit Alaçatı again in the future and to encourage their recommendations.

Theoretical and Practical Contributions

Considering that Alaçatı Herb Festival has been organized continuously since 2010, it can be said that the number of studies conducted is quite low. In this direction, the research theoretically enriches the knowledge of festival success factors and reveals the relationship between festival satisfaction, destination image and loyalty as a model. The results of the research are therefore valuable for both academia and industry. In this festival, the main theme of which is herb, the fact that the food is not sufficiently varied, not traditional, and the prices and quality are not at the expected level is an important issue that needs to be emphasized. Further research is required for the success of this dimension.

In practical terms, the research results can be used as a strategic tool to identify areas where food festivals need to be improved to enhance the destination image and loyalty. This research has shown that festival satisfaction influences destination loyalty and that the destination overall image is an integral partial mediator in the relationship between festival satisfaction and destination loyalty. Festival organizers should closely examine festival experiences and take actions to ensure that festival experiences are positive in order to increase both festival satisfaction and destination loyalty and to improve the overall image of the destination.

Limitations and Future Research

As in every research, there are some limitations in this study. First, the convenience sampling method was preferred due to its convenience in terms of time and cost. To reach more generalizable results, data can be collected by the purposive sampling method. The second is that the research data was collected in a limited period between March 24-27, 2022. Another limitation is that the visitors read and evaluated the questionnaire in the noise and crowds of the festival area. Future research could customize the success factors according to the main theme of the festivals. The impact of the festival can be evaluated from different perspectives: festival visitors, participants, organizers and local people. Behaviors between first-time and repeat visitors can be compared, thus providing a more detailed framework.

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RESEARCH ARTICLE

Decentralized Finance (DeFi): Benefits, Risks, and Risk-Mitigation Strategies

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Abstract
The 2008-2009 global financial crisis resulted in a loss of trust in traditional financial systems and the need to decentralize and democratize finance. This coincided with the birth of blockchain technology, marked by creating the pioneer cryptocurrency, bitcoin (BTC), in 2009. As blockchain technology has gained prominence, decentralized finance (DeFi) has emerged, transforming the financial landscape and offering financial services without the need for traditional financial intermediaries. While the disruption of traditional finance has opened up new opportunities, it has also introduced significant risks to the financial sector. In this study, we follow the PRISMA approach (systematic literature review) to identify several DeFi benefits and challenges, as discussed in the existing literature. Based on the Scopus database, we critically scrutinized 64 published articles to report that although DeFi promotes financial inclusion and enhances financial transparency and accountability, the ecosystem also faces security issues, regulatory ambiguities, and price volatility. By providing a balance between the benefits and risks associated with DeFi, this study will help investors and other stakeholders make informed decisions and will serve as a valuable resource for formulating strategies to better regulate the DeFi ecosystem.

Keywords: Decentralized finance, DeFi, benefits, risks, PRISMA

Introduction

From ATMs and mobile payment solutions to blockchain technology and central bank digital currencies (CBDCs), the evolution of financial technology (FinTech) has been rapid, particularly after the 2008 global financial crisis (GFC) (Pandey et al., 2023). In the aftermath of the GFC, stakeholders lost trust in the centralized nature of traditional financial systems, paving the way for the emergence of more decentralized systems (Chaklader et al., 2023). Centralized (traditional) finance (CeFi) relies on intermediaries such as banks and other financial institutions to provide financial services. There are many disadvantages related to this financial setup. First, the presence of intermediaries increases transaction fees and slows

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down transaction speeds because the central authority must validate transactions. Second, inhabitants of remote areas without financial institutions are deprived of access to financial services. In addition, there is no 24/7 service as most of these financial intermediaries have opening and closing hours. These constraints adversely affect the level of financial activities in an economy.

The development of bitcoin in 2009 marked the birth of cryptocurrencies and blockchain technology. By leveraging blockchain technology, particularly Ethereum, decentralized finance (DeFi) has emerged as an alternative to traditional financial institutions. By introducing decentralization and disintermediation in the provision of financial services, DeFi intensifies competition in the financial sector but also provides an opportunity for traditional financial institutions to integrate and improve their services (Renduchintala et al., 2022). The advantages and opportunities associated with DeFi are numerous. In particular, it addresses some of the drawbacks of traditional finance by reducing transaction costs, increasing transaction speed, enhancing financial inclusion, providing 24/7 financial services, and ensuring transparency in financial transactions (Chen & Bellavitis, 2020; Borisov, 2022).

DeFi also introduces new risks. By automating the provision of financial services through reliance on smart contracts, significant financial losses could result if malicious individuals exploit any potential vulnerabilities in the smart contracts. In addition, regulatory noncompliance and regulatory arbitrage are some issues that may arise due to the ambiguity surrounding the regulation of the DeFi ecosystem. Again, high market volatility could lead to impermanent losses for liquidity providers on DeFi platforms, while the limitations of the Ethereum blockchain pose scalability challenges and can reduce transaction throughput (Borisov, 2022).

The main aim of this study is to systematically review the existing literature on the advantages and challenges associated with DeFi using the PRISMA methodology. To achieve this, we specify the following objectives for our study:

· Investigating the benefits of decentralized finance (DeFi)

· An examination of the inherent risks and challenges in DeFi and a proposal for effective risk mitigation strategies

This study was motivated by many factors. First and foremost, as the DeFi space continues to gain popularity, widespread acceptance, and institutional adoption, investors continue to flood money into the ecosystem, increasing the total value locked (TVL) in DeFi systems (Werner et al., 2022). Hence, investors and other stakeholders must fully appreciate the related benefits and risks to make informed decisions. Second, this study will help traditional financial institutions, startups, and regulators come to terms with how DeFi has transformed

the financial sector so that they can better adapt to the ever-evolving landscape (Renduchintala et al., 2022). Moreover, the study suggests risk mitigation strategies for the identified DeFi risks and practical recommendations to aid regulators, policymakers, and other stakeholders in dealing with DeFi revolutionization.

The structure of the remainder of this paper describes the methodology employed in section 2; presents, analyzes, and discusses the results in section 3; and then provides a conclusion and suggests recommendations in section 4.

