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The Relationship Between Compliance with the Principles of Transparency and Best Practice and Journal Sustainability in Scientific Publishing

Tuğçe PEKCOŞKUN¹, Kadri KIRAN², Didem AYDAN³, Fatma BAŞAR⁴, Cem UZUN⁵

ABSTRACT

The sustainability of journals in Türkiye has emerged as a crucial and timely issue. This study aims to address this issue by analyzing journal sustainability using transparency principles. We delve into the relationship between principles of transparency and best practice and journal sustainability, aiming to shed light on the importance of compliance with these principles in scientific publishing.

In this study, all 45 peer-reviewed journals in Türkiye in economics and administrative sciences on the DergiPark platform were selected as the study sample to minimize confounding factors. The compliance of journal sustainability indicators of these journals in the 2015-2020 period, such as publication status (active-continuing publishing or ceased publishing), annual published volumes, annual manuscript submission numbers, annual number of published articles, rejection rates, combined volume or issue, was compared with 16 principles of transparency and best practice items.

As a result of the analysis, it was revealed that the compliance of the journals with the transparency principles especially the ethical principles should be increased. It has been concluded that the high rejection rate, the publication of more issues per year, the use of the DergiPark submission system, and indexing coverage increase the sustainability of the journals.

Keywords: Economics and administrative sciences, Journal, TR Index, DergiPark, Türkiye.

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INTRODUCTION

The transformation of scientific studies by scientists into publications contributes significantly to the world of science. This is how the information obtained from scientific studies reaches a broad audience and is discussed. The majority of academic journals published in Türkiye (approximately 60%) are published by higher education institutions such as universities (Kozak, 2017). The survival of journals depends on many factors, both in terms of editorial processes and financial expenses. Most university journals are funded by universities in Türkiye; the academic staff of these universities mainly carries out the workload of the journals. In order to increase the quality of scientific journals in Türkiye and to provide a suitable environment for publication, a publishing platform called DergiPark, which includes a submission system and web hosting services, has been established within TÜBİTAK-ULAKBİM in 2015 (Dergipark, 2021).

“Since the 1960s, efforts to index scientific journals in Türkiye have been underway. In 2013, TÜBİTAK-ULAKBİM established the TR Index, which includes selection committees dedicated to improving the quality of scientific journals.” (Aslan, 2019, TR Index 2021). Articles in journals covered by this index have gained importance in academic appointments and promotions in Türkiye.

With the indexing of academic journals by the TR Index, it is clear that there has been an increase in the quality of scientific journals in Türkiye and that it will go further. One of the most widely used methods to improve the quality of scientific journals is the strict application of transparency and best practice principles (transparency principles) in scientific publishing, as published by DOAJ, COPE, WAME and OASPA (Redhead, 2018). DOAJ is a reliable index for identifying predatory journals that have come to the fore in recent years (WAME, 2016).

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These principles, which were created to ensure transparency and quality in the publications of journals, began to be examined in various studies on journals shortly after their introduction. Wicherts (2016) examined transparency in peer-review practices with 14 items he developed. He stated that these developed items could be used as an evaluation indicator that makes it possible to predict the academic quality in new journals. In a comprehensive article on Principles of Transparency and Best Practice in Scholarly Publishing, da Silva and Moussa (2024) evaluated the development and comparison of these principles, as well as their adequacy. They argued that instead of blindly trusting these principles, one should examine the structure of the members who created them and question whether the selected principles alone are sufficient to label a publisher as predatory. Huh (2018) wrote an editorial for the journal he edited, *Annals of Pediatric Endocrinology & Metabolism*, which included its commitment to these principles. According to the author the journal is fully adherenced to the Principles of Transparency and Best Practice in Scholarly Publishing especially to the ethical policies. Choi et al. (2019) examined the compliance of publications indexed by Science Citation Index Expanded and published by academic societies with these principles, and found that 10 out of 33 items, including readership, data sharing, archiving policies and profit model information, were weakly or rarely implemented. Choi et al. (2020) examined the compliance with these criteria in journals published by academic societies in Korea, and found that compliance was rare in many categories. Kiran (2018), in his study investigating the compliance of Trakya University journals with the transparency principles, found that high-quality journals comply with the transparency principles at a high rate.

Although large-scale studies provide information about the general situation, it can be considered that evaluations conducted in terms of scientific fields and on a country basis will be more insightful. In this respect, we believe that a study examining the compliance of journals published in any scientific field in Turkey with the Principles of Transparency and Best Practice in Scholarly Publishing will better reveal the situation of journals in this field. In the current study, we investigated the relationship between journal sustainability parameters and transparency principles regarding the sustainability of academic journals in a specific period (2015-2020).

The organization of the paper is as follows: **Section 2** presents the methodology, describing the selection of journals, data collection, and analysis techniques used

to evaluate compliance with transparency principles and journal sustainability. **Section 3** outlines the results, highlighting key findings on transparency compliance rates, rejection rates, indexing status, and the impact of the DergiPark platform. **Section 4** discusses the implications of these findings, compares them with previous studies, and evaluates their significance for journal sustainability. Finally, **Section 5** concludes the study by summarizing key insights, identifying limitations, and providing recommendations for improving compliance with transparency principles in scholarly publishing.

METHODOLOGY AND DATA

This study assessed whether journal sustainability is related to compliance with transparency principles. We considered the 16 transparency principles and their 27 subheadings in the third edition of the Principles of Transparency and Best Practice in Scholarly Publishing (Redhead, 2018). Items from the Principles of Transparency and Best Practice in Scholarly Publishing were scored as 'compliant (1)' or 'non-compliant (0)' and compliance ratios were created. The rates of compliance with the items were analyzed according to the number of issues published annually, rejection rates, years indexed in the TR Index and whether they use the DergiPark platform or not. In order to minimize potential confounding factors, we selected all 45 peer-reviewed journals hosted on the same platform (DergiPark) and published in Türkiye with the English title "economics and administration", with Turkish title "iktisadi ve idari" or with Turkish abbreviation "IIBF", as the study sample (Table 1). All of these journals are open-access journals, and the journal staff are academics affiliated with the university.

The journals included in the study were analyzed in terms of parameters that indicate the sustainability of the journal, such as publication status (active, ceased publication), annual number of submissions, number of articles published, number of issues published, rejection rates, and combined volume or issue publications between 2015-2020. In addition, the use of the DergiPark submission system (some journals use the submission system only as an archive depositor) and indexing in important indexes (TR Index, DOAJ, Web of Science core collection or Scopus) were also investigated, and the relationship between the data obtained and journal sustainability was statistically analyzed using the Student's t-test for associations and $p < 0.05$ ($p = 0.008$) was considered significant.

Table 1. Journals included in this study.

1	Afyon Kocatepe University Journal of Faculty of Economics and Administrative Sciences
2	Ahi Evran University Journal of Faculty of Economics and Administrative Sciences
3	Journal of Mediterranean IIBF
4	Aksaray University Journal of Faculty of Economics and Administrative Sciences
5	Journal of Anadolu University Faculty of Economics and Administrative Sciences
6	n.n: Ankara Hacı Bayram Veli University Journal of Faculty of Economics and Administrative Sciences/ o.n: Gazi University Journal of Faculty of Economics and Administrative Sciences
7	Ardahan University Journal of Faculty of Economics and Administrative Sciences
8	Artuklu Kaime International Journal of Economic and Administrative Research
9	Ataturk University Journal of Economics and Administrative Sciences
10	Journal of Balıkesir University Faculty of Economics and Administrative Sciences
11	Journal of Bartın University Faculty of Economics and Administrative Sciences
12	Journal of Bingöl University Faculty of Economics and Administrative Sciences
13	Bitlis Eren University Faculty of Economics and Administrative Sciences Academic İzdüşüm Journal
14	Cumhuriyet University Journal of Economics and Administrative Sciences
15	Journal of Çankırı Karatekin University Faculty of Economics and Administrative Sciences
16	Journal of Çukurova University Faculty of Economics and Administrative Sciences
17	Journal of Dicle University Faculty of Economics and Administrative Sciences
18	n.n: İzmir Journal of Economics/ o.n: Journal of Dokuz Eylül University Faculty of Economics and Administrative Sciences
19	Erciyes University Journal of Faculty of Economics and Administrative Sciences
20	Erzincan Binali Yıldırım University Journal of Faculty of Economics and Administrative Sciences
21	Eskisehir Osmangazi University Journal of Economics and Administrative Sciences
22	Firat University International Journal of Economics and Administrative Sciences
23	G.U. İslahiye IIBF International E-Journal
24	Gaziantep University Journal of Faculty of Economics and Administrative Sciences
25	Giresun University Journal of Economics and Administrative Sciences
26	Hacettepe University Journal of Faculty of Economics and Administrative Sciences
27	Journal of Iğdır University Faculty of Economics and Administrative Sciences
28	Journal of Economic, Administrative and Political Research
29	Kafkas University Journal of Faculty of Economics and Administrative Sciences
30	Journal of Kahramanmaraş Sütçü İmam University Faculty of Economics and Administrative Sciences
31	Kastamonu University Journal of Faculty of Economics and Administrative Sciences
32	Kırklareli University Journal of Faculty of Economics and Administrative Sciences
33	n.n: Marmara University Journal of Economics and Administrative Sciences/ o.n: Marmara University Journal of Faculty of Economics and Administrative Sciences
34	Mehmet Akif Ersoy University Journal of Faculty of Economics and Administrative Sciences
35	Journal of Nazilli Faculty of Economics and Administrative Sciences
36	Osmaniye Korkut Ata University Journal of Faculty of Economics and Administrative Sciences
37	n.n: Journal of Ömer Halisdemir University Faculty of Economics and Administrative Sciences/o.n: Journal of Niğde University Faculty of Economics and Administrative Sciences
38	Journal of Süleyman Demirel University Faculty of Economics and Administrative Sciences
39	Tarsus University Journal of Faculty of Economics and Administrative Sciences
40	Trakya University Journal of Faculty of Economics and Administrative Sciences
41	International Journal of Economics and Administrative Sciences
42	International Journal of Economic and Administrative Studies
43	Journal of Unye Faculty of Economics and Administrative Sciences
44	n.n: Journal of Van Yüzüncü Yıl University Faculty of Economics and Administrative Sciences/o.n: Journal of Yüzüncü Yıl University Faculty of Economics and Administrative Sciences
45	Management and Economics: Journal of Celal Bayar University Faculty of Economics and Administrative Sciences

n.n. new name, o.n. old name.

RESULTS

It has been determined that two journals terminated their publications during the analysis period. Generally, half of the journals published 1 or 2 issues and the other half, 3 or 4 issues per year, while the highest compliance with the transparency principles was observed in journals publishing 3 and 4 issues per year (Fig. 1). Most journals received 57 to 408 submissions and published between 18 and 208 annual publications. Accordingly, the rejection rates that we calculated varied between 14% and 78%. We did not detect a combined issue or a combined volume in any of the journals.

The principles related to "Website", "name of journal" and the "peer review process" were the most consistently

followed (%98, %100 and %100 respectively). However, there was no information on "advertising" and "direct marketing". The lowest compliance with the principles of transparency is in "Advertising" and "Marketing" with 0% compliance, followed by "Revenue sources" with 6.34% compliance. More importantly, overall compliance with the principles of "Publication ethics" scored the lowest with 21%. Within its subheading of "Data sharing and reproducibility" no information exists in any of the journals (Table 2).

The highest compliance was seen among journals with the highest rejection rate. As the rejection rate decreased, a lower level of compliance was observed, albeit fluctuating. (Fig. 2).

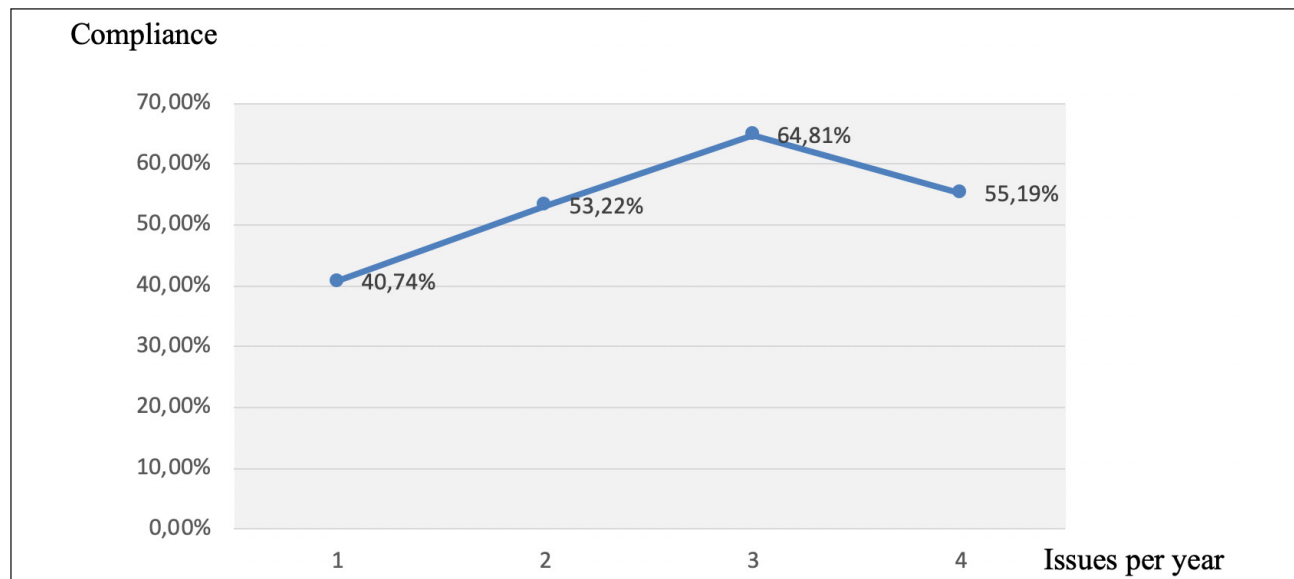


Figure 1: Relation to the transparency principles with the annual number issued.

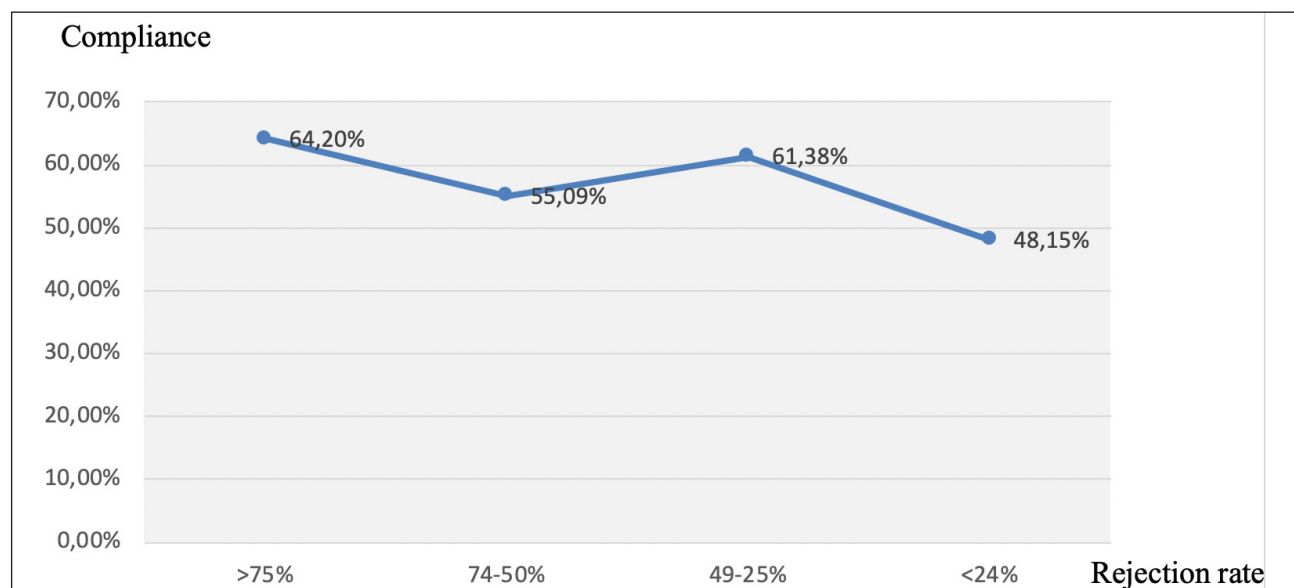


Figure 2: Rejection rate.

Table 2. Compliance of the analyzed journals with 16 items and 27 sub-items of the “Principles of Transparency and Best Practices in Scientific Publishing”.