Methodology

We apply the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) methodology to systematically review the literature on the advantages and risks associated with DeFi. The PRISMA approach is advantageous because it makes the literature review transparent and reproducible (Kim et al., 2023).

Search Strategy

In order to achieve our research objectives, we constructed an advanced search using the following equation:

((Decentrali?e* W/3 financ* OR "DeFi" OR "De-Fi" OR blockchain W/3 financ* OR crypto W/3 financ* OR cryptocurrency W/3 financ* OR web3 W/3 financ* OR digital W/3 financ*) AND ("benefit*" OR "risk*" OR "advantage*" OR "disadvantage*" OR "opportunities" OR "challenge*" OR "pros" OR "cons" OR "significance" OR "vulnerabilities" OR "importance" OR "threat*" OR "innovation*" OR "issue*" OR "solution*" OR "problem*" OR "application*" OR "limitation*" OR "drawback*"))

We used the "AND" and "OR" Boolean operators to ensure that relevant articles were captured and maximized coverage, respectively. The application of the "W/3" within operator ensured that our search did not miss relevant articles by including phrases in which the specified words were up to three words apart.

Additionally, by incorporating the "?" wildcard after "Decentrali," we ensured that articles were included regardless of whether they had the word spelled out as "decentralize" or "decentralize." Moreover, the "*" wildcard was applied to ensure that our net was widely cast in search of terms in various forms, such as "finance" and "financial." Overall, our search was comprehensive, and we ensured that no relevant article was overlooked.

We performed our search in Scopus. Scopus is a comprehensive database that extensively covers multiple disciplines. It also allows for advanced and complex searches by using

Boolean operators, proximity operators, and wildcards. By leveraging the Scopus filters, researchers can refine search results as required. In addition, by providing article abstracts and keywords, Scopus eases the initial screening stage (Musa et al., 2023).

Filtering and screening relevant studies

After the initial search, we proceeded to the filtering and screening stages. The inclusion and exclusion criteria outlined in Table 1 were used to eliminate irrelevant articles and ensure the selection of only articles in line with the study objectives. The screening process was divided into two stages. In the initial stage, we assessed the relevance of the titles and abstracts of the studies. In the subsequent stage, for the articles that passed the initial screening, we thoroughly examined their full texts to ensure that we exclusively included articles aligning with the study's intended focus.

Table 1

Inclusion and Exclusion Criteria

Inclusion Criteria	Exclusion Criteria
Articles in English	Non-English language articles
Research articles	Review papers, conference papers, reviews, books, book chapters, notes, short surveys
Scientific Journal articles	Non-journal articles, conference proceedings/Procedia articles
Open access articles	Studies whose full texts are not accessible

Data extraction

After screening for relevant studies, pertinent information was extracted from the selected studies. Initially, we conducted a descriptive analysis of the selected articles, considering factors such as publication years, research approach (primary or secondary), and research methods (quantitative, qualitative, or mixed). Subsequently, we compiled and succinctly summarized pertinent data from all selected studies regarding the advantages and risks associated with DeFi.

Data Synthesis, Analysis, Discussion, Conclusion, and Recommendations

Next, we combined the data extracted from the selected studies to comprehensively understand the benefits and risks associated with DeFi. We analyzed and interpreted the results and discussed the implications of our findings. Furthermore, we summarized the results concisely and drawn well-informed conclusions. To provide a balanced perspective, we also considered the limitations of our review and put forth recommendations for further research and practical applications.

Presentation of Results

In this section, we present, analyze, and discuss the findings of our review, ranging from the initial article search results to the data extracted from the selected articles.

Initial Search and Screening Results

We initiated the search process by using the search equation in the SCOPUS database, targeting the article title, abstract, and indexed keywords. This initial search, conducted on November 12, 2023, yielded 911 documents.

Next, we refined the search results by filtering research, journal, English, and open-access articles. This process reduced the selection to 185 documents. Subsequently, a two-stage screening process was conducted. In Stage 1 screening, we assessed the titles and abstracts of 185 documents and eliminated 75 articles that were completely unrelated to decentralized finance (DeFi). In stage 2 screening, we thoroughly examined the complete texts of the 110 articles selected from stage 1, and we found that 64 of these articles were closely aligned with the primary focus of our study. Thus, we included them in our analysis. The flowchart presented in Figure 1 outlines the systematic literature review process, which spans the initial search to the final selection of included articles.

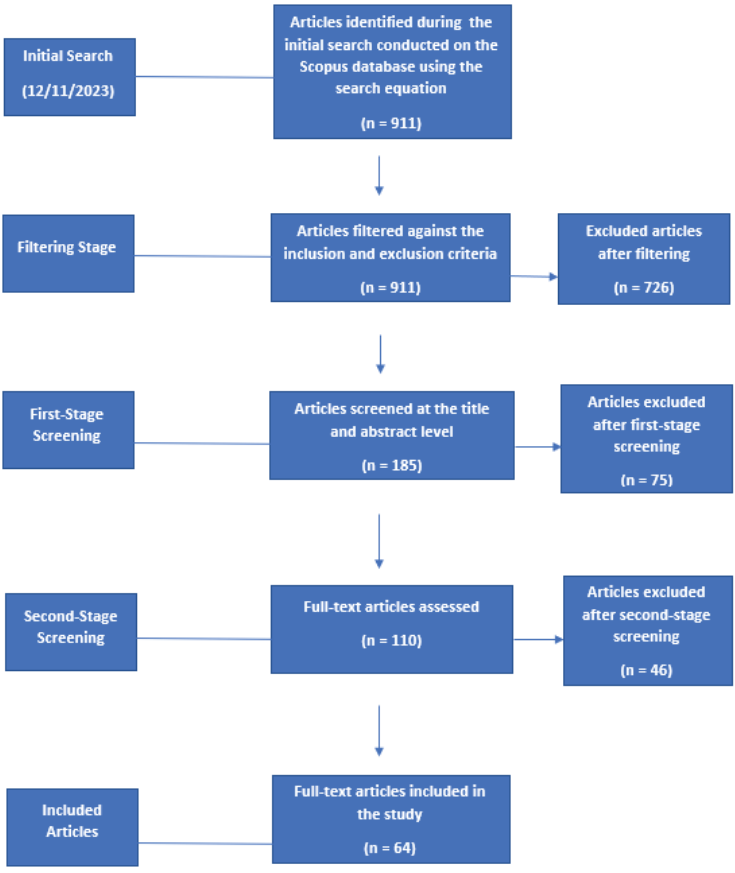

Figure 1. Systematic Literature Review Flow Chart

Data Extraction Results

This section presents the data extraction results, beginning with a descriptive analysis of the characteristics of the selected articles. Subsequently, the discussion unfolds with an analysis of the benefits and risks associated with decentralized finance (DeFi).