Principles	Subprinciples	All Journals (n=45)	Rejection rates (n= 23)		Issues per year (n=43)		Indexing (n=45)		Dergipark (n=45)	
			≥50	<50	1 to 2	3 or more	indexed	non	used	non
1. Web Site	Aim & Scope	96.01%	100.00%	91.67%	96.43%	93.33%	100.00%	91.67%	95.00%	100.00%
	ISSN	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	Overall	98.01%								
2. Name of Journal	Not Mislead	96.43%	100.00%	100.00%	71.43%	100.00%	100.00%	100.00%	100.00%	100.00%
	Unique Name	96.43%	100.00%	100.00%	71.43%	100.00%	100.00%	100.00%	100.00%	100.00%
	Overall	96.43%								
3. Peer Review Process	Peer Review marked	84.38%	81.82%	100.00%	78.57%	86.67%	90.48%	75.00%	82.50%	80.00%
	Peer Review process description	71.43%	81.82%	83.33%	67.86%	80.00%	80.95%	62.50%	75.00%	40.00%
	Not Guarantee of acceptance or short peer Review times	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%	100.00%
	Overall	85.27%								
4. Ownership and management		63.86%	63.64%	83.33%	64.29%	60.00%	57.14%	62.50%	60.00%	60.00%
5. Governing Body		95.49%	100.00%	91.67%	92.86%	100.00%	95.24%	91.67%	92.50%	100.00%
6. Editorial team info		79.07%	81.82%	66.67%	78.57%	73.33%	90.48%	66.67%	75.00%	100.00%
7. Copyright and Licensing	Statement in Web	85.32%	81.82%	83.33%	82.14%	93.33%	95.24%	79.17%	87.50%	80.00%
	Statement in published articles	5.57%	0.00%	16.67%	0.00%	13.33%	9.52%	0.00%	5.00%	0.00%
	Overall	45.44%								
8. Author fees		71.14%	72.73%	75.00%	60.71%	80.00%	85.71%	50.00%	65.00%	80.00%
9. Allegations of misconduct		26.06%	27.27%	41.67%	21.43%	33.33%	38.10%	16.67%	30.00%	0.00%
10. Publication Ethics	Authorship	9.37%	9.09%	0.00%	7.14%	13.33%	9.52%	8.33%	7.50%	20.00%
	Complains	14.39%	27.27%	16.67%	14.29%	13.33%	28.57%	0.00%	15.00%	0.00%
	Conflicts of Interest	22.81%	18.18%	41.67%	17.86%	33.33%	38.10%	8.33%	25.00%	0.00%
	Data sharing and reproducibility	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
	Ethical oversight	80.65%	100.00%	75.00%	75.00%	80.00%	95.24%	62.50%	77.50%	80.00%
	Intellectual property	17.24%	18.18%	25.00%	17.86%	20.00%	28.57%	8.33%	20.00%	0.00%
	Post-publication corrections	4.54%	9.09%	0.00%	0.00%	13.33%	4.76%	4.17%	5.00%	0.00%
	Overall	21.29%								
11. Schedule		83.82%	90.91%	83.33%	78.57%	100.00%	95.24%	75.00%	87.50%	60.00%
12. Access		64.91%	81.82%	58.33%	60.71%	73.33%	80.95%	54.17%	70.00%	40.00%
13. Archiving		92.93%	100.00%	91.67%	89.29%	100.00%	100.00%	87.50%	95.00%	80.00%
14. Revenue sources		6.34%	9.09%	0.00%	3.57%	6.67%	4.76%	4.17%	2.50%	20.00%
15. Advertising		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
16. Marketing		0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%	0.00%
Total compliance		58.13%	57.58%	56.48%	50.00%	58.02%	60.32%	48.46%	54.54%	49.69%
student's t test							p<0.001			

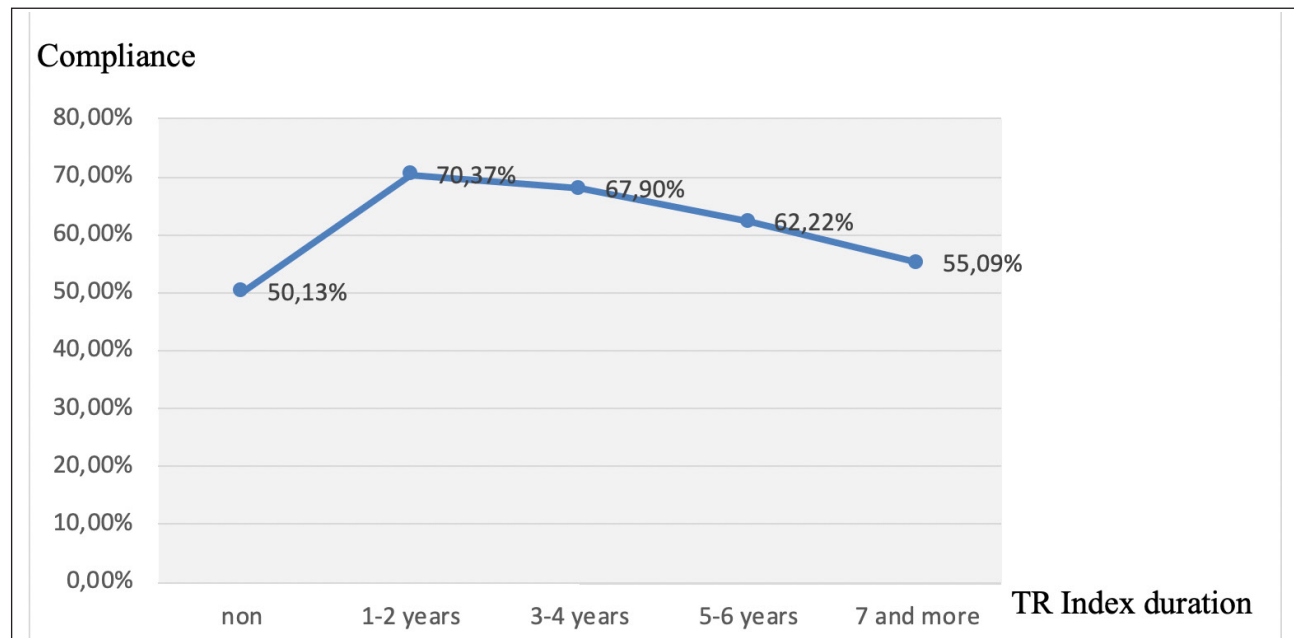


Figure 3: TR Index Duration.

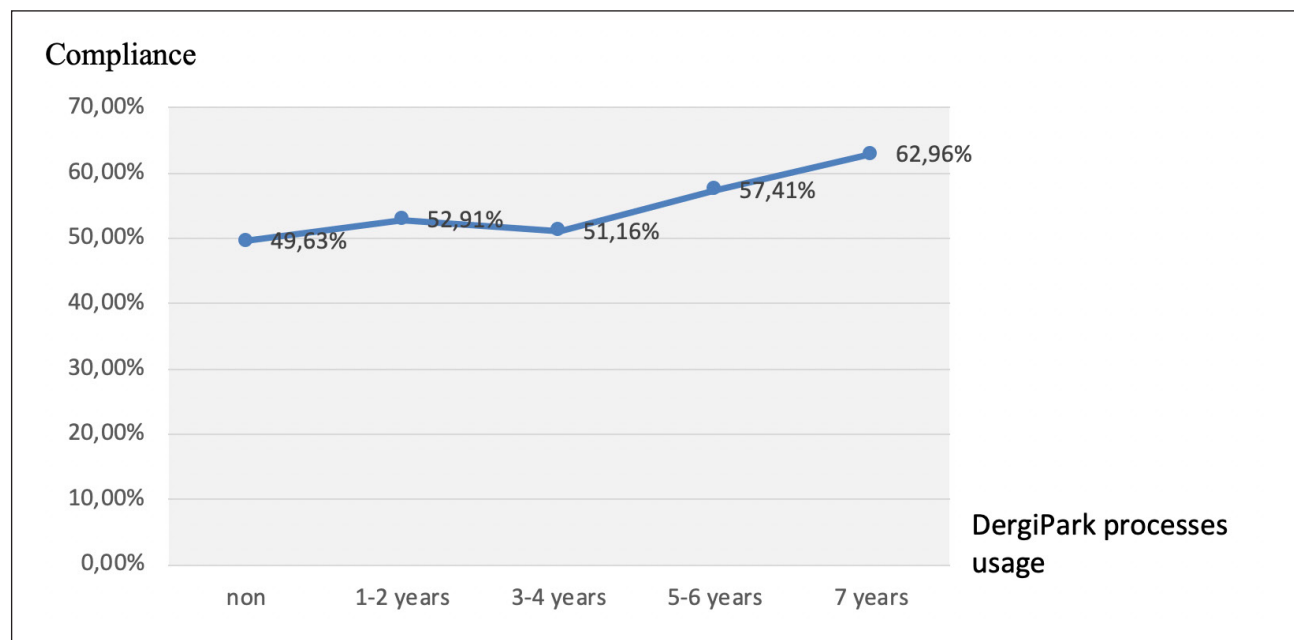


Figure 4: DergiPark Submission System Usage.

There is a direct correlation between being listed in the TR Index and compliance with transparency principles, although compliance decreases as the duration of being indexed in the TR Index increases (indexed: 63% and non-indexed: 48%; $p=0.008$) (Fig. 3).

The concordance rate was exceptionally high for newly indexed journals (70%) (Fig. 3). Twenty-one journals are covered by the TR Index and/or DOAJ, and none are indexed in the Web of Science core collection or Scopus. Four of them use the DergiPark submission system for all manuscript evaluation processes (Fig. 4).

DISCUSSION, LIMITATIONS and CONCLUSION

High-quality and sustainable journals are journals based on teamwork (the owner of the journal, the institution, the editors, the publisher, the journal boards and even the referees, authors and readers) and have a publishing principle that adheres to international publishing standards. They attract good writers and improve the quality of their work by providing a good peer-review process, support ethical science by protecting both authors and society through proactive interactions, informing authors about ethical principles, and ensure that science reaches all segments of society by

increasing visibility. It is essential for journals to maintain the sustainability of their websites, to comply with the principles of transparency in scientific publishing, to follow international editorial organizations, to determine their policies accordingly and to keep them up to date, and to make revisions in their journals accordingly. It is also necessary for them to actively engage with these standards and organizations.

In this study, economics and administrative science journals in Türkiye were analyzed to constitute a homogeneous sample. It has been revealed that the compliance of journals with the principles of transparency should be increased, especially in terms of ethical issues. We find that compliance with the transparency principles increases with a higher rejection rate and the number of issues published annually. There was a direct correlation between getting indexed in important indices and the compliance to the transparency principles (indexed: 63% vs non-indexed: 48%; $p=0.008$), especially among recently indexed journals had a high compliance rate (70%). It has also been detected that compliance with the principles of transparency has increased with the duration of using the DergiPark platform, which has made a significant contribution to journal sustainability. We also found that the newly accepted journals into the TR Index showed a high level of compliance. We think that this result may be the reason of the recent strict acceptance criteria of the index selection.

In our study, it was found that economics and administrative science journals in Türkiye showed low compliance with ethical principles, which is one of the principles of transparency (Table 2). Low compliance with ethical principles may also have negative consequences for journals in terms of gaining international visibility and prestige. In addition, low compliance with possible ethical principles may be an important factor threatening the sustainability of journals. Unless publishers and editors strengthen their commitment to these principles, it will be difficult for journals to maintain their relevance and influence in the academic world in the long term. In this context, increasing compliance with ethical principles will not only improve the scientific quality of journals, but also support their sustainability by giving them a stronger place in international academic networks.

The most important limitation about the data, as the number of journals with available data only 23 before 2020. Therefore, we analyzed the development of the journals and their compliance with transparency principles by examining their printed versions, as a comparison can be made by considering only 2020 data.

Another limitation of the study is that it was conducted only among the economic and administrative sciences journals of universities and none of them was included in the WoS core index.

In conclusion, the compliance of Turkish journals of economic and administrative sciences with the principles of transparency should be increased. In addition to being used as a quality criterion, compliance with transparency principles can also be related to the sustainability of the journal. Finally, we can say that the lack of transparency in communicating the editorial policies of journals to authors and readers and the realization of best practices is actually due to a lack of information. By knowing about such compliance analyses, publishers can easily improve their journals.

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Human Development-Crime Nexus in the European Countries: Do Unemployment and Inflation Matter?

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ABSTRACT

Difficulties in conceptualizing the crime phenomenon from past to present reveal various facts in economic, social and legal terms. In this direction, examining the linkage between crime phenomenon and human development constitutes one of the new fields of study in the economics literature. The phenomenon of crime can impose a cost on the economies and investments to be made in productive areas can be directed to crime prevention mechanisms. When the phenomenon of crime is evaluated within the framework of both social and economic policies, it can be stated that it imposes a cost on society through externalities. To solve this problem and minimize the cost, it is necessary to define the crime phenomenon and determine the effects of human development on crime. The aim of the article is to investigate the linkage between the human development and crime. In this context, the relationship between human development and crime is examined for 30 European countries based on the years 2008-2020.

Keywords: Crime phenomenon, Human development, Unemployment, Inflation, Finite mixture model.

JEL Classification Codes: E24, C33, D31

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INTRODUCTION

The phenomenon of crime can be expressed as a problem that harms the social order and affects the social structure fundamentally. There are many different factors that trigger the crime phenomenon. Crime can produce results that are very difficult to compensate, both materially and morally. In this context, the phenomenon of crime becomes one of the most important problems in interaction with social, political and economic life. When crime is evaluated within the framework of both social and economic policies, it imposes a cost on society through externalities. In order to solve this problem and minimize the cost, it is necessary to define the crime phenomenon and determine the factors that trigger the crime.

Economic theory has begun to focus on social determinants as well as macro determinants of economic growth in recent years. While economic indicators of countries provide a macro perspective, social indicators provide a micro perspective from an individual perspective. Social and economic factors interact with each other. In this context, economists have concentrated their attention to the criminal attitude of individuals since 1960s. The concept of crime, which

characterizes contemporary economies, has attracted the concentration of social scientist in recent years. In addition to the negative effects of crime on social life, its negative effects on economic activities have also been discussed. In this respect, the effect of crime on economic variables has become widely studied in the field of social sciences.

The starting point of economic crime studies is Becker's (1968) seminal article on "Crime and Punishment" (see also Stigler, 1970; Ehrlich, 1973; Merlo, 2004). Crime economy model of Becker is bottomed on the relationship between punishment and crime. In accordance with Becker, a rational individual compares his or her own benefit and cost in deciding to act illegally; that is, the illegal behavior of individuals can be clarified by the hypothesis of rational behavior under uncertainty (Becker, 1968). This may include a loss of external preference, which is often represented by revenue from the legal and less risky activity. Ehrlich (1973) develops Becker's model and also addresses the sensitivity of individuals to economic incentives and interactions. Since individuals' opportunities in legal activities and the expected returns as a result of committing a crime are variable, it is stated that other factors together with individual income are the determinants of crime. Six basic dimensions examined in

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former investigations and likely to be related to further neglected determinants are considered below (Cerulli et al., 2018: 3);

- Educational achievements,
- Employment level,
- Wage,
- Income inequality,
- Public spending for the police,
- Presence of foreign-born population.

Labor market conditions can affect different crime cases in different ways. Especially after Fleisher's (1963) study of the connection between unemployment and crime, modern investigations have focused on the monetary aspect of the labor market. Wages from legal activities are seen as both a component of income and the opportunity cost of criminal proceedings. The short and long-run impacts of unemployment differ at that point. Although individuals tend to look for another job after being unemployed for a short time, a long period of unemployment can increase criminal activity (Gumus, 2004: 5).

Another important factor that determines the crime is the inflation rate. As inflation weakens purchasing power, the real income of individuals decreases. This could potentially worsen living standards, thereby encouraging individuals to commit crimes. Thus, it is clear that inflation encourages delinquency, as income influences choices regarding crime and inflation reduces purchasing power (Lauridsen et al., 2013). It is also known that lower income groups are most affected by high inflation. Therefore, inflation give rise to low-income people to become more sensitive to crime if their wages are not improved. But wages do not immediately adjust to inflation (Seals and Nunley, 2007).

While Becker's (1968) model focuses on individual rational choice, human development can be theoretically integrated into this framework as a structural determinant that shapes individual incentives. Higher levels of education, health, and income—as reflected in the Human Development Index—enhance legal labor market opportunities, raise the opportunity cost of crime, and foster long-term planning, thereby reducing the propensity for criminal behavior. In terms of socio-economic determinants of crime, it can be stated that human development is one of the most substantial socio-economic indicators of countries. The human

development index includes education, health and economy indicators. Therefore, human development can give more reliable results as a determinant of crime. The basic goal of this article is to explore the diverse linkages that may exist among unemployment, inflation, human development and crime. For this purpose, the influence of human development on crime under the role of unemployment and inflation was empirically analyzed using panel data from 30 EU countries from 2008 to 2020. More importantly, a finite mixture model (FMM) was used to catch unobserved heterogeneity problems; this procedure presents an efficient path to describe and characterize unobserved heterogeneity (Van Dijk, 2009: 31).

The absence of the issue of choosing the thresholds to sub-separate the sample is one of the major advantages of FMM. Countries can be endogenously appointed to distinct sub-groups according to whether or not they have alike crime deployment using the FMM method. Another advantage of this model is that it permits observing different roles of human development in the determination of crime, taking into account possible inconsistencies in the regression coefficients of distinct sub-groups.

This article contributes to literature from various aspects. First, heterogeneity in countries is addressed and possible multiple relationships between human development and crime are identified. To achieve this, a FMM was applied, which ensures an endogenous data-controlled design for parting the samples. Thus, it will come up with to a better comprehension of the link between human development and crime by showing the contribution of unemployment and inflation. Second, this is the first study to concentrate on the linkage between human development and crime using FMM. Thus, group switching dynamics are captured while allowing policy objectives to be addressed for subgroups.

The rest parts of the article are composed as follows: Second section examines current literature on unemployment, inflation, human development and crime to strengthen our research motivation and better understand its fundamentals. Third section explains the FMM and presents the dataset. Fourth section ensures the empirical findings. Fifth section criticizes the primary conclusions and recommends policy inferences.

LITERATURE

Before scrutinizing the relationship between human development and crime, it is essential to examine previous studies on this subject; the current studies can be classified under three pillars.

The first is studies that discover the linkage between economic growth and crime. Some of these studies research the impacts of crime on economic growth, while others examine the influences of economic growth on crime. There are studies in which crime affects economic growth negatively in European countries (Neanidis et al., 2017; Detotto and Pulina, 2012; Ulucak and Bilgili, 2020) and in other countries (Estrada and Ndoma, 2014; Adekoya and Abdul Razak, 2017; Jeke et al., 2021; Drugowick and Pereda, 2019; Kathena and Sheefeni, 2017; Kumar, 2013; Ahmad et al., 2014; Priyadarshani et al., 2021; Mose et al., 2019), and there are studies where economic growth affects crime positively in European countries (Selmonaj and Morina, 2021) and in other countries (Mulok et al., 2016; Ahmed and Idrees, 2018; Dundar, 2021). According to the Goulas and Zervoyianni (2015), In periods when market sentiment is pessimistic, crime has a negative influence on economic growth, while in periods when economic conditions are favorable, crime does not have a significant negative influence on economic growth. On the other hand, Remeikiene et al. (2022) found that the linkage between crime and economic growth is not one-way.

The second is the researches that focus on the linkage between crime and unemployment. While some of these studies revealed that unemployment increases the crime rate in European countries (Altindag, 2012; Lojanica and Obradović, 2020; Recher, 2019; Ayhan and Bursa, 2019; Järvenson, 2022; Umbach, 2020; Buba et al., 2018), some of them found the same relationship in other countries (Rungsisawat et al., 2019; Anser et al., 2020; Rafique, 2021; Kassem et al., 2019; Tabar and Noghani, 2019; Verma et al., 2022). Conversely, Onwuka et al. (2020) claimed that unemployment influences economic growth negatively because of high level of crime. According to the Schleimer et al., 2022, unemployment led to a rising on crime during Covid-19 pandemic.

The third one is the studies that deal with the linkage between crime and inflation. The linkage between inflation and crime was found to be positive both in the context of European countries (Kizilgol and Selim, 2017; Lauridsen et al., 2013; Ulucak and Bilgili, 2020), and in the context of other countries (Gillani et al., 2009; Tang and Lean, 2007; Torruam and Abur, 2014; Tang, 2009; Santos

et al., 2021; Rosenfeld and Vogel, 2021). In addition to all these, there are also studies that analyze other economic and social variables and crime.

Studies investigating the relationship between human development and crime are very limited. Andzenge (1991) examine social and economic development-crime nexus context of 34 countries from 6 regions. He found that development may have actually contributed to the decrease in crime. According to the Sarvaria (2019), while economic development affects certain types of crime, crime cannot be attributed to a single cause. He states that necessity can lead to crime, but current modernization and development has changed the perspective of crime. On the other hand, Wanzinack et al. (2022) analyzed the relationship among homicides, urbanization, population, inequality and development for Brazil. Their findings reveal that lower inequalities and higher human development could reduce the number of homicides.

Studies in the literature ensure major senses on the relationship amongst unemployment, inflation, human development and crime. Nevertheless, these studies may be exposed to some limitations. First, Studies investigating the relationship among the four variables are limited. There are only a few studies in the literature have concentrated on human development. Although prior research has established significant associations between unemployment or inequality and crime, they typically do not account for latent subgroups that may respond differently to socio-economic pressures. Such an omission may lead to biased estimates or mask meaningful cross-country variations. Second, because these studies do not address the heterogeneity problem, the sample may be subject to partition bias. In order to detect heterogeneity in the literature, the entire sample is separated into multi sub-samples with respect to income levels. But this presumption may not be certain. This study contributes to the literature by combining a socio-economic development perspective with a latent group estimation approach, offering a more nuanced and empirically grounded understanding of how macro-level variables influence crime in diverse European contexts.

METHOD and DATA

Method

Panel datasets consist of units (N) and observations (T). The tests and methods applied to analyze panel time series contain common information about panel data and time series analysis methods. However, the

problem of heterogeneity may arise in panel data analysis. Recently, the finite mixture model (FMM) has been introduced to correct this possible heterogeneity. FMM is a semi-parametric method and helps to address potential heterogeneity in the panel without any prior ad-hoc grouping. Unlike fixed effects or GMM estimators, which assume homogeneity within units or over time, the FMM allows for unobserved heterogeneity by identifying latent subpopulations with different regression structures. In this method, units are divided into different classes endogenously to solve the heterogeneity problem (McLachlan et al. 2019; 370). FMM method provides some advantages for our study. Developing the parameters by class allows us to observe the impact of human development on crime on a class-by-class basis. FMM with concomitant variables can reveal the sources of different human development-crime relationships. In addition, FMM ensures some particular information about the vital linkage between fundamental variables in the selected period range. Within the framework of this definition, the FMM can formulate as follows (Green, 2018);

$$f(y_{it}) = \sum_{g=1}^G \pi_g \cdot \phi(y_{it} | x_{it}, \theta_g) \quad (1)$$

In the equation (1) y_{it} is the observed dependent variable, G is the number of latent groups, π_g is the mixing probability for group g , and $\phi(\cdot)$ is the normal density function conditional on covariates x_{it} and group-specific parameters θ_g . In light of this information, the estimated model can be presented below;

$$y_{it} = x'_{it}\beta_g + \varepsilon_{it}, \varepsilon_{it} \sim N(0, \sigma_g^2) \quad (2)$$

This is the regression model applied separately within each group g , where β_g is the group-specific coefficient vector, and σ_g^2 is the group-specific error variance. Various inferences can be made for equation (2). Dependent variable is the CRI (crime) and explanatory variable is the HUD (human development). Human development can perform distinct effects on crime rates among various groups. Likewise, the influences of control variables (c) are allowed to vary for various groups. Gross domestic product (GDP) as a determinant of CRI is included in the model as control variables (c) in order to develop the prediction of FMM and to achieve precise findings. In addition, the probability of being classified in a latent group is calculated from the polynomial logit regression.

$$\pi_g(z_{it}) = \frac{\exp(z'_{it}\gamma_g)}{\sum_{g=1}^G \exp(z'_{it}\gamma_g)} \quad (3)$$

This multinomial logit model determines the probability that observation i belongs to group g , depending on the concomitant variables z_{it} and logit parameters γ_g . On

the other hand, under the supposition that the error term is normally distributed, the log-likelihood equation can be expressed as:

$$\log L = \sum_{i=1}^N \sum_{t=1}^T \log \left(\sum_{g=1}^G \pi_g(z_{it}) \cdot \phi(y_{it} | x_{it}, \beta_g, \sigma_g^2) \right) \quad (4)$$

This equation represents the full log-likelihood function to be maximized in the EM algorithm. It combines the likelihood across all groups and all observations in the panel dataset. There is no specific standard for determining the optimum number of groups. Therefore, Akaike (AIC) and Bayesian (BIC) information criterions were selected to determine the most effective number of groups based on the literature (Celeux et al. 2018). Next, the margin of groups on the sample is calculated:

$$\hat{g}_{it} = \underset{g}{\operatorname{argmax}} \left[\pi_g(z_{it}) \cdot \phi(y_{it} | x_{it}, \beta_g, \sigma_g^2) \right] \quad (5)$$

After estimation, each observation is assigned to the most likely group using this rule, which maximizes the posterior group probability.

In the FMM framework, explanatory variables directly affect the dependent variable within each latent group. In contrast, concomitant variables influence the probability of group membership by affecting the multinomial logit function that determines group classification. In this study, the Human Development Index (HDI) is used as the main explanatory variable affecting crime rates, while unemployment and inflation serve as concomitant variables that determine the likelihood of a country belonging to a specific latent crime group.

In the Finite Mixture Model (FMM), the classification into groups is latent and probabilistic. Each group represents a distinct regression regime with its own set of coefficients. Therefore, the model does not rely on dummy variables for group membership. All groups are estimated simultaneously; there is no reference or omitted group as in traditional categorical variable coding. The term "base class" used in Table 4 simply reflects the normalization point for interpreting the multinomial logit probabilities, not a dummy variable framework. Unlike models with categorical dummy variables, FMM does not estimate one group relative to another. Instead, it fits separate models for each latent group and estimates both the regression parameters and the group membership probabilities.

While HDI may be correlated with macroeconomic variables such as unemployment and inflation, its multidimensional structure (education, life expectancy, and income) ensures that it captures broader socio-economic development. Moreover, by modeling

unemployment and inflation as concomitant variables—affecting group membership but not directly entering the regression equation—we reduce the risk of simultaneity bias in the estimated coefficients of HDI. To address potential endogeneity, a robustness check was performed using lagged values of unemployment, inflation, and HDI. Results remained consistent, supporting the reliability of the causal interpretation of HDI's effect on crime.

Data

This article analyzes the crime rates in 30 EU countries between 2008-2020 using the panel data method, as shown in Table 1. The dependent variable is crime (CRI, international homicide per hundred thousand inhabitants) based on Eurostat. Although the concept of crime covers a wide spectrum, this study focuses specifically on homicide due to its comparability across countries and consistent data availability in Eurostat. Moreover, homicide is considered a reliable proxy for broader violent crime trends in empirical economic research. The explanatory variable is human development index (HUD, 0-1) United Nations (Development Reports). HUD includes three dimensions: (i) health (life expectancy at birth), (ii) education (mean and expected

years of schooling), and (iii) standard of living (GNI per capita). With higher values indicating higher levels of human development. Unemployment rate (UNE, as percentage) and inflation rate (INF, as percentage) are used as concomitant variables and both variables are collected from WB (World Development Indicators). Gross domestic product (GDP, as percentage growth) is tested as control variable in the model. Table 2 includes the descriptive statistics for series.

EMPIRICAL FINDINGS

Specification Test

The aim of this section is to discover the linkage among crime, human development and unemployment. Before the FMM test results, it is essential to specify the optimal group number for human development-crime nexus. In the FMM model, the optimal group number is decided on the basis of AIC and BIC information criteria. Three different models will be investigated in the study: (I) unemployment as a concomitant variable without control variables; (II) unemployment and inflation as concomitant variables without control variables; (III) unemployment and inflation as concomitant variables with control variable gross domestic product. The Expectation-

Table 1. Sample list

Austria	Greece	Norway
Belgium	Hungary	Poland
Bulgaria	Iceland	Portugal
Croatia	Ireland	Romania
Cyprus	Italy	Serbia
Czechia	Latvia	Slovak Republic
Denmark	Lithuania	Slovenia
Estonia	Luxembourg	Spain
France	Malta	Sweden
Germany	Montenegro	Switzerland

Table 2 Descriptive statistics

Variable	Obs.	Mean	Std. dev.	Min	Max
Dependent variable					
International homicide per hundred thousand inhabitants (CRI)	390	1.43851	1.249036	0	8.9
Explanatory variable					
Human development index (HUD)	390	0.8800026	0.0455911	0.765	0.962
Concomitant variables					
Unemployment rate (UNE)	390	9.062949	5.081321	2.01	27.47
Inflation rate (INF)	390	1.895654	2.317373	-4.478103	15.40232
Control variable					
Gross domestic product (GDP)	390	0.8571736	3.975753	-15.20847	23.20087

Maximization (EM) algorithm is an iterative method used to estimate model parameters in the presence of latent variables, such as unobserved group memberships in FMM. By means of the EM algorithm, single-group, two-group and three-group FMM models are estimated separately. The outcomes of the specification tests acquired from the AIC and BIC information criterions are given in Table 3. Three model specifications were used to test the robustness of group classification under different assumptions regarding control variables. This also allowed assessment of whether inflation adds explanatory power beyond unemployment alone. For all three cases, the two-group FMM model is optimal since the AIC and BIC information criterions are minimum in the three-group model.

5% level. The coefficients for the INF are 0.5561318 and 0.6384973 for group 2 and 3, respectively. These results propose that higher inflation rates are accompanied with a higher possibility of owing to group 2 and 3 instead of group 1. These outcomes obviously indicate considerable distinctions in unemployment and inflation among group 1, 2 and 3. The rate of unemployment and inflation in group 1 is higher than in group 2 and group 3.

Looking at the explanatory variable, the influence of human development on crime rates is negative and significant at the 1% level irregardless if group 1, 2 or 3. It indicates that human development decreases crime. These results are compatible with prior studies (Andzenge, 1991; Sarvaria, 2019; Wanzinack et al. 2022). More significantly, the linkage between human development

Table 3. Specification test results

(I) UNE as a concomitant variable without control variable					
Class number	Obs.	LogL.	Df	AIC	BIC
G = 1	390	-612.6666	3	1231.333	1243.232
G = 2	390	-329.3717	8	674.7433	706.4725
G = 3	390	-312.7094	13	651.4187	702.9786
(II) UNE and INF as concomitant variables without control variable					
Class number	Obs.	LogL.	Df	AIC	BIC
G = 1	390	-612.6666	3	1231.333	1243.232
G = 2	390	-327.2612	9	672.5224	708.2177
G = 3	390	-305.3574	15	640.7147	700.2069
(III) UNE and INF as concomitant variables with control variable GDP					
Class number	Obs.	LogL.	Df	AIC	BIC
G = 1	390	-612.2372	4	1232.474	1248.339
G = 2	390	-327.1856	11	676.3713	719.9989
G = 3	390	-304.9172	18	645.8345	717.2251

FMM test

According to the left panel of Table 4, model (II) has the minimum information criteria among the three models. Therefore, the focus will be on model (II) in order to discuss the empirical results. In the selected FMM, the proportion of group 1, 2 and 3 are 21%, 60% and 19%, respectively. Group 1, 2 and 3 are defined as low crime, medium crime and high crime according to the number of crimes in different groups.

The results regarding the concomitant variables are given in Table 4. The multiple of UNE is positive and significant at 1% level in group 2 and 3. It means that relative to group 1, higher crimes with higher unemployment are more likely to belong to group 2 and 3. Besides, the coefficients for INF are significant at

and crime has meaningful differentiation on discrete groups. The marginal effect of human development on crime in group 1, 2 and 3 are (-2.082414), (-5.677106) and (-26.08943), respectively. Also, the joint test results in Table 5 show that the H_0 hypothesis that all parameters are identical was rejected. It means that human development's influence on crime is heterogeneous among distinct groups and ensures empirical evidence for argument.

Here are some important results in terms of literature. First, human development has a reducing influence on crime usually; but this influence weakens when UNE expands, indicating that the unemployment rate has a substantial role on the relationship between human development and crime. Second, it can be also inferred

Table 4. FMM test results

AIC		UNE	INF	HUD	GDP	C	Group proportion
(I) 651	Group (1)	(base class)		-2.056569* (1.059387)		2.572058*** (0.9937271)	17%
	Group (2)	1.019226*** (0.2928194)		-5.656358*** (0.479364)		6.027958*** (0.4172539)	64%
	Group (3)	1.019099*** (0.2936276)		-27.03361*** (5.907988)		26.87695*** (5.180418)	19%
(II) 640***	Group (1)	(base class)	(base class)	-2.082414* (1.18799)		2.616112*** (1.122508)	21%
	Group (2)	1.197375*** (0.3242367)	0.5561318** (0.2598707)	-5.677106*** (0.5624436)		6.048933*** (0.4893649)	60%
	Group (3)	1.188229*** (0.3251322)	0.6384973** (0.2556674)	-26.08943*** (6.430993)		26.03161*** (5.649484)	19%
(III) 645	Group (1)	(base class)	(base class)	-2.276163** (1.063704)	-0.0014983 (0.0095486)	2.802907*** (1.002811)	22%
	Group (2)	1.20556*** (0.33691)	0.5617692** (0.2631369)	-5.717275*** (0.564342)	0.0051009 (0.0063935)	6.081976*** (0.4882078)	59%
	Group (3)	1.194063*** (0.3374342)	0.6347125** (0.2611792)	-27.14201*** (6.178067)	0.0237617 (0.0400348)	26.94295*** (5.413026)	19%

Note: *, ** and *** represents 0.1, 0.05 and 0.01 significance level, respectively.

Table 5. Joint test results

Variable	Chi ₂	Prob.
UNE	25.70	0.0000
INF	50.64	0.0000
HUD	25.68	0.0000
GDP	1.79	0.4085

that INF performs a similar influence to unemployment on the human development-crime relationship; that is, human development will achieve less crime in low inflationist countries. Third, when there are higher inflation and lower unemployment, there is a more negative linkage between human development and crime (i.e., group 3).

Actually, unemployment and inflation are the most important macroeconomic factors and quite effective on crime. Therefore, human development, which is the outcome of a strong socio-economy, will be able to reduce crime. Groups are latent classes endogenously determined by the model based on similarities in crime dynamics. Countries are not grouped a priori but based on shared statistical patterns in homicide rates. Overall, the findings suggest that human development reduces crime more effectively in countries with lower unemployment and inflation. While macroeconomic

factors may influence HDI to some extent, they function independently in our FMM framework—HDI explains crime within groups, while unemployment and inflation determine the probability of group membership. Thus, the model structure prevents simultaneity bias and ensures consistency of parameter estimates.

Country level analysis

Having identified how the unemployment and inflation rates affects the human development-crime relationship from a static view, particular knowledge about the conversion on the human development-crime relationship is presented on the basis of countries throughout the sampling date.

On a country-by-country basis, Figure 1 serves up the dispersion of the crime number per hundred thousand inhabitants in countries on the basis of group affiliation. Switzerland, Spain, Slovenia, Norway, Luxembourg,

Italy, Iceland, Czechia and Austria are in the low crime

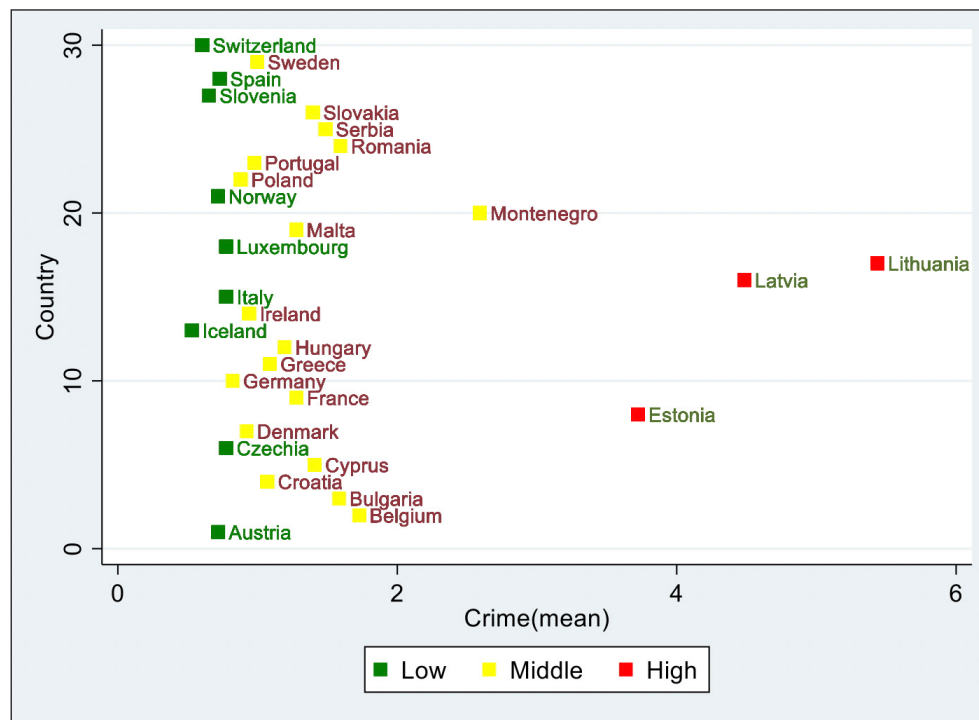


Figure 1: Country classification

(group 1). Low-crime countries, such as Switzerland, Norway, and Austria, share characteristics such as long-standing welfare systems, low income inequality, high institutional trust, and robust law enforcement systems. These structural advantages likely explain both their lower crime rates and the stronger negative relationship between human development and crime. Sweden, Slovakia, Serbia, Romania, Portugal, Poland, Montenegro, Malta, Greece, Ireland, Hungary, France, Denmark, Cyprus, Croatia, Germany, Bulgaria and Belgium are in the middle crime (group 2). On the other hand, Lithuania, Latvia and Estonia are in the high crime (group 3). The Baltic countries exhibit high crime rates. This pattern may be linked to the socioeconomic transitions these countries experienced following the collapse of the Soviet Union, which led to prolonged institutional restructuring, income inequality, and social disruption. Despite recent economic improvements, persistent inequalities and weaker institutional trust may contribute to higher levels of violent crime. What draws attention in Figure 1 is group 3. The outcomes display that there has been a sharp fall in the level of crimes throughout of 2008-2020 in Estonia, Latvia and Lithuania. Namely, the human development will give rise to a lower level of crimes in group 3 countries and unemployment and inflation play a vital role in this relationship.