Descriptive Analysis of the Studies

The descriptive statistics of the included articles are presented in Table 2 as frequency distribution.

As indicated in Table 2, among the 64 articles exploring the benefits and risks of decentralized finance (DeFi), 52 incorporated secondary research, with an additional 6 articles not relying on any data. Additionally, 5 articles incorporated primary research, and 1 used both primary and secondary data. Notably, about 83% of the studies leaned heavily on secondary research, emphasizing its prevalence in this domain because of its cost effectiveness, time efficiency, and ability to draw from a diverse existing knowledge base.

Table 2

Descriptive Statistics of the Included Studies

Category	Item	Frequency Distribution
Research Approach	Primary	5
	Secondary	52
	Primary and secondary	1
	No Data Used	6
	TOTAL	**64**
Research Method	Qualitative	46
	Quantitative	12
	Mixed	6
	TOTAL	**64**
Publication Year	2023	23
	2022	27
	2021	7
	2020	5
	2019	2
	TOTAL	**64**

Regarding the research methods applied in the 64 articles, 46 carried out a qualitative study, 12 relied on a quantitative design, and 6 used both qualitative and quantitative methods (mixed approach). Unsurprisingly, more than 81% of the studies relied on qualitative methods because qualitative methods help researchers explore the complexities of DeFi and provide sufficient context.

97% of the studies were published in or after 2020. This is not surprising considering that cryptocurrencies and blockchain technology have gained mainstream acceptance and adop-

tion since 2020, leading to the concept of DeFi (Chen et al., 2022). Even more interestingly, more than 78% of the studies were published in just 2022 and 2023, indicating the growing body of research in this field.

Benefits of Decentralized Finance

From the 64 articles included in this study, the benefits of DeFi are presented in Table 3.

Table 3

Benefits of Decentralized Finance

Benefits	**Sources**
1. Disintermediation	Patel and Shrimali (2021), Han et al. (2023), Kaur et al. (2023), Saengchote et al. (2023), Bartoletti et al. (2022), Ziegler and Zehra (2023), Hassan et al. (2020), Zhao et al. (2022), Ozili (2022), Stepanova and Eriņš (2021), Zachariadis et al. (2019), Zetzsche et al. (2020), Kumari and Devi (2022), Jensen et al. (2021)
2. Decentralization	Song et al. (2023), Mnohoghitnei et al. (2022), De Collibus et al. (2022), Dodmane et al. (2023), Axelsen et al. (2023), Shahbazi and Byun (2022), Park and Youm (2022), Saengchote et al. (2023), Weingärtner et al. (2023), Barbereau and Bodó (2023), Zhao et al. (2022), Hameed (2019), Chen and Bellavitis (2020), Stepanova and Eriņš (2021), Al-Shaibani et al. (2020), Zetzsche et al. (2020)
3. Accessibility, Permissionlessness, and Democratization of Finance	Shokri et al. (2022), Mnohoghitnei et al. (2022), De Collibus et al. (2022), Dodmane et al. (2023), Kaur et al. (2023), Barbereau et al. (2023), Shahbazi and Byun (2022), Saengchote et al. (2023), Weingärtner et al. (2023), Barbereau and Bodó (2023), Bartoletti et al. (2022), Smith (2021), Vidal-Tomás et al. (2023), Ziegler and Zehra (2023), Salami (2021), Kumari and Devi (2022), Schär (2021), Hassan et al. (2020), Zhao et al. (2022), Schueffel (2021), Chen and Bellavitis (2020), Popescu (2020), Momtaz (2022), Stepanova and Eriņš (2021), Xu and Feng (2022), Bennett et al. (2023)
4. Financial Inclusion	Wu et al. (2023), Alsagheer et al. (2023), Kaur et al. (2023), Allen et al. (2022), Chiu et al. (2022), Alamsyah and Syahrir (2023), Weingärtner et al. (2023), Barbereau and Bodó (2023), Bartoletti et al. (2022), Vidal-Tomás et al. (2023), Salami (2021), Yang (2022), Zhao et al. (2022), Jensen et al. (2021), Schueffel (2021), Ozili (2022)
5. Transparency/Accountability (Traceability and Verifiability) / Trustlessness	Song et al. (2023), Patel and Shrimali (2021), Shokri et al. (2022), Wu et al. (2023), Mnohoghitnei et al. (2022), Dodmane et al. (2023), Burger and Weinmann (2022), Han et al. (2023), Xu et al. (2023b), Kaur et al. (2023), Lupaiescu et al. (2022), Xu et al. (2023a), Shahbazi and Byun (2022), Saengchote et al. (2023), Weingärtner et al. (2023), Seven et al. (2022), Smith (2021), Vidal-Tomás et al. (2023), Ziegler and Zehra (2023), Salami (2021), Kumari and Devi (2022), Schär (2021), Hassan et al. (2020), Zhao et al. (2022), Jensen et al. (2021), Schueffel (2021), Chen and Bellavitis (2020), Stepanova and Eriņš (2021), Al-Shaibani et al. (2020)
Security, Immutability, and Cryptography	Shokri et al. (2022), De Collibus et al. (2022), Dodmane et al. (2023), Han et al. (2023), Shahbazi and Byun (2022), Alamsyah and Syahrir (2023), Park and Youm (2022), Saengchote et al. (2023), Li and Shen (2022), Hassan et al. (2020), Yang (2022), Hameed (2019), Ozili (2022), Popescu (2020), Al-Shaibani et al. (2020)
Anonymity	Schueffel (2021)