The outcomes noticed here demonstrate that the human development-crime linkage has transformed across countries throughout the period 2008-2020. Findings indicate that disregarding the various linkages between crime and human development along with the transformation of these linkages may follow in specious outcomes. It can be also said that unemployment and inflation are one of the most important socioeconomic indicators in most countries' development and play more and more substantial component in the human development-crime nexus. Overall, the country-level evidence suggests that lower unemployment strengthens the crime-reducing effect of human development. That is, in countries with lower unemployment, improvements in human development are more strongly associated with reductions in crime. This will be the main driver of diminishing number of crimes, thus ensuring of appropriate and reliable social life.

An important feature of FMM is that the entire pattern consists of sub-samples with undetached heterogeneity. In order to expose that issue, three unobserved crime densities in group 1, 2 and 3 are plotted. In Figure 2, it is obvious that density functions provide evidence for the presence of multiple groups.

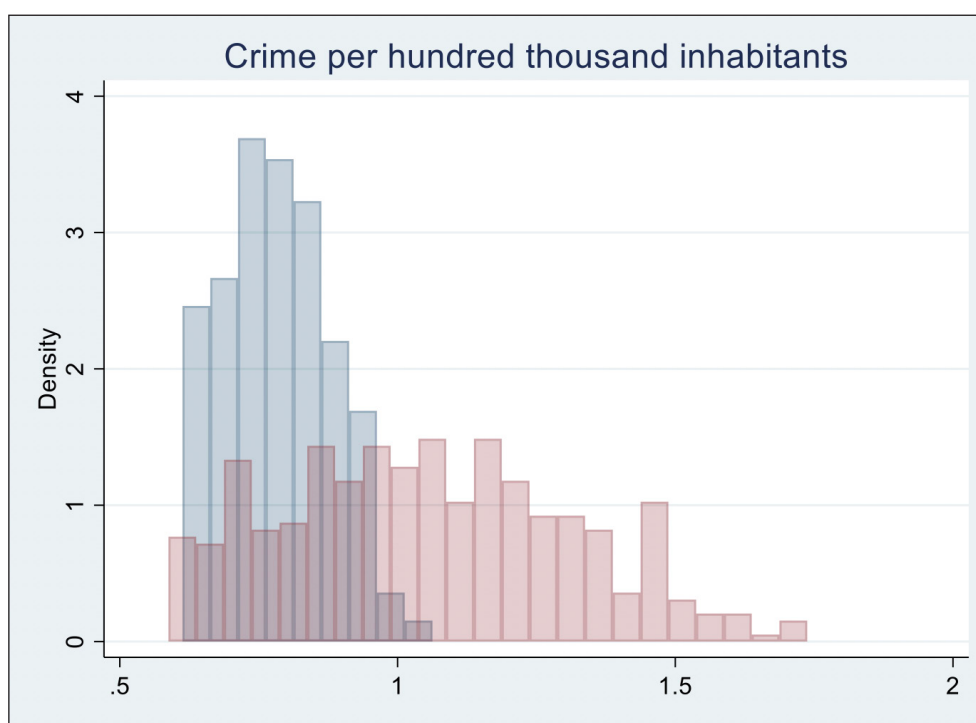


Figure 2: Kernel density of crime

Robustness check

To examine the robustness of the findings, various robustness tests will be applied. The presented outputs verify the findings and improve comprehension of the linkages among unemployment, inflation, human development and crime.

First (i), the academic literature on the human development-crime linkage has disclosed the probable response from crime to human development. To figure out probable endogeneity issues between concomitant variables (unemployment and inflation) and the dependent variable (crime), model (II) has been re-estimated with a first-order lag of unemployment

and inflation. The first panel of Table 6 serves up the outcomes of robust prediction: the coefficients of human development in group 1, 2 and 3 are similar to those in Table 4. It denotes that outcomes are still robust, even taking into account probable endogeneity issues.

Second (ii), some studies bring forward that there might also reside mutual causality between the explanatory variable and dependent variable (Jeke et al., 2021), which diverts to implement alternative robustness test to cope with the probable influence of crime on human development. For this reason, using the first lag of human development as an instrument variable, model (II) is recalculated. The second panel results of Table 6 put forward that the parameters of human development in

Table 6. Robustness test result

		UNE	LUNE	LINF	INF	HUD	C
Robust (i)	Group (1)		(base class)			-2.935054*** (0.7965465)	3.419847*** (0.7419301)
	Group (2)		1.230405*** (0.4089107)	0.5210863* (0.3192897)		-5.841229*** (0.5228939)	6.185129*** (0.4539865)
	Group (3)		1.206593*** (0.4143632)	0.5618392* (0.3150775)		-27.58367*** (5.951369)	27.36581*** (5.220696)
Robust (ii)	Group (1)	(base class)				-2.476409*** (0.672407)	2.987502*** (.639892)
	Group (2)	1.056532*** (0.2793245)			0.453247* (0.2499918)	-5.950269*** (0.6608713)	6.4404*** (0.5936225)
	Group (3)	1.048379*** (0.2823749)			0.5239674** (0.243913)	-30.83856*** (8.136156)	30.6349*** (7.617894)

Note: Note: * = 0.1, ** = 0.05 and *** = 0.01 significance level.

group 3 are lightly higher negative to the early outcome. It describes that human development in countries with high unemployment and inflation can lead to lower crime.

CONCLUSION and POLICY INFERENCES

Dataset in the analysis consists of 30 EU countries covering the period between 2008-2020. This article aims to ensure a wide evaluation of multi relations for the first time among unemployment, inflation, human development and crime within a unified framework. One of the most important features of the study is the presentation of the FMM. This model can not only identify the human development-crime relationship endogenously, but also but also assist to improve comprehension of the human development-crime relationship by defining the contribution of unemployment and inflation.

The clearest evidence to appear from this article is identifying the various linkages among unemployment, inflation, human development and crime at country level. Overall, it has been confirmed that the negative effect of human development on crime. Particularly, by predicting a three-group FMM with a concomitant variable (unemployment), it has been found that in the first group with a higher unemployment and inflation, human development can conduce to decreased crime, while in the second and third group with a lower unemployment and inflation, the effect of human development will decrease on crime.

Second, countries classified into low, middle and high crime. Switzerland, Spain, Slovenia, Norway, Luxembourg, Italy, Iceland, Czechia and Austria are in the low crime (group 1). Sweden, Slovakia, Serbia, Romania, Portugal, Poland, Montenegro, Malta, Ireland, Greece, Hungary, France, Denmark, Cyprus, Croatia, Germany, Bulgaria and Belgium are in the middle crime (group 1). On the other hand, Lithuania, Latvia and Estonia are in the high crime (group 3).

Third, besides unemployment, the role of inflation in identifying the influence of human development on crime is also verified. The human development from countries that are have higher inflation is largely responsible for crime.

When considered together, findings propose a role for key macroeconomic variables (unemployment and inflation) in coping with the deadlock of diminishing crime without negatively influencing human development. Considering the heterogeneity of each

country, it can be offered probable policy inferences for various country groups. Given heterogeneous linkage between development and crime in diverse countries, heterogeneous macroeconomic policy should be applied and encouraged. Beside center should be formed on some countries in the high inflation group, since their human development will decrease more crime compared to the rest of the country groups. Therefore, anti-inflationist policies, such as inflation targeting, money supply control and balanced budget, and promoting employment policies, such as increasing investments and improving working conditions, should necessitate upward progress to lighten the impediment of enlargement of human development to these countries. Namely, governments should pay attention development levels and take comprehensive precautions to provide the appropriate implementations of diverse macroeconomic policies in different countries.

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From Cyberpunk to Cypherpunk: The Technical and Ideological Roots of Bitcoin

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ABSTRACT

Cryptocurrencies initially gained prominence by eliminating intermediaries in payment systems and later found applications in various business sectors. The crypto network, pioneered by Bitcoin, has spurred new business forms and organizational structures with diverse motivations. Bitcoin's emergence is technically dated to 2008. However, its ideological and technical roots trace back to the cyberpunk literature of the late 1970s and the cypherpunk movement that began in California in 1992. The cypherpunk manifestos significantly influenced cryptographic work, shaping Bitcoin's technical foundation. This study aims to explore Bitcoin's ideological origins through a qualitative content analysis of cypherpunk manifestos, Nakamoto's posts on the 'Bitcointalk' forum, and 'Cryptography Mailing List' correspondence. By examining these sources, the study identifies the historical dimensions of Bitcoin's technical structure and highlights the impact of ideological debates on its development. Findings reveal that while cryptographic research influenced Bitcoin's technical evolution, ideological discussions were relatively less significant. Nonetheless, Bitcoin's developers, particularly Nakamoto, incorporated a strong ideological emphasis on 'privacy' despite the primary technical focus.

Keywords: Bitcointalk, Bitcoin, Ideology, Privacy, Cypherpunk.

JEL Classification Codes: Z13, A13, D70

Referencing Style: APA 7

INTRODUCTION

The "Bitcoin: Peer-to-Peer Electronic Cash Payment System", which was published under the pseudonym "Satoshi Nakamoto", has been cited more than twenty thousand times since 2008, paving the way for new fields of study and business lines. It is critical for the study of the topic as it has initiated areas of study where different disciplines such as computer science, economics/business sciences, artificial intelligence and the Internet of Things converge. Studies on the historical/ideological origins of the technical document are relatively scarce in the literature. The neglected technical and historical origins of Bitcoin constitute the primary motivation of this study. Inspired by the cyberpunk movement that emerged in literature in the late 1970s, the ideological origins of cryptocurrencies, which have gone through different processes, can provide researchers with a different perspective on blockchain technology.

The cyberpunk movement that emerged in literature was shaped by the understanding of technology and the

environment depicted in William Gibson's *Neuromancer* (Easterbrook, 1992). The cyberpunk universe is dominated by a multicultural structure and a gloomy description of cities in the post-industrial society with the impact of mass urbanization (Jones, 1994). Cyberpunk culture focuses on how technological development which was influenced by the wars and social events until the 1980s will shape the future. Therefore, in the cyberpunk universe, the future is depicted through a society in which postmodern aesthetics, cultural diversity, urbanization and military forces establish hegemony through high technology (Edwards, 1994).

Barbrook and Cameron (1996) argued that technological innovations would cause changes in social life in the long run. In this context, they named the utopian ideas of a structure consisting of different segments in the USA about the way technology works as the 'California ideology'. The California ideology is an ideological system that combines the bohemian lifestyle of San Francisco and the high technology of Silicon Valley (Barbrook and Cameron, 1996). Proponents of this ideology have worked

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to ensure freedom in cyberspace. While the meaning attributed to technology in California ideology creates a deterministic structure, the technological structure experiences a pessimistic and oppressive process on the way to social freedom. There is a semantic unity with the Californian ideology and the origins of blockchain and cryptocurrencies. As cryptocurrencies have become more widespread, they have been defined as anti-system and anti-state, is a sign that this field is undergoing a repressive process. The deterministic, innovative and yet oppressive nature of technology is the totality of this context. Since the debut of blockchain technology and Bitcoin coincided with 2008 crisis, many researchers have interpreted it as a revolutionary and anti-systemic movement.¹ Only a few studies argued that blockchain technology has reinforced the continuity of the status quo through discourses such as technological revolution and disruption (Herian, 2018).

The cyberpunk movement later influenced the cypherpunk movement that emerged in California in 1992. Thanks to the mailing list established in the cypherpunk movement, software developers and hackers carried out activities to ensure 'cryptographic encryption' and internet freedom. Hellegren (2017) stated that the word 'cyber' was used in the sense of encryption and secrecy, and the word 'punk' referred to the opposition to authority representing the subculture. The cypherpunk group's concerns about privacy led them to struggle in this area. According to them, ensuring privacy in cyberspace is seen as one of the measures taken against the state.

Consequently, the basis of the cypherpunk movement is using cryptocurrencies to protect privacy on the internet through cryptography, as well as the free realization of economic transactions (Jarvis, 2021). These increasing trends in the cultural and intellectual structures of cryptocurrencies are guiding in terms of determining their ideological tendencies. Malherbe et al. (2019) argued that the ideological foundations of cryptocurrencies should be sought in the cypherpunk culture by stating that cryptographic encryption and decentralization are significant in the cypherpunk culture. The importance given to privacy in the cypherpunk culture and the ability to carry out transactions by eliminating intermediaries constitute the origins of the digital economy (Brekke, 2020). The fact that the state and economic institutions prevent the effective functioning of social distribution

has led to the advocacy of decentralization and the emergence of the 'cryptoeconomy'. Brekke defines cryptoeconomics as the community formed by using concepts from computer science, economics and game theory, as well as blockchain and distributed ledger technologies, to create a decentralised structure and ensure security. Thus, the foundations of the cypherpunk movement laid the groundwork for today's blockchain, cryptoeconomy and cryptocurrencies. In this context, the manifestos published by cypherpunk advocates are critical to understanding their ideology.

The first manifesto published by May (1988) emphasised that computer technologies could provide anonymity. According to him, eliminating privacy was no longer needed to carry out transactions. New technologies allow people to exchange messages, conduct economic transactions and enter into contracts without being tied to their real names and legal identities. Hughes (1993), on the other hand, sees it as quite possible that privacy concerns will increase with the widespread use of internet technologies. This situation also increases the importance of ensuring confidentiality. With privacy, it should be possible to ensure that transactions are perceived only by the desired parties. Cryptography is highly emphasised in the published manifestos. In 2008, the creation of Bitcoin based on the blockchain led to the embodiment of this whole structure. Crypto-anarchists and libertarians claim that as cryptography gains importance, privacy will be ensured, and individuality will increase (Swartz, 2018). The privacy provided by cryptography also leads to the anonymization of transactions.

This study aims to examine the ideological dimension of Bitcoin by clarifying its historical and theoretical structures. The methodology used here is the qualitative content analysis (QCA). The scope of the QCA includes cypherpunk manifestos, Nakamoto's technical document, 'bitcointalk' forum posts and 'cryptography mailing list' correspondence. In particular, the literature discusses blockchain technology and cryptocurrencies in terms of their volatility. However, blockchain technology has also created new socio-technical and techno-political areas. In this context, the study consists of five chapters. In the first part, Bitcoin's relations with the cypherpunk movement, which bears traces of its ideological origins, were revealed. At the same time, the distinction between secrecy and privacy, which Hughes mentions in his manifesto, was analysed through Nakamoto's technical document and ideological connections were shown. The second section categorised the qualitative data used in the study and explained the methodology of qualitative

¹ See for example Weber, 2016; Appukuttan Nair, 2018; Corradi and Höfner, 2018; Malharbe et al., 2019; Heister and Yuthas, 2020; Faustino et al., 2021; Brekke, 2021.

content analysis. In the third part, the findings section, word frequencies were analysed through Nakamoto's writings on the 'Bitcointalk' forum. At the same time, the elements that influenced Nakamoto up to the creation of bitcoin were detailed in chronological order. The fourth section discusses the ideological connections of cryptocurrencies based on the findings of the study using Bitcoin as an example. Finally, the analysis is concluded with a general evaluation.

HISTORICAL AND THEORETICAL BACKGROUND

The universe created by the cyberpunk movement in science fiction literature has also influenced the cypherpunk movement. Founded in 1992 in California, this organization consists of the basic elements of freedom, decentralization, cryptography and privacy in cyberspace. In the light of all these developments, the concept of 'crypto anarchism' came to the fore with the cypherpunk movement. As an ideological armament, crypto anarchism tries to protect the rights to privacy and autonomy by advocating the liberation of the individual in the digital space (Chohan, 2017). Thus, the ideas of the cypherpunk movement regarding the digital world are associated with anarchism. Therefore, the texts 'Crypto Anarchist Manifesto' and 'Cypherpunk Manifesto' that emerged in the cypherpunk movement are concrete indicators of the community's ideology.

Cryptography is the technology that presents the security, integrity and timeliness of a data in a way that cannot be denied, along with who sent it. In the cypherpunk movement, the emphasis on cryptography, along with all these features, is on ensuring privacy. Therefore, cryptography is seen as a means of freedom and privacy in cyberspace, expressing an attitude against centralised structures. Cryptography has the potential to undermine the power of states and established institutions by enabling comprehensive social and political change (Narayanan, 2013: 76).

The vision of Bitcoin, which emerged on the basis of blockchain, is also influenced by these developments and includes decentralised structure, privacy and anonymity. Their opposition to the trust mechanisms provided by centralised structures has led to a political attitude. The cypherpunk movement has a techno-political approach. In other words, it tries to realize its political goals via technological means (Bertelloni, 1998). For the cypherpunk movement, the political attitude is not only a mechanism shaped around the political structure, but also an area where the economic structure is taken as

a basis. In the cypherpunk movement, overcoming the traditional order is only possible with the emergence of new technological structures. In this context, it can be said that technological determinism is the dominant view in the cypherpunk movement.

The first text in the cypherpunk movement was the 'Crypto Anarchist Manifesto' written by Timothy C. May. According to May (1988), with the provision of anonymity and privacy, users should be able to carry out transactions in the virtual environment without depending on their legal identities. Therefore, the use of cryptographic technologies makes these structures possible.