Innovation	Song et al. (2023), Wu et al. (2023), Burger and Weinmann (2022), Kaur et al. (2023), Hickey and Harrigan (2022), Aspembitova and Bentley (2022), Xu et al. (2023a), Allen et al. (2022), Axelsen et al. (2023), Chiu et al. (2022), Barbereau et al. (2023), Kitzler et al. (2023), Saengchote (2023), Alamsyah and Syahrir (2023), Bennett et al. (2023), Weingärtner et al. (2023), Barbereau and Bodó (2023), Bartoletti et al. (2022), Smith (2021), Ziegler and Zehra (2023), Kumari and Devi (2022), Yang (2022), Zhao et al. (2022), Hameed (2019), Jensen et al. (2021), Schueffel (2021), Chen and Bellavitis (2020), Ozili (2022), Momtaz (2022), Zachariadis et al. (2019), Zetzsche et al. (2020)
Efficiency/Speed	Shokri et al. (2022), Wu et al. (2023), Schuler et al. (2023), Mnohoghitnei et al. (2022), Dodmane et al. (2023), Han et al. (2023), Xu et al. (2023a), Chiu et al. (2022), Shahbazi and Byun (2022), Alamsyah and Syahrir (2023), Weingärtner et al. (2023), Barbereau and Bodó (2023), Andolfatto and Martin (2022), Seven et al. (2022), Yan and Zhou (2023), Li and Shen (2022), Smith (2021), Schär (2021), Hassan et al. (2020), Yang (2022), Zhao et al. (2022), Chen and Bellavitis (2020), Momtaz (2022), Stepanova and Eriņš (2021), Zachariadis et al. (2019), Al-Shaibani et al. (2020)
Cost Effectiveness	Shokri et al. (2022), Alsagheer et al. (2023), Burger and Weinmann (2022), Han et al. (2023), Kaur et al. (2023), Allen et al. (2022), Chiu et al. (2022), Alamsyah and Syahrir (2023), Grassi et al. (2022), Park and Youm (2022), Barbereau and Bodó (2023), Yan and Zhou (2023), Li and Shen (2022), Kumari and Devi (2022), Hassan et al. (2020), Yang (2022), Hameed (2019), Chen and Bellavitis (2020), Ozili (2022), Stepanova and Eriņš (2021), Al-Shaibani et al. (2020)
Automation/Programmability	Schuler et al. (2023), Mnohoghitnei et al. (2022), De Collibus et al. (2022), Han et al. (2023), Amini et al. (2023), Saengchote et al. (2023), Weingärtner et al. (2023), Bartoletti et al. (2022), Smith (2021), Hassan et al. (2020), Zhao et al. (2022)
Democratic governance/community engagement	Song et al. (2023), Shokri et al. (2022), Hickey and Harrigan (2022), Grassi et al. (2022), Rikken et al. (2023), Andolfatto and Martin (2022), Vidal-Tomás et al. (2023), Ziegler and Zehra (2023), Jensen et al. (2021), Zachariadis et al. (2019)
Diversification and risk management	Mnohoghitnei et al. (2022), Alsagheer et al. (2023), Hickey and Harrigan (2022), Aspembitova and Bentley (2022), Chen and Chang (2022), Grassi et al. (2022), Bennett et al. (2023), Weingärtner et al. (2023), Metelski and Sobieraj (2022), Salami (2021), Tetiana et al. (2022), Jensen et al. (2021), Song et al. (2023)
User Empowerment / Non-Custodial Finance	Wu et al. (2023), Vidal-Tomás et al. (2023), and Salami (2021)
Yield Generation, High Returns, and Passive Income	Schuler et al. (2023), Xu and Feng (2022), Smith (2021), Metelski and Sobieraj (2022), Tetiana et al. (2022), Jensen et al. (2021), Stepanova and Eriņš (2021)
Tokenization	Burger and Weinmann (2022), Han et al. (2023), Barbereau et al. (2023), Saengchote (2023), Rikken et al. (2023), Andolfatto and Martin (2022), Seven et al. (2022), and Smith (2021)
Global Funding Access	Han et al. (2023), Allen et al. (2022), Chiu et al. (2022), and Chen and Bellavitis (2020)
Composability/Interoperability	Kaur et al. (2023), Kitzler et al. (2023), Saengchote (2023), Park and Youm (2022), Seven et al. (2022), Chen and Bellavitis (2020), and Schär (2021)
Borderlessness	Chen and Bellavitis (2020), Ozili (2022), Popescu (2020), Stepanova and Eriņš (2021)
Liquidity Provision (Automated Market Makers (AMMs) and Liquidity Pools)	Grassi et al. (2022), Kim et al. (2022), Jensen et al. (2021)

Fewer Volatility/Stablecoins	Andolfatto and Martin (2022)
Financial Autonomy and Flexibility	Tetiana et al. (2022), and Schueffel (2021)
Less defaults/overcollateralization	Schuler et al. (2023), and Li and Shen (2022)
Alternative Financial Ecosystems	Salami (2021), Kumari and Devi (2022), and Zetzsche et al. (2020)
Increased Competition	Kumari and Devi (2022)
Data Consistency	Al-Shaibani et al. (2020)
Censorship Resistance	Ozili (2022) and Popescu (2020)
Reduced Information Asymmetry	Dodmane et al. (2023), Grassi et al. (2022), and Li and Shen (2022)
Herding Prevention	Yan and Zhou (2023)
Less Counterparty Risk	Schueffel (2021)
Wide Acceptance and Adoption/Market Significance	Aspembitova and Bentley (2022), Kitzler et al. (2023), Bennett et al. (2023)
Financial Stability	Amini et al. (2023)
Economic Growth	Kaur et al. (2023), Axelsen et al. (2023)
Applications beyond Finance	Hameed (2019)

As shown in Table 3, numerous benefits of decentralized finance (DeFi) have been identified in the existing literature. First and foremost, DeFi eliminates the need for traditional financial intermediaries. This disintermediation reduces user transaction costs. As a result, financial services are becoming more affordable. In addition, through the absence of intermediaries, DeFi eliminates bureaucratic delays, improves transaction speed, and enhances efficiency. Again, efficiency is enhanced by smart contracts that automate DeFi processes. In addition, due to smart contracts, reliance on counterparty trust is reduced. This mitigates counterparty risk.