May (1988) states that computer technology enables individuals and groups to communicate and interact with each other in a completely anonymous way, enabling two people to exchange messages, conduct business and negotiate electronic contracts without knowing the real name or identity of the other. The messaging process mentioned by May has become possible since 2002 with the privacy of legal identities thanks to the 'Tor' software. Through blockchain technology, electronic transactions and contracts can be realised by ensuring the privacy of users. The peer-to-peer (P2P) transactions mentioned by May have become possible in blockchain technology. May's emphasis on privacy and anonymity is based on concerns about trust. It is therefore clear that cypherpunk is concerned about the dangerous dimensions of the mechanism of trust, which in the traditional system is largely mediated by the state and institutions. Appukuttan Nair (2018) states that cryptocurrencies such as Bitcoin challenge the Hobbesian understanding of the state. In this context, it can be said that the way crypto anarchists perceive the state is identified with 'Leviathan'. In his Leviathan, Hobbes argued that self-regarding people recognise that it is in their interest to trade some of their liberty for security of self and property, and in so doing enter into a contract with a sovereign, a deified figure who sets the rules of engagement for society. In other words, Bitcoin has replaced the sovereign with the general will (Scott, 2017). The potential of blockchain technologies to transform the institutions monopolised by the state is made possible by removing the element of trust and providing privacy and anonymity to the individual within the system. In centralized systems, trust is often vested in a central authority, whereas Bitcoin relies on a network of nodes and a consensus mechanism (Riedl et al., 2024). Securing these technological developments, which May also highlighted, will make transformations possible in relation to the state.

May (1988) emphasised the potentials created by cryptography and new technological transformations. He stated that this structure would be especially effective in the transformations it would create regarding the state. By anticipating the revolutionary nature of technology, May preserved the language of the Communist Manifesto while changing its form and function (Applegate, 2012). Instead of creating a space for revolutionary struggle, May's manifesto drew attention to the consequences of the use of technology by creating a practice of resistance.

The other manifesto in the cypherpunk movement was Eric Hughes' "A cypherpunk manifesto" which was published in 1993. It is clear that the manifesto published by Hughes had similar tendencies to the one published by May. According to Hughes, the introduction of the internet and computer technologies has led to increased concerns about privacy. Therefore, ensuring confidentiality in such an environment becomes the main problem. Ensuring confidentiality is possible through developments in the field of cryptography.

When Hughes (1993) mentions the necessity of privacy for an open society in the electronic age, he also explains what privacy means. He describes privacy as something that a person does not want the whole world to know and secrecy as something that a person does not want anyone to know. Thus, he defines privacy as the power to reveal oneself selectively to the world.

When Hughes referred to the electronic age, he meant that the dynamics experienced in the process of globalization had turned societies into an open structure. He stated that with the development of global networks, there were differences between privacy and confidentiality and that the connection between these two structures was important (Hughes, 1993). According to Warren and Laslett (1977), there is a moral difference between privacy and confidentiality. Privacy and confidentiality are important concepts in determining the boundaries between individuals and others in their lives. Where there is no privacy, privacy is consensual; that is, there is a 'right to privacy' but not an equivalent 'right to secrecy' (Warren and Laslett, 1977: 43). Therefore, the fact that individuals can be monitored electronically and the state's intervention in this area is a significant threat to 'privacy' (Akman and Övgün, 2022: 38).

While giving the magazine example, Hughes (1993) emphasizes the 'right to privacy'. As he exemplifies, when you buy a magazine and pay for it in cash, there is no need for the seller to know who you are. Similarly, your e-mail service provider does not need to know what your

message is or who you are communicating with. When your identity is known to the mechanism through which you transact, you have no privacy. The right to privacy has a consensual basis in society. Hughes emphasizes that the right to privacy is prevented in non-consensual systems. Therefore, in systems where privacy is denied, confidentiality cannot be ensured.

Hughes (1993) also highlights that anonymous transaction systems are necessary for privacy in an open society. Anonymous transaction systems only ask for the identity information of individuals by request, which is the essence of privacy. Privacy is ensured in consensual systems. According to Hughes, anonymous transaction systems must be provided to make this happen. Conducting transactions in the fiat money of a state provides partial anonymity and privacy, while decentralized structures based on cryptography can provide complete privacy. This is where the structure between privacy and secrecy emerges in Hughes' manifesto. Anonymous transactional systems offer privacy to individuals based on consent, but the provision of confidentiality does not depend on this structure. Since secrecy is non-consensual, the behaviour subject to secrecy is seen as illegal and involving the interests of the excluded (Warren and Laslett, 1977).

Hughes (1993) states that cryptography has an important role in ensuring privacy. While cryptography has different functions such as ensuring the security of information, Hughes discusses it in the context of ensuring privacy. While it is possible to ensure the privacy of individuals through decentralized structures, it is not enough. At the same time, identity must be secured with a cryptographic signature. Thus, the ideological perception created by secrecy is transformed into privacy with cryptography and legitimacy is tried to be ensured. The spaces created by privacy in cyberspace are structures that must be prevented by the state and institutions. Hughes, on the other hand, tries to provide legitimacy by stating that they are ideologically in favour of privacy.

Hughes (1993) explained that as cypherpunks they were dedicated to building anonymous systems and protecting their privacy through cryptography, anonymous mail forwarding systems, digital signatures and electronic money. He emphasised that the cypherpunk team had an important role in ensuring privacy. The emphasis on privacy rather than secrecy is important for the study. Privacy includes information that can be shared consensually through decentralised structures. Secrecy, on the other hand, includes information that

is developed non-consensually and does not carry the desire to share. At this point, Hughes states that there is an important distinction between privacy and secrecy after May's manifesto and that they endeavour to ensure privacy. In this context, it is noteworthy that the anarchist expressions used by May are not present in Hughes. In his manifesto, Hughes does not directly guarantee the shaping of a political form. Rather, he emphasises that he has concerns about privacy and that these structures can be overcome through the use of cryptographic technologies. In this context, rather than using a form of expression that will shake the world like May, Hughes comes up with a solution proposal at the point where there are concerns about the system.

As can be seen, there are both similarities and differences between the two main manifestos of the cypherpunk movement. Considering what Nakamoto wrote in the technical document in the context of the cypherpunk manifestos will give clues about how the ideological context is shaped. In the technical document published in 2008, Nakamoto first established a payment system between peers and proved that the peer-to-peer network would be a solution for the double spending problem. A fully peer-to-peer electronic payment system enables online payments to be made without the need for the intermediation of a financial institution (Nakamoto, 2008). Thus, the cryptography-based electronic money mentioned by Hughes came to life with the blockchain network established by Nakamoto. At this point, it cannot be said that Nakamoto has a direct political stance; however, an implicit/indirect political stance is present in his work. The indirect political stance is the claim that blockchain technology will transform traditional money and payment systems. At this point, it can be said that the language used by Nakamoto in the technical document is closer to Hughes' language. Similarly, Nakamoto (2008) notes that financial institutions serve almost exclusively as trusted third parties for processing electronic payments in online commercial transactions. He adds that although the system works well enough for most transactions, it is still affected from the weak points inherent in the trust-based model.

In traditional payment systems, the centralised structure has an important function in ensuring the trust element for the maintenance of the system. This structure is perceived by cryptocurrency advocates as the main problem of the system. At this point, Nakamoto implicitly emphasised the need to ensure privacy, which is similar to what Hughes stated in his manifesto. This leads to the conclusion that the function of traditional

systems to ensure trust violates the 'right to privacy'. According to cryptocurrency advocates, the presence of the state and intermediary institutions in the monetary system prevents the provision of privacy. Therefore, the existence of decentralised structures and developments in cryptography overcome this problem and create a privacy space.

Proponents of cryptocurrencies and opposition to centralised structures in this area are also ideologically linked to the neo-Austrian approach. According to the neo-Austrian approach, state intervention is at the root of monetary instability. In this context, the decentralised structure of cryptocurrencies interferes with the monopolistic structure of the state in this field (Dow, 2019). According to Dow, the emergence of cryptocurrencies not only enables payments between peers but also bears the characteristics of neo-Austrian libertarian philosophy in the context of 'privatization' of money. Bitcoin is important because it is the first cryptocurrency to be issued on blockchain technology. Within this framework, the first introduction of Bitcoin as a payment mechanism does not imply a concern for the privatisation of money. In the technical document he published, Nakamoto emphasised that the traditional system cannot provide privacy based on the element of trust. Therefore, it creates an alternative to the traditional system providing a payment system without the need for intermediaries on the basis of cryptography and proof of work. The indirect effects created by this structure may resemble the structures claimed by different ideologies such as the privatization of money. However, this is not enough to explain the ideologies of cryptocurrencies. The fact that states and institutions have started to use this technology has led to the emergence of new debates. In his study on how cryptocurrencies will take a place in monetary payment systems in the world, Duque (2020), points out that the potential of cryptocurrencies to become reserve currencies in the international arena will lead states to become more involved in this field. However, it is a key feature of the blockchain that it can be easily obtained through cryptographic algorithms that verify and record transactions thanks to the consensus between the users of the database, without necessarily recognising or trusting each other (Duque, 2020).

The fact that blockchain technology does not provide information about who the transactions are linked to is important in terms of ensuring privacy. Therefore, it is seen that there is no perception of individuality inherent in the system, and privacy is more important.

DATA and METHODOLOGY

Qualitative content analysis is a method that not only analyses the content of the relevant material, but also analyses the theme, main idea and formal aspects of the text (Mayring, 2004: 267). Thus, it also performs an analysis on the hidden meaning connections of the relevant materials analysed. In addition, the formal characteristics of the texts analysed are critical in terms of showing the different layers influenced by the study under consideration. Although qualitative content analysis is a flexible method with a unique structure, the analysis process can be classified according to specific procedures (Schilling, 2006). Therefore, the data obtained from the texts are made transparent and systematically investigated in an inductive and interpretive manner (Mackensen and Wille, 1999). The reason for using inductive content analysis in this process is the absence or fragmentation of previous studies on the phenomenon under investigation (Elo and Kyngäs, 2008: 107). As a result, the main point of qualitative content analysis begins with summarizing and continuously comparing the data, thus evaluating the relevant materials within the scope of the research question (Kuckartz, 2019).

Table 1. Materials Analysed in the Study

1	The crypto anarchist manifesto	Timothy C. May
2	A cypherpunk's manifesto	Eric Hughes
3	Bitcoin: A peer-to-peer electronic cash system	Satoshi Nakamoto
4	Cryptography mailing list	Satoshi Nakamoto vd.
5	Bitcointalk	Satoshi Nakamoto vd.

In this study we use inductive content analysis, which is one of the QCA methods and which is a data driven approach. In contrast to the deductive approach, inductive content analysis is a bottom-up approach to meaning making that starts with no preconceived codes or theories. Instead of using a pre-existing framework or previous research, you develop a theory from the

Table 2. Information about 'satoshi' in the forum

Name	'satoshi'
Posts	575
Activity	364
Merit	4639
Status	Founder
Registration Date	November 19, 2009, 07:12:39
Last Active Date	December 13, 2010, 04:45:41

Source: <https://bitcointalk.org/index.php?action=profile;u=3>

bottom up as you analyse the entire data set. Regardless of which variant of QCA is used, the focus will always be on working with categories (codes) and developing a category system (coding frame). Within several different types of categories in the social science research literature, we use the thematic one. Thematic categories refer to certain topics, arguments, schools of thought etc. Based on our research question, we took ideology as a thematic category.

May and Hughes' texts, unlike the other three, have been used as starting texts to follow the trajectory of bitcoin ideology. As discussed above in the history section, these texts are included because of their role in the historical trajectory as the beginning and foundation of the ideological debates around bitcoin. The 'Bitcointalk' forum is a website founded by Nakamoto in November 2009. Nakamoto registered on this forum site under the name 'satoshi' and was last active on December 13, 2010, during which time he posted a total of 575 posts.² The content of the posts varied, but mostly he answered users' questions and provided information about the technical structure of the Bitcoin network. There are posts where he introduces updates to the Bitcoin network and

explains the difference between old and new versions. Thus, there are posts detailing the technical structures of Bitcoin's development process. Satoshi's first post was on November 22, 2009, to introduce the 'bitcointalk' forum site.³ His last post was on December 12, 2010, under the title 'development and technical discussion'.

After Nakamoto published his technical document in 2008, he discussed the technical aspects of Bitcoin with different people in the same year.⁴ The existing correspondence has been developed through e-mail exchanges. In this context, his correspondence with Ray Dillinger, Hal Finney, James A. Donald and Dustin D. Trammel is available on the Cryptography Mailing List.

² <https://bitcointalk.org/index.php?action=profile;u=3>

³ <https://bitcointalk.org/index.php?action=profile;u=3;sa=showPosts;start=520>

⁴ <http://satoshinakamoto.me/source/cryptography-mail-list/?order=asc>

Table 3. Information about 'Hal' in the forum

Name	Hal
Posts	314
Activity	314
Merit	2587
Status	VIP
Registration Date	November 30, 2010, 01:29:24
Last Active Date	March 29, 2017, 06:22:58

Source: <https://bitcointalk.org/index.php?action=profile;u=2436>

One of the details that stands out at this point is the correspondence with Hal Finney. Hal Finney, himself a member of the cypherpunk team, is known for his work on the 'RPOW' (reusable proof of work) and the digital currency prototype.⁵ The discussions between 'Hal' Finney and Nakamoto took place not only on the cryptography mailing list but also on the bitcointalk forum.

technical document he published.

FINDINGS

Bitcoin has an extensive history of research in its historical/theoretical background. If we analyse this history of Bitcoin, we can see that its ideological, technical and theoretical dimensions have different determinants. In this context, if we were to chronologically express development stages of Bitcoin historically, we can trace the starting point of this structure to the cyberpunk literature of the late 1970s.

The first cryptographic protocol studies used in payment systems before Bitcoin can be traced back to David Chaum's work in the 1980s (Dostov and Shoust, 2014). Later, Chaum's work on digital signatures and anonymity against third parties influenced Bitcoin technically. As Arslanian and Fischer (2019: 92) pointed out Chaum's work probably laid the foundation for

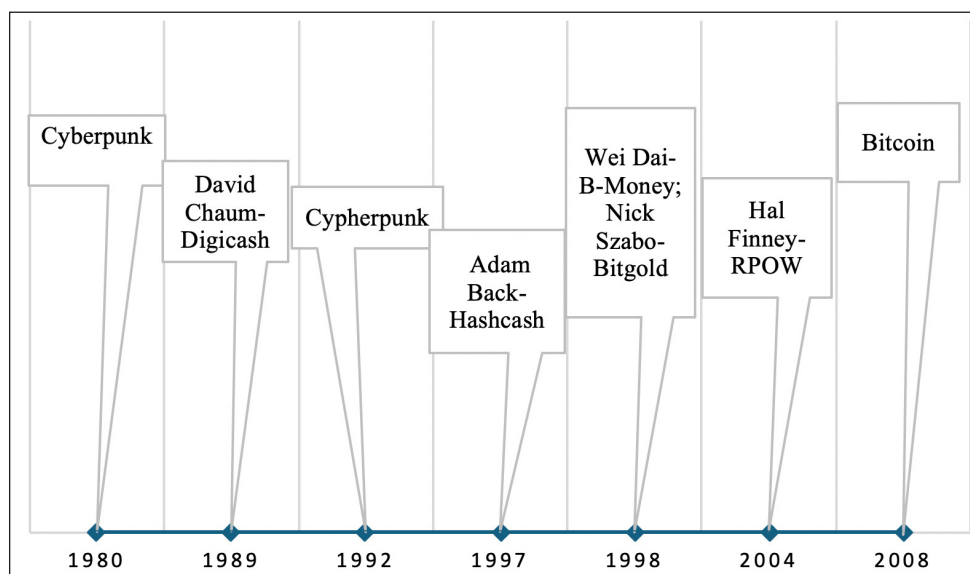


Figure 1: Technical and Ideological Origins of Bitcoin

The Bitcointalk forum has facilitated the development and understanding of Bitcoin in the contexts of past correspondence. In this context, studies on the Bitcointalk forum are scarce in the literature. In this section, the posts of 'satoshi' on Bitcointalk were analysed using qualitative text analysis with MAXQDA to examine the word frequencies of the correspondence and to discuss how they were theorised in ideological and social contexts. Since Nakamoto is the founder of the first 'functional' cryptocurrency, his existing correspondence in forums and emails was also included in the analysis, not just the

blockchain and cryptocurrencies today. Considering the historical development phase of Bitcoin, the 'technical' and 'ideological' layers have been shaped by different structures. The technical layer that has influenced Bitcoin is based on the work of Adam Back. The technical structures of the proof-of-work protocol are based on Back's Hascash proof-of-work (Ma et al., 2018: 4). Although Bitcoin emerged with technical innovations, different digital currency instruments with similar features had already been discussed. B-Money (Wei Dai) and Bitgold (Nick Szabo) are examples of past cryptocurrencies (Chohan, 2022: 8). Finally, it can be said that Hascash's proof-of-work idea was developed further

⁵ <https://nakamotoinstitute.org/finney/rpow/>

with Hal Finney's RPOW protocol, leaving an experience for Bitcoin.

The ideological layer of Bitcoin has been associated with libertarian philosophy in terms of providing transparency, anonymity and privacy. Golumbia (2013) defines cyber libertarianism as an ideology which states that as a result of the integration of computer technologies into human life, this structure will make people free. According to him, in cyber libertarianism, computer technologies should be integrated into human life and technical methods should be used to solve the problems that will arise. As measurable phenomena become more important, calculations should be based on certain standards. Golumbia (2015) states that the social and political functions claimed by cryptocurrency advocates and cyber libertarians are superior to the technical functions of Bitcoin. At the same time, their libertarian presentation of the possibility of using blockchain technology in different fields has led them to use the concept of democratization. Golumbia emphasises that these discourses serve neoliberal ideology, noting that the devices and software used to operate the technical infrastructure require competence and that this process feeds technocratic authoritarianism. Thus, Bitcoin works technically but not socially and politically as its proponents claim (Golumbia, 2015: 119). Bitcoin's decentralised structure and limited supply with a deflationary tendency are indicative of its attitude towards traditional structures. Bitcoin creators claim that the economic role of the state will weaken, and politics will play a lesser role in social life due to libertarian ideology (Kalström, 2014). Crypto advocates and cyber libertarians argue that the weakening of the role of the state and its institutions in economic life will lead to a more efficient functioning of the market and a greater emphasis on individualism. In Bitcoin ideology, the elimination of intermediaries, and thus the reduction of the need for the state, is associated with techno-leviathan by Scott (2017). The techno-leviathan is a crypto-sovereign to whose rules we can contract. And these rules are a series of algorithms, step-by-step procedures for calculations that can only be overridden with great difficulty. This may initially represent the general will of the participants in the contract network, but the key point is that once you are locked into a contract in this system, there is no getting out. The decentralised structure of cryptocurrencies causes some legal problems. The anonymity of users thanks to cryptographic encryption makes it impossible to monitor and control cryptocurrencies (De Filippi, 2014).