DeFi reduces the dependence on central authorities by operating on decentralized networks. Decentralized mechanisms in DeFi contribute to financial stability. This ensures robustness against system failures. In addition, decentralization in DeFi discourages herding behavior. This reduces market bubbles. Again, decentralization enhances financial system security. In security, DeFi employs cryptographic techniques and leverages the immutability of blockchain records. This ensures the security of DeFi transactions. Due to the immutability of blockchain records, data are consistent in DeFi. This enhances data integrity. Anonymity is another DeFi factor that secures users' data and protects their privacy. Users can transact on DeFi platforms without disclosing personal information.

In addition, DeFi enhances transparency and accountability. This is due to its ability to limit asymmetric information and to the blockchain network, where all DeFi transactions are traceable and verifiable.

In addition, by extending financial services to unserved and underserved populations, DeFi enhances financial inclusion. By increasing accessibility to financial services and due to the borderless nature of DeFi, international trade (and, hence, economic growth) increases, and it becomes relatively easier for financial institutions and the general public to raise funds.

DeFi drives innovation as well. Thanks to DeFi, and especially due to the composability and interoperability of its protocols, users can enjoy various innovative financial products and services.

DeFi allows for community participation and engagement on its platforms (decentralized autonomous organizations – DAOs), since users can have a say in governance by holding voting tokens.

Furthermore, DeFi offers investment opportunities for users, promising relatively high returns. In addition to cryptoassets, users can stake in digital tokens of physical assets, even without fully owning the physical assets. Due to the numerous investment options, users can easily diversify their portfolios. The non-custodial nature of DeFi gives investors total control over their assets, mitigating the risk of asset loss.

Unlike traditional finance, which relies on traditional market makers for liquidity, this is less of a problem in DeFi, where liquidity is enhanced by automated market makers (AMMs). In addition, by encouraging fractional ownership of assets via tokenization, liquidity in DeFi is further enhanced.

In DeFi, users are free to be flexible and make whatever financial decisions they want; there is no censoring of user transactions, and the risk of default is low due to the requirement of overcollateralization.

Finally, by providing alternative financial services, DeFi increases competition for conventional finance and; hence , improves the quality of the services it provides to customers.

DeFi has applications beyond financial realms. It also has real estate, supply chain management, and healthcare applications. This encourages cross-industry innovation.

Thanks to the numerous benefits of DeFi, it has gained acceptance and adoption in mainstream markets, thereby enhancing its legitimacy.

Risks and Challenges of Decentralized Finance and Risk Mitigation Strategies

Based on the 64 articles included in this study, the risks and challenges associated with DeFi are presented in Table 4. As Table 4 shows, there are numerous risks and challenges associated with decentralized finance (DeFi), as indicated in the existing literature. The most common risks and challenges of decentralized finance in Research by De-Fi systems are summarized in Table 5.

To begin with, there could be security issues related to vulnerabilities in smart contracts. If hackers exploit these vulnerabilities, users of DeFi platforms may lose both their money

Table 4

Risks and Challenges of Decentralized Finance

Risks and Challenges	**Sources**
1. Security Concerns, Smart Contract Vulnerabilities, Bugs, and Oracle Challenges	Patel and Shrimali (2021), Wu et al. (2023), Alsagheer et al. (2023), Kaur et al. (2023), Aspembitova and Bentley (2022), Xu et al. (2023a), Allen et al. (2022), Chiu et al. (2022), Shahbazi and Byun (2022), Grassi et al. (2022), Saengchote et al. (2023), Weingärtner et al. (2023), Barbereau and Bodó (2023), Andolfatto and Martin (2022), Bartoletti et al. (2022), Li and Shen (2022), Smith (2021), Vidal-Tomás et al. (2023), Ziegler and Zehra (2023), Kumari and Devi (2022), Schär (2021), Hassan et al. (2020), Tetiana et al. (2022), Zhao et al. (2022), Hameed (2019), Jensen et al. (2021), Schueffel (2021), Chen and Bellavitis (2020), Ozili (2022), Popescu (2020), Stepanova and Eriņš (2021), Zachariadis et al. (2019), Zetzsche et al. (2020), Xu and Feng (2022)
2. Regulatory Challenges and Uncertainties	Patel and Shrimali (2021), Wu et al. (2023), Mnohoghitnei et al. (2022), Dodmane et al. (2023), Burger and Weinmann (2022), Han et al. (2023), Kaur et al. (2023), Hickey and Harrigan (2022), Xu et al. (2023a), Allen et al. (2022), Axelsen et al. (2023), Saengchote (2023), Alamsyah and Syahrir (2023), Grassi et al. (2022), Weingärtner et al. (2023), Barbereau and Bodó (2023), Andolfatto and Martin (2022), Bartoletti et al. (2022), Smith (2021), Vidal-Tomás et al. (2023), Salami (2021), Kumari and Devi (2022), Yang (2022), Hameed (2019), Schueffel (2021), Chen and Bellavitis (2020), Ozili (2022), Popescu (2020), Momtaz (2022), Stepanova and Eriņš (2021)
3. Market Volatility	Song et al. (2023), Mnohoghitnei et al. (2022), Chiu et al. (2022), Bennett et al. (2023), Weingärtner et al. (2023), Smith (2021), Tetiana et al. (2022), Hameed (2019), Chen and Bellavitis (2020), Ozili (2022), Xu and Feng (2022), Kaur et al. (2023), Allen et al. (2022)
4. Scalability Issues and Low Transaction Throughput	Tsepeleva and Korkhov (2022), Alamsyah and Syahrir (2023), Yan and Zhou (2023), Kumari and Devi (2022), Schär (2021), Hameed (2019), Schueffel (2021), Zachariadis et al. (2019), Li and Shen (2022), Popescu (2020)
5. Privacy concerns/consumer protection risks	Wu et al. (2023), Alsagheer et al. (2023), Hickey and Harrigan (2022), Xu et al. (2023a), Allen et al. (2022), Chen and Bellavitis (2020), Zachariadis et al. (2019), Al-Shaibani et al. (2020)
6. Absence of Know Your Customer (KYC) Requirements /Ilicit Activities (Money Laundering, Tax Avoidance)	Wu et al. (2023), Allen et al. (2022), Barbereau and Bodó (2023), Salami (2021), and Schär (2021)
7. Composability Risks, Systemic Risks, and Single Point of Failure	Xu and Feng (2022), Kitzler et al. (2023), Saengchote (2023), Grassi et al. (2022), Saengchote et al. (2023), Weingärtner et al. (2023), Schär (2021), and Jensen et al. (2021)
8. Spillover and Contagion Risks	Schuler et al. (2023), Mnohoghitnei et al. (2022), Bennett et al. (2023)
9. Operational Risks	Mnohoghitnei et al. (2022), Kaur et al. (2023), Allen et al. (2022), Weingärtner et al. (2023), Tetiana et al. (2022)
10. Technological Complexity /UI Challenges	Song et al. (2023), Popescu (2020), Hassan et al. (2020), and Burger and Weinmann (2022)
11.	
12. Technological Constraints	Burger and Weinmann (2022), Kaur et al. (2023), Grassi et al. (2022), Weingärtner et al. (2023), Ozili (2022)
13. Immutability, Rigidity, and Inflexibility	Chen and Bellavitis (2020)

14. Governance Concentration/Low Voting Participation	Barbereau et al. (2023), Vidal-Tomás et al. (2023), Schär (2021), Jensen et al. (2021)
15. Concentration Risk/Reliance on Ethereum	Grassi et al. (2022)
16. Slippage and Impermanent Loss	Dodmane et al. (2023), Kaur et al. (2023), Xu et al. (2023a), Bartoletti et al. (2022), Kim et al. (2022)
17. High gas prices/fees	Dodmane et al. (2023), and Saengchote (2023)
18. Integration Challenges	Dodmane et al. (2023)
19. Adaptability Challenges	Hassan et al. (2020) and Song et al. (2023)
20. Network Congestion	Schuler et al. (2023), Jensen et al. (2021), Ozili (2022)
21. Property Rights Challenges	Andolfatto and Martin (2022)
22. Financial Illiteracy Risk, User Education, and Challenges in Widespread Adoption	Kaur et al. (2023), Stepanova and Eriņš (2021), Hameed (2019)
23. Liquidity Risk	Kaur et al. (2023), Allen et al. (2022), and Andolfatto and Martin (2022)
24. Lack of Shock Absorbers	Saengchote et al. (2023)
25. Strategic defaults and credit risk	Schuler et al. (2023), Kaur et al. (2023), and Allen et al. (2022)
26. Liquidation Risk	Tetiana et al. (2022)
27. Leverage Risk	Mnohoghitnei et al. (2022)
28. Reputational Risk	Weingärtner et al. (2023)
29. Inter-Platform Competition	Burger and Weinmann (2022)
Dependence on Large Network Size	Yan and Zhou (2023)
Algorithm-Human Balance Challenge	Grassi et al. (2022)
Risk of Insufficient Reserves for Back Stablecoins	Salami (2021)
Dependence on network monitoring	Li and Shen (2022)
Job Loss (Unemployment)	Ozili (2022)
Environmental Degradation (Energy Consumption and Carbon Emissions)	Han et al. (2023)

and trust in the system. To mitigate this risk, there should be improvements in smart contract coding, and the contracts' security should be audited at regular intervals. In addition, depending on oracles for data, there is always a risk that data inputs may be tampered with. This risk can be reduced by transitioning from centralized to decentralized oracles.

Second, the uncertainty surrounding the regulatory landscape of DeFi has impeded its growth and adoption. Regulatory arbitrage may also be encouraged due to heterogeneity in cross-country regulations. To address this problem, developers of DeFi platforms should engage with regulators, and regulators in different countries should collaborate to ensure homogeneity in DeFi regulations.

Third, reliance on the Ethereum blockchain introduces the problem of scalability for DeFi. DeFi platforms struggle to deal with too many transactions at a time, leading to network congestion and slowing transactions. To address these problems, DeFi platforms should transition to the Ethereum 2.0 blockchain, employ layer 2 scaling solutions, and/or leverage cross-chain solutions.

Table 5

Common Risks and Challenges in Decentralized Finance

Security risks
Due to their decentralized structure, questions arise about how DeFi organizations can properly manage and control customer data. It can lead to data leaks and fraud (Stein Smith, 2021). This increases the risk of potential exploitation of vulnerabilities, even if transparency is provided (Zatonatska et al., 2022). The security of DeFi systems depends on the secure programing and execution of smart contracts. Smart contracts are automated agreements executed on a blockchain, enabling secure transactions without the need for third parties. However, coding errors or vulnerabilities in such contracts can lead to significant losses. For example, smart contracts running on platforms like Ethereum can be vulnerable to attacks that could compromise user funds. Structures like decentralized autonomous organizations (DAOs) also face these risks (Andolfatto & Martin, 2022; Alsagheer, Xu & Shi, 2023). There are also re-entry vulnerabilities, block randomness, and overcharging vulnerabilities (Weingärtner et al., 2023). Analyzing transaction data and addresses can expose users' identities and transaction activities, jeopardizing individuals' privacy (Hickey & Harrigan, 2022). Patel and Shrimali (2023) mentioned security risks related to their developed systems and other systems. They suggested that to achieve security goals, such as integrity, non-repudiation, confidentiality, and authentication, integrity can be provided with hash functions, such as SHA-256, to ensure that data have not been altered, that an authorized entity has performed transactions by signing them with the sender's private key to ensure non-repudiation, that symmetric key encryption, such as AES, should be applied to protect confidentiality, and that the concept of digital signature should be implemented using algorithms, such as RSA, for authentication. Researchers have stated in their studies that by implementing these measures, these security goals have been achieved and maintained in both the shipment and insurance claim processes (Patel & Shrimali, 2023).
Price Volatility
DeFi often uses digital assets such as cryptocurrencies and tokens; thus, the financial services offered are highly volatile and subject to significant price fluctuations. Mnohoghitnei and colleagues also stated that the risks associated with DeFi are moderate. DeFi users may be exposed to significant financial risks, such as the possibility of losing investments or the value of their assets (Weingärtner et al., 2023). Many authorities warn consumers that the funds they invest in cryptocurrency may be lost. However, it has been noted that institutional investors' interest in cryptocurrency, including leverage use, has increased throughout 2021 (Mnohoghitnei, Horobet & Belascu, 2022) Price volatility is a significant risk factor in DeFi systems. In particular, cryptoassets often exhibit high price volatility (Stein Smith, 2021; Zatonatska et al., 2022). For example, stablecoins can be sensitive to sudden market changes and lose value. The value of a token can fluctuate depending on trading volume, supply, and demand, which pose significant risks for investors (Hickey & Harrigan, 2022). In collateralized debt cases, the collateral's value can be subject to sudden fluctuations, increasing liquidation risk. Fluctuations in prices also affect investors' and users' investment decisions (Andolfatto & Martin, 2022).
Regulatory Ambiguities
The decentralization of DeFi poses different challenges for regulators. The absence of a central authority makes it difficult to regulate and determine which laws apply in different cases. Additionally, regulatory uncertainties, such as KYC (Know Your Customer) and AML (Anti-Money Laundering) are difficult to enforce (Zatonatska et al., 2022; Stein Smith, 2021). DeFi protocols operate without being subject to traditional financial regulations; thus, there is a risk that their regulations are often not updated to suit these technologies. Products such as stablecoins lead to uncertainty about what standards regulators will apply and how these products will be audited (Andolfatto & Martin, 2022). It is difficult for regulators to monitor such systems. Lack of regulation or uncertainty makes the prevention of illegal activities and fraud difficult. Decentralized financial transactions like those experienced with the DAO and BSQ tokens, can allow users and projects to evade regulatory oversight, increasing legal risks (Hickey & Harrigan, 2022).
Scalability Issues and Low Transaction Throughput
An increase in the number of transactions in the Defi systems both prolongs the time required for transactions to be performed and slows down the network (Alamsyah & Syahrir, 2023). During periods of intense transactions, efficiency may decrease, and the network may slow down (Tsepeleva & Korkhov, 2022; Kumari & Devi, 2022; Alamsyah & Syahrir, 2023). Developers are researching expanding network connections and optimizing gas costs using multiple back-end nodes. If this is achieved, the efficiency of the blockchain may increase (Tsepeleva & Korkhov, 2022; Kumari & Devi, 2022).