The idea of using strong encryption to protect people's freedom and privacy from governments and large corporations dates back to the cypherpunk and crypto-anarchist culture of the late 1970s (Atzori, 2015). In this context, we can see that the main concern of cyber libertarians and crypto advocates is primarily to defend privacy against the state and large capitalist corporations. However, this is not enough to explain their main justifications. The question of the contexts in which privacy should be guaranteed, rather than against whom, explains the ideological dimension of cryptography. In this respect, the adoption of blockchain and cryptographic technologies by governments and large corporations obscures the ideologies of their proponents. The use of blockchain technology by states and banks reduces the credibility of its proponents who claim that blockchain is anti-state and anti-capitalist (Caliskan, 2020).

There are two main actors in blockchain technology: transactors and miners. Initially, it is stated that transactors and miners generally exist in blockchain technology by taking individual actions. However, in the following processes, the intensification of computing power led to an increase in mining activities and as a result it became costly. The increase in mining activities requires high processing power to create blocks. In this context, the fact that 80 per cent of Bitcoin mining activity in 2017 was carried out by a total of just five mining pools is indicative of the industrialisation of mining (Swartz, 2017). Swartz discusses the emergence of new classes of intermediaries instead of people transacting on the blockchain base. The emergence of intermediaries to enable financial transactions specific to cryptocurrencies undermines the decentralised structure of blockchain technology.

When considering the ideological layers of Bitcoin, Nakamoto's posts on Bitcointalk are instructive. In the forum, Nakamoto provides technical information and answers questions from Bitcoin users. First of all, if we look at Nakamoto's posts, he mostly provides information about the technical structure of Bitcoin. While introducing Bitcoin, it is noteworthy that Nakamoto's primary goal is not a political organisation. 'Bitcoin', 'Block' and 'Transaction' are the most used words. The most frequently used words mostly cover the technical structures of Bitcoin. Nakamoto also used the word 'cypherpunk'. In the first mention of the word 'cypherpunk', he referred to 'Wei Dai' and 'Nick Szabo' in the first place where the word 'cypherpunk' was mentioned, and stated that Bitcoin was influenced by and an adaptation of these preliminary

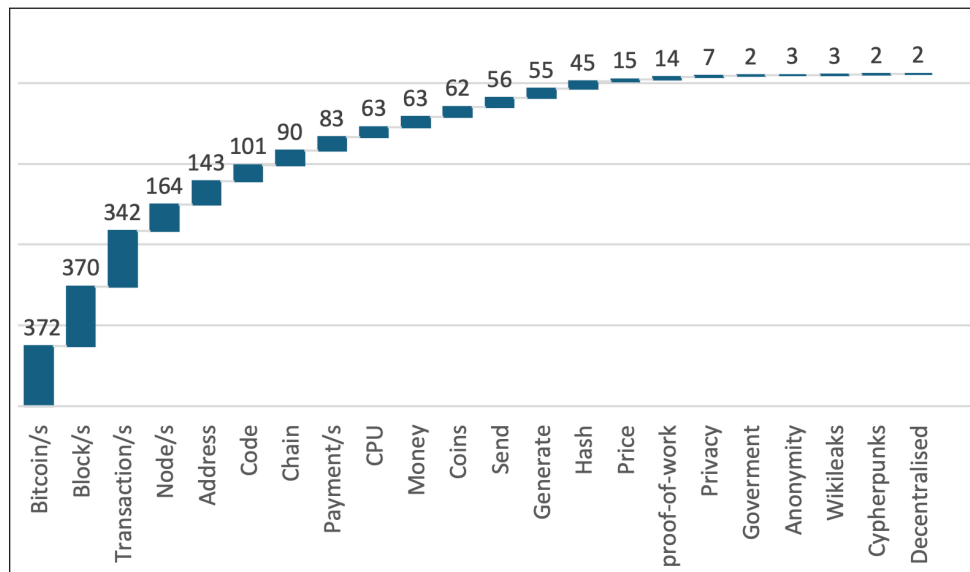


Figure 2: BitcoinTalk posts of Satoshi Nakamoto

Source: <https://bitcointalk.org/index.php?action=profile;u=3;sa=showPosts>

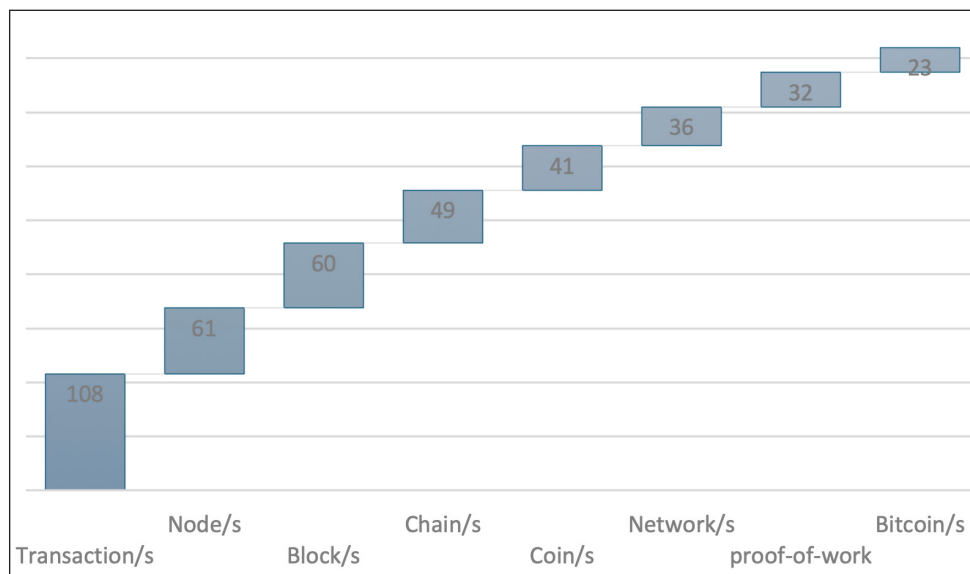


Figure 3. Word Frequencies of Cryptography Mailing List

Source: <http://satoshinakamoto.me/source/cryptography-mail-list/?order=asc>

studies.⁶ In addition, it is understood from the forum posts that Nakamoto is closer to Hughes because of his preference for the word 'privacy' in the language he uses, based on the debate about privacy and confidentiality. Another noteworthy dimension of Bitcoin's ideological orientation is found in Nakamoto's posts on the 'WikiLeaks' debate. In the 2010s, discussion on the forum focused on the need to help WikiLeaks through Bitcoin to overcome the financial obstacles it faces. Nakamoto explained that Bitcoin was still in the early stages of its development and that donations via bitcoin would not

be enough for WikiLeaks' pocket money.⁷ In another post, Nakamoto stated that WikiLeaks had kicked a swarm of 'hornets' and that this swarm would turn on Bitcoin.⁸ It is noteworthy that Bitcoin does not want to be labelled as an anti-system movement while it is still in its initial stages of development. In conclusion, when analysing the posts on BitcoinTalk, it is very difficult to say that Bitcoin has a direct ideological orientation. In this context, when the word frequencies are analysed, there is a pool of posts that are mostly based on the technical structure of Bitcoin.

⁶ <https://bitcointalk.org/index.php?action=profile;u=3;sa=showPosts;start=280>

⁷ <https://bitcointalk.org/index.php?action=profile;u=3;sa=showPosts;start=20>

⁸ <https://bitcointalk.org/index.php?action=profile;u=3;sa=showPosts;start=0>

When Nakamoto's mailing list is analysed, his correspondence with Ray Dillinger, Hal Finney, James A. Donald and Dustin D. Trammel also exhibits a similar tendency. As analysed here, the technical aspects of Bitcoin have been the subject of more discussion. A noteworthy detail at this point is that the correspondents are from the cypherpunk team (Hal Finney and James A. Donald). James A. Donald is a Canadian cypherpunk member. He corresponded with Nakamoto on the scaling of Bitcoin. In conclusion, Nakamoto's technical documentation, as well as his forum and e-mail correspondence, shows a tacit ideological stance. The structure and possibilities provided through his technical and historical background make the ideological orientation more revealing. In this context, it has been revealed within the scope of the study that Nakamoto is fed by the tradition of cypherpunk. The possibilities provided by the technical structure are discussed within the scope of the literature with which ideology they are associated, and their similar aspects are revealed.

DISCUSSION

The fact that blockchain technology has different application areas has led to its association with different ideologies by economic and organizational theories. The association of Bitcoin and other cryptocurrencies with different ideologies is due to the wide scope of blockchain technology. Despite this, research on the political/ideological dimensions of blockchain technology tends to take a critical stance against the utopian and viability of the technology (Inwood and Zappavigna, 2021). Dodd (2018) argues that there is a paradoxical aspect to Bitcoin's success as a monetary system. This paradox is built on the premise that the criterion for Bitcoin's success as a currency is that it must fail ideologically. Bitcoin ideology is based on an anti-state and anti-system attitude. Cryptocurrencies can be ideologically differentiated depending on their function. According to Dodd, although Bitcoin is associated with anarchist and libertarian ideas, the way it works in practice is incompatible with the infrastructure. Nevertheless, it can be said that the distinct layers of Bitcoin's ideological dimension are shaped in a techno-political manner. The basic dynamics of this ideology lies in the use of technological possibilities without engaging in political debates, and in the independence of monetary control mechanisms from centralised structures on the axis of states and institutions.

According to Doria (2020), Bitcoin deconstructs centralised structures and reduces the element of 'trust' to algorithmic bases, eliminating centralised controls

in the money and payment system. The possibilities provided by this structure have led the ideology of Bitcoin to be associated with the Austrian School. According to Corradi and Höfner (2018), Hayek's idea that competition between different currencies would increase efficiency by all banks issuing their own money (free banking) is similar to Bitcoin's decentralization. Studies in the literature⁹ mostly focus on the similarities between the cypherpunk movement and libertarianism in terms of 'cyber freedom' and Bitcoin in terms of 'eliminating intermediation'. However, the structure of Bitcoin which eliminates intermediaries goes beyond the ideology of the Austrian School. Additionally, Hayek's term 'spontaneous order' refers to an unplanned complex system. Libertarians understood Hayek's term to mean an unplanned complex order that emerges as a result of different individual actions to meet short-term needs (Arnhart, 2018). According to the findings of this study, Bitcoin cannot be said to be related to the concept of 'spontaneous order'. Bitcoin is a cryptographic and algorithmic understanding of order that has been developed in a planned way, drawing on a rich historical background. According to Dos Santos (2017), this order is provided in a technical manner and has a structure that is not 'complex'.

The main problem with the cypherpunk movement is that the areas related to 'freedom' are brought to a level where they cannot be destroyed by the state and its institutions, rather than ensuring freedom. This is why cypherpunks have been wrongly associated with 'libertarianism', because they respond to the crisis of freedom by opposing 'technocratic authoritarianism' (Beltramini, 2021). When analysing Nakamoto's writings on Bitcoin, although the focus is on the technical dimension, there is an ideological background to 'privacy'. For example, the privacy offered by cryptography in Bitcoin stems from the fact that it is seen as a basic necessity of freedom. In this respect, Bitcoin cannot be said to have a direct relationship with libertarianism. Although the emphasis on individuality is prominent in libertarianism, it can be said that the technical structure of Bitcoin transcends individuality.¹⁰

⁹ See for example Miscione and Kavanagh, 2015; Bartlett, 2016; Dahlberg, 2017; Redshaw, 2017; Dallyn, 2017; Jarvis, 2021; Nabben, 2021; Jansen, 2013.

¹⁰ By providing this structure, the transactions carried out in the blockchain technology provide privacy to the users and allow the users to transform into another form within the system. The fact that there is only one address for those who perform the transaction contradicts the argument that the system will increase the individuality of the users. However, the system can affect the self-concept in terms of its results. These dimensions of the blockchain create conditions where individuals are responsible for

Another dimension of Bitcoin ideology is its reference to the problem-solving nature of cryptography. Bitcoin's decentralization of money and payment systems has undermined the legitimacy of the state and its institutions, leading to the consideration of cryptography as a new armament in Deleuze's 'society of control'¹¹ (DuPont, 2014). Furthermore, Bitcoin's infrastructure that does not need centralised structures has also led to its understanding as a 'techno-centralist' ideology (Parkin, 2019). With the interventionist structure of the state and institutions, it has led to an increase in libertarian discourses by encouraging the use of cryptography technologies to prevent 'panopticons'¹² in cyberspace. Since the existence of panopticons in cyberspace will lead to the ignoring of privacy, it can be said that Bitcoin advocates are influenced by the libertarian discourses of the cypherpunk culture. In addition, the driving forces behind the development of Bitcoin are ideologically driven by the solution of the double-spending problem and ensuring privacy in cyberspace (Hayes, 2019).

With cryptographic encryption in the Bitcoin blockchain, users can carry out transactions with a virtual identity, hiding their real identity. The anonymity of transactions can alter the way people feel about doing business (Heister and Yuthas, 2020). With the anonymity of virtual identities, the privacy of users is also ensured. With the blockchain, in an environment where intermediaries are eliminated and privacy is ensured, data is under the control of users. As people start to realise that they are able to take back control of their personal data from big business and government institutions, it is estimated that support for blockchain technologies will accelerate and threaten traditional or existing systems (Heister and Yuthas, 2020). The irreversibility and inalterability of

the transactions which are recorded in the blockchain represent the radical aspect of the transaction structure of the system. The fact that this structure is inalterable creates an inherent trust in the system. Therefore, when discussing the principle of insecurity in the blockchain, although there is trust in the system, the parties can carry out their transactions without the need for mutual trust for the realisation of transactions. When the principles of anonymity, confidentiality, immutability and insecurity are evaluated, the future of the system makes potential transformation possible for many institutions. Although the impact of this transformation on the individual is important, whether the individual will exist in this system is one of the important questions in our opinion.¹³ However, institutions that are intermediaries in cryptocurrency exchanges (e.g. Coinbase, Binance) gain the appearance of pseudo-anonymity by enabling users to switch from cryptocurrencies to fiat money to carry out transactions (Heister and Yuthas, 2020). Therefore, it is possible for institutions and governments to access the information of users who transact through cryptocurrency exchanges. The existence of cryptocurrency exchanges gives the impression that users cannot be anonymous, but this structure is not a feature of the blockchain. Since blockchain technology is an address-dependent system, the identity of the individual becomes uncertain. The emphasis on anonymization and cryptography leads to the concealment of identities rather than emphasizing individuality. Thus, addresses transcend individuality as the location of the individual is concealed, making it unclear to whom the addresses belong.

CONCLUSION

Since the cypherpunk movement, it has been a generally accepted view that privacy should be ensured in cyberspace. Hence, the rise of cryptography has played an important role in the secrecy process. Cryptography is often associated with privacy and the concealment of information and identities, but it is likewise concerned with verifying the authenticity of information and

the ownership, security and management of their own data (Heister and Yuthas, 2020). Although the nature of the blockchain system itself does not contain any principles that enhance individuality, it does provide for the basic principles of privacy, anonymity and decentralisation. These principles can be said to affect the concept of self in terms of the outcomes they produce, but there is no concern for individuality inherent in the system.

¹¹ Deleuze (1992) discusses the society of control with reference to Foucault's disciplinary societies. In societies of control, structures have become more complex. In order for the individual to overcome these complex structures, as Deleuze puts it, "fear or hope is not a remedy; one must attempt to find new weapons". Thus, 'cryptography' is a good example of Deleuze's new weapon in control societies.

¹² 'Panopticon' is a concept developed by Jeremy Bentham and later analysed by Foucault in the context of knowledge and power. The Panopticon is a system in which control, surveillance and intervention mechanisms are structured using prison architecture as an example. As a metaphor, it is discussed whether blockchain technology is a panopticon (Robb and Deane, 2021). In this structure where transparency is emphasised, blockchain technology may have the potential to increase control and surveillance at the point where the area of privacy is not considered.

¹³ This structure, which does not require the state and intermediary institutions to ensure agreements between spouses, seems to give the impression that individuality is at the forefront. The fact that peers are anonymised by cryptographic algorithms and carry out their transactions without the need for intermediary institutions is an indication that individuality has disappeared in its known dimension. In this system, transactions are now realised through algorithms without the need for an individual. It is not important for the blockchain whether the transactors are individuals or not. The algorithm in question is that the algorithm works effectively, and transactions take place between peers, who the peers are is not important to the system. Heister and Yuthas (2020) found blockchain technology valuable in terms of affecting the concept of self, as it enables transactions to be carried out without the need for intermediaries by providing privacy and anonymity.

identity claims (Hütten, 2019). Bitcoin's ability to provide privacy in the blockchain and prevent the problem of double spending reveals the innovative nature of the system. In addition, one of the measures taken against the state and institutions in Bitcoin is the emphasis on privacy. The findings obtained from qualitative data such as cypherpunk manifestos, technical documents, Bitcointalk and cryptography mailing lists, which were discussed in the historical context of this study, reveal the 'tacit' ideological dimension of Bitcoin and blockchain technology in the debate on how privacy should be technically ensured.

Bitcoin ideology benefits from a historically deep-rooted past. This historical structure shows that Bitcoin has a planned trajectory that cannot be explained by Hayek's concept of 'spontaneous order'. In addition, Bitcoin's algorithm-based creation of trust by destroying traditional perceptions of trust has caused it to be interpreted as an anti-system movement. Firstly, the creation of a system that eliminates intermediaries in the payment system has created the perception that an anti-state order has been created. Blockchain technology offered an alternative to traditional payment systems by enabling transactions to take place without the need for intermediaries. The ability of individuals to carry out transactions without intermediaries prevents their data from being stored in third parties. The general attributes of the blockchain create an environment in which individuals assume greater responsibility for both managing and protecting their private data and maintaining the trustworthiness of the participants with whom they trade (Heister and Yuthas, 2020). All this has led to Bitcoin being associated with different ideologies. However, when the structures that paved the way for the development of Bitcoin are analysed, it is found that an ideological orientation inherent in the system is linked to the ideology of cypherpunk, defined in terms of technically enhanced privacy. Instead of the 'distorted' Bitcoin ideology of the libertarian literature, the article finds findings consistent with the arguments of Brekke (2021), Scott (2017) and Inwood and Zappavigna (2021). Although the technical structure of Bitcoin is associated with different ideologies, Nakamoto's language and the structures he was influenced by cannot be said to have a 'crude' libertarian ideological dimension.