Fourth, the high volatility of DeFi assets could cause investors to incur significant financial losses. Diversification and use of stablecoins could help mitigate this risk.

However, stablecoins are not without risks. There is always a risk of insufficient reserves to support stablecoins. If the stability of stablecoins is compromised, volatility may arise, potentially resulting in significant financial losses for investors. This concern can be addressed by regularly auditing and reporting reserves holdings, and audits and reports should be transparent.

Another disturbing issue with DeFi is privacy. The transparency of blockchain networks may compromise user privacy by exposing their information to other users. To tackle this challenge, users should be cautioned about the type of private information to provide. Very sensitive user information should not be required or requested on DeFi platforms, and new technologies should be geared toward protecting user privacy.

Again, illicit activities such as money laundering and tax evasion, have been predominant on DeFi platforms. This is because Know Your Customer (KYC) procedures are not required on DeFi platforms. This problem can be solved by incorporating ways to identify customers without compromising their privacy.

In addition, the composability of DeFi protocols introduces the risk of systemic failure, as vulnerabilities in one protocol may affect other protocols. Regular stress testing can help control this risk. Likewise, volatility spillovers could occur between DeFi markets due to their connectedness. Portfolio optimization can help investors construct optimal portfolios when investing across DeFi markets.

In addition, non-technical users may not feel comfortable navigating the complex interfaces of DeFi platforms, thereby preventing their adoption of DeFi. To prevent this from happening, platform developers should ensure that the interfaces are user-friendly and should provide user guides.

Blockchain immutability prevents the rectification of transactions errors. This rigidity and inflexibility may make it difficult to adapt to changing circumstances or correct any financial mistakes. To address this challenge, upgradable smart contracts could be employed, and the community (users) should be more involved in DeFi governance.

In terms of governance, there is the risk that power may be concentrated in a few wealthy token holders (voters). Although governance concentration may speed up the decision-making process, it may lead to centralized control, resulting in limited decision-making representation. Potential solutions include improved governance mechanisms, broad community participation, and unconcentrated voting power.

Furthermore, many DeFi platforms are built on the Ethereum blockchain, and overreliance on a single blockchain poses concentration risks, particularly posing challenges during network disruptions. In addition, any security vulnerabilities in the Ethereum blockchain will compromise the security of DeFi platforms. Other blockchain networks should also be employed to reduce dependence on the Ethereum blockchain.

In addition, over-competition between DeFi platforms may lead to aggressive strategies that may harm the ecosystem. To avoid this, DeFi platforms should be encouraged to collaborate and cooperate more; even when competing against each other, they should adhere to sustainable practices.

In addition, it is difficult to balance the use of algorithms and humans in DeFi. Suboptimal decisions may be made if human intervention is not sufficient. While relying significantly on algorithms to make decisions, this should be supplemented with human judgment, especially for critical issues.

Again, market fluctuations may result in slippage and impermanent losses for liquidity providers on DeFi platforms. Losses reduce returns for liquidity providers and may discourage liquidity provision in times of high volatility. To address these liquidity challenges, dynamic liquidity strategies should be employed, liquidity providers should be incentivized, and liquidity pools should be fostered across various assets.

Another DeFi risk is credit risk. DeFi loans are non-recourse , and there are limited means of enforcing loan repayments. This may cause users to strategically default on their loans (credit risk), resulting in financial losses for lenders. As a result, confidence levels drop, impacting the creditworthiness of decentralized lending platforms. Reputation-based lending systems, collateral management solutions, and responsible lending practices can help mitigate this risk.

Other risks in DeFi include leverage and liquidation risks. It is possible to take high leverage positions in DeFi. Excessive leverage may result in margin calls, and DeFi participants may face the risk of liquidating their collaterals in decentralized lending protocols if the collateral values fall below specified levels. This may result in users' financial or asset losses in volatile markets or during market downturns. Potential solutions include dynamic collateral management, clear risk disclosures, conservative leverage limits, conservative liquidation thresholds, and user education on responsible leveraging.

Finally, from a social perspective, the growth and widespread adoption of DeFi may lead to job losses in the traditional finance sector, raising unemployment concerns. Disintermediation in financial services could lead to a loss of traditional intermediary jobs, leading to financial difficulties. It would be helpful to encourage workers in the traditional finance sector to acquire digital finance skills.

Conclusion

While DeFi has revolutionized the traditional financial landscape, it offers a balance between benefits and risks. Regarding its advantages, DeFi increases accessibility to financial services and enhances financial inclusion. It ensures the transparency and accountability of financial transactions, drives innovation and economic growth, and ensures transaction security by leveraging the immutability of the blockchain network. On the other hand, DeFi faces various risks and challenges, such as smart contract vulnerabilities, regulatory uncertainties, market volatility, scalability limitations, and privacy concerns.

This balance of advantages and challenges means that policymakers and regulators must strike equilibrium in regulating the DeFi ecosystem in such a way that minimizes risks without stifling innovation. Proper risk minimization will reduce stakeholders' financial losses and regulatory backlash, while continuous innovation will ensure the sustainable growth and progress of DeFi.

Based on the findings, recommendations for developers, regulators, and investors were developed:

Developers: One of the important roles of developers is to minimize security risks in DeFi systems. Developers must constantly follow new technologies and implement the most secure and up-to-date encryption techniques. In addition, updates should be made continuously according to user feedback to identify security vulnerabilities in the system. Developers can prepare seminars and educational videos that contain detailed information about smart contract security to investors and regulators.

Regulators: To develop laws and standards, regulators must first understand the logic and execution of DeFi systems. Regulators can learn the process and system in detail by collaborating with DeFi technology experts. International laws and protocols should be considered when developing laws and standards, and joint work should be carried out if necessary.

Investors: There are a few important points that investors should pay attention to in order to reduce security risks. First, they should undergo a detailed evaluation process for their investment projects. Who are the project supporters? How long has the project been in operation? They should answer such questions and conduct an analysis. Investors should constantly conduct security assessments to secure their DeFi systems. In addition, encryption technologies change constantly. The most innovative encryption techniques should be followed, and secure ones should be used.

Researchers can follow new technologies related to encryption techniques and conduct studies to determine their strengths and weaknesses. In addition, stress tests can be designed to determine the level of liquidity concerns of investors and guide other stakeholders. To add-

ress scaling challenges, research can be conducted to create technological solutions that will increase network speed and balance gas costs.

This study is not without limitations. First, only the Scopus database was used to search for relevant articles. Although the comprehensive coverage of the Scopus database is appreciated, the comprehensiveness of the Scopus database could be enhanced by searching for articles from other reliable databases. Second, this study's findings were obtained from only the 64 articles selected after the final screening stage. There is a risk of bias because the findings may reflect only the views presented in the 64 selected articles. Moreover, not all potential risks and challenges associated with DeFi have been identified. As the DeFi space evolves at a very rapid pace, new risks and challenges that are beyond the analyses conducted in this study will emerge.

To address the identified limitations of our study, we propose that future researchers try answering the research questions by searching for relevant articles from a wide range of databases to ensure comprehensiveness and possibly capture all the benefits and risks of DeFi discussed in the literature. Also, data sources should extend beyond scholarly articles to include industry reports, interviews, other primary sources, and real-world data. Practically, we recommend that practitioners integrate the risk-mitigation insights we have presented in this study and have comprehensive and effective risk management frameworks to deal with the numerous risks associated with DeFi.

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de Cillia, R., Reisigl, M., & Wodak, R. (1999). The discursive construction of national identity. *Discourse and Society, 10*(2), 149–173. http://dx.doi.org/10.1177/0957926599010002002

b) Journal Article with DOI and More Than Seven Authors

Lal, H., Cunningham, A. L., Godeaux, O., Chlibek, R., Diez-Domingo, J., Hwang, S.-J. ... Heineman, T. C. (2015). Efficacy of an adjuvanted herpes zoster subunit vaccine in older adults. *New England Journal of Medicine, 372,* 2087–2096. http://dx.doi.org/10.1056/NEJMoa1501184

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Sidani, S. (2003). Enhancing the evaluation of nursing care effectiveness. *Canadian Journal of Nursing Research, 35*(3), 26–38. Retrieved from http://cjnr.mcgill.ca

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Turner, S. J. (2010). Website statistics 2.0: Using Google Analytics to measure library website effectiveness. *Technical Services Quarterly, 27,* 261–278. http://dx.doi.org/10.1080/07317131003765910

e) Advance Online Publication

Smith, J. A. (2010). Citing advance online publication: A review. *Journal of Psychology.* Advance online publication. http://dx.doi.org/10.1037/a45d7867

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Henry, W. A., III. (1990, April 9). Making the grade in today's schools. *Time, 135,* 28–31.

Doctoral Dissertation, Master's Thesis, Presentation, Proceeding

a) Dissertation/Thesis from a Commercial Database

Van Brunt, D. (1997). *Networked consumer health information systems* (Doctoral dissertation). Available from ProQuest Dissertations and Theses database. (UMI No. 9943436)

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d) Dissertation/Thesis abstracted in Dissertations Abstracts International

Appelbaum, L. G. (2005). Three studies of human information processing: Texture amplification, motion representation, and figure-ground segregation. *Dissertation Abstracts International: Section B. Sciences and Engineering, 65*(10), 5428.

e) Symposium Contribution

Krinsky-McHale, S. J., Zigman, W. B., & Silverman, W. (2012, August). Are neuropsychiatric symptoms markers of prodromal Alzheimer's disease in adults with Down syndrome? In W. B. Zigman (Chair), *Predictors of mild cognitive impairment, dementia, and mortality in adults with Down syndrome.* Symposium conducted at the meeting of the American Psychological Association, Orlando, FL.

f) Conference Paper Abstract Retrieved Online

Liu, S. (2005, May). *Defending against business crises with the help of intelligent agent based early warning solutions.* Paper presented at the Seventh International Conference on Enterprise Information Systems, Miami, FL. Abstract retrieved from http://www.iceis.org/iceis2005/abstracts_2005.htm

g) Conference Paper - In Regularly Published Proceedings and Retrieved Online

Herculano-Houzel, S., Collins, C. E., Wong, P., Kaas, J. H., & Lent, R. (2008). The basic nonuniformity of the cerebral cortex. *Proceedings of the National Academy of Sciences, 105,* 12593–12598. http://dx.doi.org/10.1073/pnas.0805417105

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i) Paper Presentation

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