In future studies, the data set used in this study can be expanded to include all posts of the Bitcointalk forum. However, how the perception of 'self' will be shaped in the light of the possibilities provided by blockchain technology is the subject of another study.

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Determination of the Industries that Integrate Türkiye to the World: An Empirical Analysis Using Intercountry Forward and Backward Linkage Coefficients

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ABSTRACT

Global value chain (GVC) is defined as a production process involving value-added from at least two countries with increasing global integration. This study aims to identify the industries triggered by the exports/imports of intermediate inputs in the rest of the world /Türkiye for the industries that Türkiye has identified as targets in the 2023 Industry and Technology Strategy Document. In this way, it is determined in which industries Türkiye is articulated to GVCs through its target industries. The analysis is carried out by calculating the forward and backward linkage coefficients between countries in the multi-country input-output matrix. As an analysis tool, the input-output matrix with 45 industries and 64 countries produced by the OECD for 2018 is used. In the analysis, the matrix is used by aggregating it as two countries in the form of Türkiye and the rest of the world.

Analysis indicates that inter-country calculated forward and backward linkage coefficients for both intermediate input exports and imports of the target industries "electrical equipment", "chemicals", "machinery" and "motor vehicles" are greater than 1. This finding can be interpreted as a mutual interdependence between the production of the world and Türkiye through these industries. Additionally, it can be said that Türkiye is unidirectionally dependent on imports from abroad in the "computers and electronic and optical products" industry. Another finding is that there is a relative compatibility between the industries that Türkiye has been exporting the most for many years and the industries with high value-added and high technology content that are targeted to be exported in the recent period.

Keywords: Global Value Chain, Intermediate Input Foreign Trade, Input-Output Matrix, Inter-Country Forward Linkage, Inter-Country Backward Linkage.

JEL Classification Codes: C67, D57, F13, O25

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INTRODUCTION

Global value chains (GVCs) are a concept that allows outsourcing of intermediate and final production, leading to increased trade through exports and imports and a rapidly growing exchange of intermediate input volumes between different countries (Kılıçaslan et al., 2021, p. 150). GVCs are linked to increased utilisation of foreign value-added when production is export-oriented (Antràs, 2020). In this study, it is aimed to determine which industries in Türkiye and in the world are triggered by the foreign trade of intermediate inputs of the industries that Türkiye has set as targets in the 2023 Industry and Technology Strategy Document. In this way, it is determined in which industries Türkiye is articulated to GVCs through its target industries. The analysis is carried out by calculating forward and backward linkage coefficients between countries in a multi-country input-output matrix. As an analysis tool, a 45-industry,

64-country input-output matrix produced by the OECD for 2018 is used. This matrix is used by aggregating the rest of the world (ROW) and Türkiye (TR) into two groups of countries. In this study, the basic hypothesis put forward is that the industries that Türkiye aims to focus on in its exports in the 2023 Industry and Technology Strategy Document, which are claimed to have high technology content and value-added potential, are not very compatible with the leading exporting industries that Türkiye has been articulating with the world for many years. In order to test this hypothesis empirically, the main industries in which Türkiye has articulated with the world have been identified. In this context, it is aimed to reveal the compatibility between the main industries in foreign trade and the target industries identified in the Document.

In this study, Türkiye's industries of articulation with the world are examined in terms of final consumption

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goods and intermediate inputs. The paper focuses on determining the backward and forward linkage coefficients of the leading industries identified in Türkiye's foreign trade of intermediate goods. Although the reviewed literature is econometric, the relatively less use of global value chain, intermediate input foreign trade and multi-regional input-output models makes the subject different. The next section introduces the related concepts and the theoretical background, and the third section offers a review of the related literature. The fourth section presents the empirical methodology and the results of the analyses, and the final section concludes with an interpretation based on the findings.

Theoretical Background:

GVC and Foreign Trade in Intermediate Inputs

The Value Chain is a concept that encompasses all the research and development, design, production, marketing, distribution and end-consumer access activities that firms and their workforce undertake to move a product from its inception to its end use and beyond (Fernandez-Stark & Gereffi, 2019, p. 55). The GVC has emerged in the 21st century as the production chains of various countries continue to expand towards domestic and foreign markets, restructuring and specialisation of the international production segment (Baldwin & Evenett, 2015). The value chain and the GVC differ in two respects. The first one is that the value chain is limited to national markets. Another difference is that the production process cannot be divided into sub-stages in the value chain. In the global value chain, actors receive shares according to their position in the value chain and the functions they undertake (Alemdar, 2008, p. 36).

GVCs contribute to a large part of worldwide trade. In the globalising economy, countries' access to foreign demand, inter-industrial productivity increases and optimum cost understanding can be considered as an indicator that GVCs have reached a high level of integration in world international trade relatively quickly (Giovannetti et al., 2023, p. 854). Creating new models of international production organisation on the basis of trans-border production, GVCs are becoming a fundamental part of the global economic structure. Increasing importance of GVCs in the international organisation of production increases the necessity to measure countries' export performances and thus their competitiveness (Beltramello et al., 2012, pp. 3–5). In this context, Türkiye's export values in the 2015-2023 period decreased by 9.3%, 1.1% and 6.2% in 2015, 2016 and 2020, respectively, and increased by 10.2%, 7.7%, 2.1%,

32.8%, 12.9% and 0.6% in 2017, 2018, 2019, 2021, 2022 and 2023, respectively.

The position of countries in GVCs is important in influencing their level of development. The position of a product in the first, middle or last stage of GVCs is according to the specialisation area of the countries. In the first stage, specialised countries produce raw materials. Countries involved in activities in the middle of the value chain carry out standard labour-intensive manufacturing industry activities. The countries that specialise in customer service specialise in the last stage of value chains (World Bank, 2014, p. 40). Türkiye is centrally specialised in standardised labour-intensive segments of the value chain. It also exports mostly consumer goods and semi-finished products as intermediate inputs. On the other hand, Türkiye is an importer of capital goods, semi-finished and primary goods. This situation affects income distribution by showing that Türkiye is specialised in labour intensive industries and production processes. Moreover, being a source country for production facilities gives Türkiye an advantage. This advantage stems from the fact that Türkiye is well connected with European markets. On the other hand, trade costs are higher for distant markets. Türkiye has relatively low trade costs compared to its competitors in the region, which positively affects its logistics performance in comparison (World Bank, 2014, pp. 40-41). Cross-border trade of cleaner production technologies facilitated by Türkiye's global value chain participation is another important concept. As integration into GVCs deepens, sensitivity to environmental standards set by major actors in the international trading system becomes clearer (Olasehinde-Williams & Özkan, 2023, p. 29156).

LITERATURE REVIEW

Global Value Chain, Intermediate Input Foreign Trade and Input-Output Analysis

Studies that address the global value chain by using cross-country input-output tables (ICIOts) have benefited from analyses such as vertical specialisation measurement method and GVC analysis. The vertical specialisation measurement method is based on the use of imported inputs to produce a country's export goods. In this method, all of the imported products consist of intermediate goods. The exported product can be for the final consumption or intermediate goods demand of the other country. GVC analysis is conducted to calculate to what extent the country-industry pair's outputs for final use are sold to consumers around the world or intermediate inputs are sold to other productive industries around the world (Mancini et al., 2024, p. 670)

Studies on GVC using multi-country input-output tables are summarized in Table 1. De Backer & Yamano (2007) described globalisation in terms of the emergence of a 'GVC' and employed the content of imports in exports as a proxy for globalisation. In the study, input-output tables are used to investigate the new trend in international trade. In the analysis, the import contents of exports of 38 countries are calculated and the global integration trend in the 1995-2000 period is empirically verified by using the 1995, 2002 and 2006 versions of the OECD Input-Output Database. Koopman et al. (2010) develop a combined measurement for sources of value-added in gross exports with a straightforward conceptual framework based on the block-matrix structure of the cross-country input-output model. The study constructs a global ICIO table for 2004 using a database used for global trade and economic analyses (GTAP-7th version) and detailed trade data from UN COMTRADE. The database covers 26 countries and data for 41 industries are used as the main data source for this study. By utilising the results of country-industry level decomposition, an index has been constructed to help measure a country's position between the upstream and the downstream of the global value chain in any given industry. The approach to database development and the disaggregation of domestic value-added to provide industry average information on the role of each country in GVCs is a contribution to the literature. On the other hand, the establishment of a database covering granular global trade in terms of gross and value-added has enabled to move from a largely descriptive empirical study to analysing reasons and consequences of differences on supply chain involvement. In terms of decomposing value-added exports of manufacturing and servicing industries as a share of gross exports, the results show that upstream emerging economies such as Russia and Indonesia produce primary products for global supply chains. In addition, upwardly developed countries such as Australia and New Zealand also produce goods and services for these chains.

Wang et al. (2017) suggested an activity of production based on whether its factor content crosses national borders for production. In the analysis, the two-way GVC participation measure is being done with data from the World Input-Output Database covering 44 countries and 56 industries in the time period between 2000 and 2014. The indexes can be calculated aggregated at the world level and more disaggregated at the "bilateral-industry" level. In this respect, the study allows for the decomposition of a country/industry's GDP and final goods production into domestic activities and GVC

production activities. With this decomposition, it is seen that the two-way GVC participation index has more preferable features than the existing indices in the literature. Moreover, GVC is found to be the most important driving force for globalisation.

Chen et al. (2022) examine the effects of GVC forward embedding and backward embedding models on carbon emissions. The data are obtained from 46 industries in China for the period 2000-2014 and reveal the elements involved in exports. The results of the analysis show that the forward and backward embedding models increase the carbon emissions in China's exports, and this effect is reflected more strongly with the increase in forward participation. On the other hand, the forward embedding model is associated with increasing the length of the advanced production chain and the location index in the global value chain in order to contribute to the reduction of carbon emissions in exports. Kim (2024) proposes two new global integration indicators in his study. These indicators are defined as the ratio of imports to gross output from exports and the relative degrees of utilisation of the global production network relative to that of the local supply chain in terms of production. Obtained from the (OECD, 2021) input-output database, the data include trends for 66 countries and 25 industries for the period 1995-2018. The results of the analysis show clearly that the latest deceleration in foreign trade is largely caused by the decline in foreign trade in intermediate goods, which has important consequences for the prospects of global integration.

Dimas et al. (2024), in their study, aim to plan Greece's participation in GVCs and different dimensions of GVC integration at industrial and country level. For this purpose, the study applies a production-based decomposition to obtain bilateral value-added flows related to the GVC components of international trade for forward and backward participation. The study covers 45 NACE Rev. 2 industries for 76 countries for the period 1995-2020, using the latest set of OECD cross-country input-output tables (ICIOts). Greece's participation in GVCs is analysed in terms of forward and backward production linkages. In the last stage, 1995-2007 was a period of deepening of the GVC and national economic prosperity for Greece; 2008-2014 was a period of disruptions in global supply chains caused by the economic crisis and the so-called recession/recovery years afterwards; and 2015-2020 revealed a new steady state in global markets and value chain trade before the COVID-19 pandemic.

Yanikkaya et al. (2025) examine the greenhouse gas emission intensity embedded in GVCs of 186 countries and 26 industries in the period 1990-2015. In this

Table 1: Literature Review-Global Value Chain and Foreign Trade in Intermediate Inputs-Input-Output Analysis

Authors	Period	Database	Findings
De Backer & Yamano (2007)	1995-2000	OECD Input-Output Database	It presents empirical evidence on the increasing importance of GVCs and interdependence between countries.
Koopman et al. (2010)	2004	Inter-Country Input-Output Model	Upstream developing economies such as Russia manufacture primarily goods for global supply chains. Upstream developed economies such as Australia produce goods and services for GVCs.
Wang et al. (2017)	2000-2014	World Input-Output Database	It has been determined that GVC is the most important driving force for globalization.
Chen et al. (2022)	2000-2014	Multi-Regional Input-Output Model	GVC integration increases carbon emissions from China's exports. In particular, the forward embedding model results in production processes that increase carbon intensity.
Kim (2024)	1995-2018	OECD Input-Output Database	Decrease in foreign trade of intermediate goods slows down foreign trade.
Dimas et al. (2024)	1995-2020	OECD Cross-Country Input-Output Tables	Some of the best performing industries in forward-looking GVC participation in 1995, 2010, 2020 are basic metals, waterway transport, support services for mining, metal mining and mining and quarrying.
Yanikkaya et al. (2025)	1990-2015	EORA Global Supply Chain Database (EORA26)	Higher capital stock increases the greenhouse gas emission intensity embedded in GVCs. Renewable energy shares are negatively related to greenhouse gas emission intensity.

Source: Compiled by the author.

context, the data obtained from the EORA Global Supply Chain Database analyses the determinants of emission intensity, country and industry level variables in a gravity-like framework. The top five countries in terms of GHG emission intensities embedded in trade flows are China,

the US, Germany, Japan and Russia. It is stated that higher capital stock may lead to higher GHG emission intensity embedded in GVCs. However, industries emphasise renewable energy consumption as a factor that reduces emission intensity.

Table 2: Forward and Backward Linkage Coefficients for Türkiye's Intermediate Goods Exports

	INTERMEDIATE DEMAND		FINAL DEMAND		TOTAL DEMAND
	TR	ROW	TR	ROW	
TR	A^{TRTR}	A^{TRRW}	Y^{TRTR}	Y^{TRRW}	X^{TR}
ROW	A^{RWTR}	A^{RWRW}	Y^{RWTR}	Y^{RWRW}	X^{RW}

Source: Compiled by the author.

This study aimed to provide the compatibility between the industries that Türkiye aims to focus on exports in the 2023 Industry and Technology Strategy Document, which are claimed to have high technology content and value-added potential, and the leading exporting industries that Türkiye has been articulating with the world for many years. The study benefits from the raw data from the OECD Inter-Country Input-Output Tables (OECD, 2021). In the input-output analysis, aggregation is made for 63 countries in the rest of the world, excluding Türkiye. For TR and the ROW, 45 industries were analysed. Within this scope, forward and backward linkage coefficients are calculated on the basis of the 2018 multicountry input-output tables used to identify the industries that Türkiye is integrated with the ROW. This descriptive analysis was carried out for industries in which Türkiye has both robust forward and backward linkages with the world.

When the related literature is analysed, this study differs in two aspects. Firstly, calculating the forward and backward connectivity coefficients between countries is a different approach. Secondly, analysing the industries through which Türkiye is articulated with the world in terms of supplying and receiving intermediate inputs has not been studied before to the best of our knowledge.

EMPIRICAL METHOD

Database

In this study, raw data from the OECD ICIO Tables (OECD, 2021) is being used. In 2018, the data subject to analysis are considered for 64 countries and 45 industries, and 45 industries are included in the scope of the analysis by aggregating 63 countries in the ROW excluding

TR. Following the aggregation, in the table showing Türkiye's input-output relations with the ROW, the TR-ROW intermediate-input matrix gives the relationship of goods and services produced in TR used as intermediate inputs by the ROW. The ROW-TR intermediate-input matrix presents the relationship between goods and services produced in the ROW and used as intermediate inputs by TR (Table 2). includes intermediate inputs of goods and services produced in Türkiye procured domestically; refers to the part of the goods and services produced in Türkiye that is used as an intermediate input by the rest of the world; refers to the part of the goods and services produced in Türkiye that is used as the final demand in the country; is the portion produced by Türkiye and consumed by the rest of the world as final demand. is Türkiye's output vector; is the part of the goods and services produced in the outside world that are used by Türkiye as intermediate inputs. means that part of the goods and services produced in the outside world that is used as an intermediate input in the outside world; is the part that is produced by the outside world and consumed by Türkiye as final demand. refers to the portion of the goods and services produced in the world that is consumed as the final demand in the world; refers to the output vector of the rest of the world.

The products produced by Türkiye are consumed abroad or in the country as intermediate inputs or final products. In equation (1), X^{TR} is the $N \times 1$ -dimensional gross output vector of Türkiye, $A^{TRTR}X^{TR}$ is goods used as intermediate inputs within the country, Y^{TRTR} is domestic final demand, $A^{TRRW}X^{RW}$, how intermediate goods purchased by the rest of the world are used in production, Y^{TRRW} is the $N \times 1$ -dimensional final

demand vector produced by Türkiye and consumed as final demand by the ROW, and A^{TRRW} is the fraction of goods and services produced in Türkiye that are used as intermediate inputs by the ROW and is expressed as the $N \times N$ -dimensional input output coefficient matrix.

$$X^{TR} = A^{TRTR}X^{TR} + Y^{TRTR} + A^{TRRW}X^{RW} + Y^{TRRW} \quad (1)$$

The production and trade system involving two countries is presented starting from equation (2), and based on equation (2), the Leontief inverse matrix is formed as presented in equation (3).

$$\begin{bmatrix} X^{TR} \\ X^{RW} \end{bmatrix} = \begin{bmatrix} A^{TRTR} & A^{TRRW} \\ A^{RWTR} & A^{RWRW} \end{bmatrix} \begin{bmatrix} X^{TR} \\ X^{RW} \end{bmatrix} + \begin{bmatrix} Y^{TRTR} + Y^{TRRW} \\ Y^{RWTR} + Y^{RWRW} \end{bmatrix} \quad (2)$$

$$\begin{bmatrix} X^{TR} \\ X^{RW} \end{bmatrix} = \begin{bmatrix} I - A^{TRTR} & -A^{TRRW} \\ -A^{RWTR} & I - A^{RWRW} \end{bmatrix}^{-1} \begin{bmatrix} Y^{TRTR} + Y^{TRRW} \\ Y^{RWTR} + Y^{RWRW} \end{bmatrix} = \begin{bmatrix} L^{TRTR} & L^{TRRW} \\ L^{RWTR} & L^{RWRW} \end{bmatrix} \begin{bmatrix} Y^{TR} \\ Y^{RW} \end{bmatrix} \quad (3)$$

It's here;

In the basic equation $x = \begin{bmatrix} I - A^{TRTR} & -A^{TRRW} \\ -A^{RWTR} & I - A^{RWRW} \end{bmatrix}^{-1} \cdot y$, the expression $\begin{bmatrix} I - A^{TRTR} & -A^{TRRW} \\ -A^{RWTR} & I - A^{RWRW} \end{bmatrix}^{-1}$ is equal to the expression $\begin{bmatrix} L^{TRTR} & L^{TRRW} \\ L^{RWTR} & L^{RWRW} \end{bmatrix}$, consisting of an $N \times N$ block matrix, and is defined as the Leontief inverse matrix. From this point of view, $x = L \cdot y$ is written as the basic equation of demand-side analysis. Each factor of the Leontief inverse matrix is described as a total needs matrix and deals with the relationship between final demand and output (production). Therefore, it is known as demand-side analysis. Based on this information, any element of the Leontief inverse matrix displays the amount of production required by the industry in the row in order to meet the 1 unit final demand of the industry in the column. The row sums of the Leontief inverse matrix for the relevant industry give the values found as the total forward linkage effect, and the column sums of the relevant industry give the values found as the total production multiplier and the total backward linkage effect.

Backward and forward linkage coefficients are mainly computed by two approaches in the literature; Chenery & Watanabe (1958) & Rasmussen (1956)-Hirschman

(1958) approaches. In the former case (so called direct linkage coefficients), the column sums of the input or technical coefficients matrix are called backward linkage coefficients and the row sums of the output or distribution coefficients matrix are called forward linkage coefficients. In the latter (so called total linkage coefficients), the column sums of the Leontief inverse matrix are calculated as backward linkage and the row sums of the Ghosh inverse matrix as forward linkage (total linkage coefficients). In our study, the second method was preferred as these include both direct and induced effects. At the same time Ghosh coefficients provide how inputs are distributed across industries i.e. these provide more relevant information regarding forward linkages. All linkage coefficients were normalised by dividing the calculated coefficients across countries by the average of the backward/forward linkage coefficients of all industries in order to make those comparable across industries (Table 3 provides the general formulae). Backward linkage coefficients are calculated using the sub-matrices and in equation 3 and forward linkage coefficients are calculated using the sub-matrices and derived in endnotes.

Within the scope of the analysis, a two-region aggregation is made including Türkiye and the rest of the world using the multi-region input-output method, and industrial aggregation is not made. If the rest of the world were not aggregated; Türkiye's foreign trade with all other countries, the countries it entered into and the value added trade relations would be analyzed on a country basis. Since this type of analysis is a large data stack, industrial sales and regional differences would be examined in more detail. While aggregation events are separated by bilateral progress on a country basis, Türkiye and the total world relations have gained importance. Türkiye was a net product/service and/or value added exporter against some and an importer against others. With two-region aggregation, it is determined in which industries *Türkiye is a global exporter and in which industries more competitive products are offered*. In addition, the degree of harmony of Türkiye's exporting industries that have spread all over the world

Table 3: Backward and Forward Linkage Coefficients

	Normalised Backward Linkage	Normalised Forward Linkage
Total Linkages	$\overline{BL}(d)_j = \frac{BL(t)_j}{(1/n) \sum_{j=1}^n BL(t)_j}$ $= \frac{\sum_{i=1}^n l_{ij}}{(1/n) \sum_{i=1}^n l_{ij} \sum_{j=1}^n l_{ij}}$ $\bar{b}(t) = \frac{i'L}{(i'Li)/n} = \frac{ni'L}{i'Li}$	$\overline{FL}(t)_i = \frac{FL(t)_i}{(1/n) \sum_{i=1}^n FL(t)_i}$ $= \frac{\sum_{j=1}^n g_{ij}}{(1/n) \sum_{j=1}^n g_{ij} \sum_{i=1}^n g_{ij}}$ $\bar{f}(t) = \frac{Gi}{(i'Gi)/n} = \frac{nGi}{i'Gi}$

Source: Miller & Blair, 2009, p. 562

for many years and the advanced level departments with high technology content and high value added creation potential have been determined. The adequacy status of the change factor for target industries in the industries in this segment has been investigated.

EMPIRICAL METHOD

Industries in Which Türkiye is Integrated into the Rest of the World

Two descriptive analyses were conducted to identify the industries that Türkiye is engaged with the rest of the world. In the first part of the analyses, the prominent industries in Türkiye's foreign trade are described using the OECD's 2018 multi-country input-output tables. In this part, we focus on both exports and imports and consider both final goods and intermediate goods trade under both.

"textiles", "wholesale and retail trade", "motor vehicles", "air transport", "land transport" and "electrical equipment".

Imports

Table 5 presents the Türkiye's first 10 industries of final products and intermediate goods that Türkiye imports the most from abroad.

Forward and Backward Linkage Analyses

The descriptive analysis used to identify the industries in which Türkiye is integrated with the outside world is the forward and backward linkage coefficients calculated based on multi-country input-output tables for 2018. This analysis is conducted for the industries in which Türkiye has strong forward and backward linkages with the world. Forward and backward linkage coefficients obtained from two different matrices firstly consist of the matrix in which Türkiye gives inputs to the outside world

Table 4: Türkiye's First 10 Final and Intermediate Product Industries to which Türkiye Exports the most

Industries	Share of Final Goods Exports-2018 (%)	Industries	Share of Intermediate Goods Exports-2018 (%)
Textiles	17,3	Basic metals	17,3
Wholesale and retail trade	12,6	Wholesale and retail trade	10,6
Motor vehicles	11,9	Motor vehicles	7,3
Accommodation and food service activities	7,3	Textiles	7,2
Food products	6,0	Fabricated metal products	4,7
Air transport	5,0	Land transport	4,7
Land transport	4,5	Air transport	4,6
Machinery	4,1	Electrical equipment	4,4
Electrical equipment	4,0	Rubber and plastics products	4,4
Agriculture	2,9	Chemicals	4,0

Source: Calculated from OECD World Input-Output Table-2018 data.

Exports

Table 4 presents the first 10 final and intermediate goods industries that Türkiye exported the most to the outside world in 2018. The first 10 final and intermediate goods industries that Türkiye exports the most include

and the matrix in which Türkiye receives inputs from the outside world. The methodological contribution of the study is that the calculation of forward and backward linkage coefficients from the multi-regional input-output matrix over the trade between the two countries is an approach that is not very common in the literature.

Table 5: Türkiye's First 10 Final and Intermediate Product Industries to which Türkiye Imports the most

Industries	Share of Final Goods Imports-2018 (%)	Industries	Share of Intermediate Goods Imports (%)
Machinery	14,5	Chemicals	13,7
Motor vehicles	12,0	Mining and quarrying, energy producing products	12,7
Wholesale and retail trade	10,7	Coke and refined petroleum products	12,6
Computer, electronic and optical equipment	8,7	Basic metals	11,0
Other transport equipment	6,1	Wholesale and retail trade	9,3
Textiles	5,4	Agriculture	3,3
Electrical equipment	4,5	Motor vehicles	3,3
Food products	4,3	Machinery	3,2
Coke and refined petroleum products	3,6	Textiles	3,2
Machinery repair	3,4	Electrical equipment	3,1

Source: Calculated from OECD World Input-Output Table-2018 data.

Since the industries in the foreign trade of intermediate goods of the target 7 industries have different characteristics, forward and backward linkage coefficients should be normalised. "Electrical equipment", "chemicals", "machinery" and "motor vehicles" with normalised forward and backward linkage coefficients greater than 1 in Table 6 are evaluated as industries with high production and demand power.

Among these industries, the total forward linkage coefficient of the motor vehicles industry is higher than other industries. This means that the motor vehicles industry is used as an intermediate input for production

in different industries in the products of other target industries that Türkiye sells to the world. In other words, in the intermediate goods that Türkiye sells to the world, it is observed that the products belonging to the target industries are mostly transformed into final production by receiving inputs from different industries. On the other hand, the backward linkage coefficient of the motor vehicles industry is also higher than other industries. This means the extent to which the motor vehicles industry demands output from other target industries in order to produce one unit of output. Table 7 illustrates that the chemicals industry has the highest forward linkage

Table 6: Forward and Backward Linkage Coefficients in Intermediate Goods Exports of Target 7 Industries

Target Industries	Forward Linkage-2018	Backward Linkage-2018
Electrical equipment	1,000018	1,000006
Chemicals	1,000011	1,000003
Pharmaceutical products	0,999988	0,999990
Computer, electronic and optical equipment	0,999995	0,999998
Machinery	1,000009	1,000014
Motor vehicles	1,000038	1,000048
Other transport equipment	0,999996	0,999998

Source: Calculated from OECD World Input-Output Table-2018 data.

coefficient among the manufacturing intermediate goods that Türkiye imports from the world.

These findings were evaluated within the scope of the industries that Türkiye has identified as targets in its

Table 7: Forward and Backward Linkage Coefficients of Intermediate Goods Imports of the Target 7 Industries

Target Industries	Forward Linkage-2018	Backward Linkage-2018
Electrical equipment	1,001845	1,001639
Chemicals	1,011223	1,001225
Pharmaceutical products	0,99937	0,998602
Computer, electronic and optical equipment	1,000763	0,998838
Machinery	1,002088	1,000377
Motor vehicles	1,002174	1,003032
Other transport equipment	0,999601	0,998616

Source: Calculated from OECD World Input-Output Table-2018 data.

This industry indicates that the products of other target industries that Türkiye imports from the world are mostly used as intermediate inputs for production in different industries in Türkiye. Furthermore, with the chemicals industry, the products belonging to the target industries that Türkiye imports from the world are mostly transformed into final production by receiving inputs from different industries. The motor vehicles industry is the target industry with the highest backward linkage coefficient. This means in order to produce one unit of goods and services in Türkiye, the measure of industrial output demanded from the outside world is mostly seen in the motor vehicles industry.

Caution is still required when drawing the above conclusions based on the forward and backward link coefficients calculated in Tables 6 and 7. This is because the calculated linkage coefficients of the highlighted industries are greater than 1, but do not show a major difference compared to the coefficients of other industries.

CONCLUSION

Global value chain is the value created by firms operating in global markets by dividing the production process among their suppliers (Erkök, 2020, p. 640). It aims to identify the industries triggered by Türkiye's domestic and foreign exports and imports of intermediate inputs. To achieve this goal, the 2018 input-output matrix produced by the OECD, covering 45 industries and 64 countries, was used. Based on this matrix, forward and backward linkage coefficients for foreign trade in intermediate goods between Türkiye and the world are calculated.

2023 Industry & Technology Strategy Document. The main hypothesis put forward in this study is that the industries that Türkiye aims to focus on exports in the 2023 Industrial and Technology Strategy Document and which are claimed to have high technology content and high value-added potential are relatively compatible with the leading exporting industries that Türkiye has been articulated with the world for many years. For the empirical testing of this hypothesis, the main industries in which Türkiye is articulated with the outside world are identified. In this context, it is aimed to reveal the alignment between the main industries in foreign trade and the target industries determined in the Document.

In terms of manufacturing industries, the study identified Türkiye's leading final and intermediate goods exporter industries as textiles, food, motor vehicles, machinery, electrical equipment, basic metals, fabricated metal products, rubber and plastic products and chemicals. In the service industries, Türkiye's leading exporters of final and intermediate goods are wholesale and retail trade, accommodation and food services, air transport, land transport and agriculture.

Türkiye has been implementing export-oriented industrialisation since the early 1980s. In this context, the Turkish economy has gone through different stages of economic restructuring. Türkiye restructured its economy in line with the export-oriented industrialisation strategy due to the bottlenecks in import-substitution industrialization (Güvercin, 2020, p. 1). Thus, the process of integration into GVCs has gained momentum in Türkiye's economic development process. Understanding

Türkiye's position in foreign trade and addressing it with input-output analyses and developing economic policies in this regard is a critical indicator. Considering Türkiye's development experience and changing/developing foreign trade relations with the world, the adoption of an export-led growth strategy requires the stability of the increase in production capacity. Türkiye's orientation towards high value-added industries by increasing its global competitiveness is considered as one of the factors that increase its exports. For instance, in the industries of computers and electronic and optical products, it is possible to reduce foreign dependency in one direction by encouraging domestic production.

The analyses reveal that the inter-country forward and backward linkage coefficients of "electrical equipment", "chemicals", "machinery" and "motor vehicles" industries in Türkiye are greater than 1 for both intermediate input exports and imports. This indicates that these industries are integrated into global production networks and are among the key industries for the Turkish economy. The fact that the industries are both connected to a wide supply chain and provide inputs to different industries reveals that they can be the driving force of economic growth. Supporting the automotive and machinery industries in particular by integrating them into industrial policies may enable them to benefit more from economies of scale. On the other hand, "pharmaceutical products", "computers and electronic and optical products" and "other transport equipment" industries are classified as independent industries since their forward and backward linkage coefficients in exports of intermediate goods are less than 1. Among these industries, "pharmaceutical products" and "other transport equipment" are also independent in imports of intermediate goods, while "computers and electronic and optical products" industry is dependent on inter-industry demand. In this context, it can be said that Türkiye is dependent on the rest of the world, especially in the electronic and optical products industry. In order to reduce this dependency, it is important to develop policies that encourage high technology production.

Considering the forward and backward linkage coefficients of Türkiye's intermediate goods exports, pharmaceutical products, computers, electronic and optical products and other transport equipment are industries with low production and demand power. In this context, policymakers in Türkiye can indirectly create a positive increase in the growth rate by encouraging the export of other target industries produced within the country by allocating resources and providing

externalities to non-export industries to reduce external dependence. In addition to this, determining the optimum resource allocation among countries and specializing in high value-added goods can enhance productivity and competitiveness. Effects of this situation on economic growth may determine the scope and realism of the export-led growth strategy. Furthermore, the strategies adopted by policymakers under a flexible exchange rate regime may lead to accelerated levels of imports of intermediate and capital goods necessary for export growth. Türkiye's adoption of an export-led growth strategy in its roadmap may offer a window of opportunity to benefit from economies of scale with an increase in output capacity. At this point, utilisation of advanced technologies is important in increasing efficiency on a national scale.

Ensuring optimum resource allocation is of critical importance in Türkiye's foreign trade policy. Determining the optimal resource allocation across countries and specialising in high value-added industries can improve Türkiye's export performance. Moreover, policies adopted under a flexible exchange rate regime can help expand production capacity by accelerating imports of intermediate and capital goods. The sustainability of Türkiye's export-led growth strategy will provide a window of opportunity to increase production capacity and benefit from economies of scale. The efficient functioning of this process requires strengthening the connection between advanced technologies and industry. If the roadmap drawn by Türkiye while determining its long-term development strategy is supported by an industrial policy that strengthens domestic production and is integrated into global trade networks, an important step will be taken towards reducing foreign dependency.

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Financial Soundness Performance in Member Countries of the Organization of Turkic States: An Application Using Multiple MCDA Methods for the Period of 2018-2022

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ABSTRACT

The growing significance of cooperation between nations has become increasingly evident in recent years, largely due to the accelerating impact of globalization. Bilateral agreements and regional partnerships have been observed more frequently. One of the recent successful examples of such efforts is the Organization of Turkic States, which includes Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan, and Türkiye. This study examines the financial soundness performance of Organization of Turkic States member countries with sufficient data from the period of 2018 to 2022. Using data from the International Monetary Fund database, an integrated approach of CRITIC, GRA, and SAW methods is employed. The results, consolidated using the Borda Count technique, provide a ranking of the financial soundness of these countries during the specified period. According to the analysis findings, the financial soundness performance rankings are as follows: Kazakhstan, Türkiye, Uzbekistan, and Kyrgyzstan. This study is the first to comparatively examine the financial soundness performances of member countries of the Organization of Turkic States, and as such, it contributes to the literature in this area.

Keywords: Financial Soundness, Financial Stability, Organization of Turkic States, CRITIC, GRA Method, SAW Method.

JEL Classification Codes: G01, G20, G21

Referencing Style: APA 7

INTRODUCTION

Relations between countries have been rapidly expanding due to globalization. Growing bilateral and regional alliances have facilitated access to new trade markets, financing opportunities and information. One of the important regional alliances that has been recently organized is the Organization of Turkic States (OTS). OTS represents a collaborative effort between the Republic of Türkiye and the Central Asian Turkic Republics. It is a social, cultural, and economic community of countries that have significant energy resources, especially natural gas, and oil, have a big potential in sectors such as agriculture, tourism, and construction, and are located on the trade routes between Asia and Europe, including the historical Silk Road.

The OTS is relatively young compared to other organizations established for similar purposes, aiming at economic and cultural cooperation among Turkic-speaking countries. Organizations with similar objectives, such as the Association of Southeast Asian Nations

(ASEAN) and the Black Sea Economic Cooperation (BSEC), have been often established between countries with different structures and diverse cultural and historical ties. What distinguishes the OTS from similar organizations is that it is a union based on the Turkic language, emphasizing not only economic but also cultural cooperation and solidarity among its member countries. The cultural and geographical proximity of OTS countries, along with their role as a bridge between developed European nations and large emerging Asian economies, are significant advantages for the OTS. With a population of approximately 160 million, an economic size of 1.5 trillion dollars, and a trade volume exceeding 1 trillion dollars, the OTS holds significant potential for economic development. However, the trade volume of around 42 billion dollars between OTS countries is relatively low compared to the potential of its member countries. Increased economic cooperation and solidarity between countries will contribute to the growth of low-volume trade.

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The strength and stability of a nation's financial system, along with its ability to withstand economic shocks, play a crucial role in shaping the country's risk premium. Therefore, investigating the soundness of countries' financial structures is of great importance both for financial stakeholders and for the health of economies (Okur et al., 2021: 94). Financial Soundness (FS) Indicators (FSIs) published by the International Monetary Fund (IMF) are significant indicators in this regard. This paper undertakes an in-depth assessment of the financial stability performance of OTS member states, offering a comparative analysis across recent years. This study represents the first comprehensive evaluation aimed at investigating the comparative financial soundness performance of OTS member countries, and so marking a significant and original contribution to the body of research on the economic cooperation and stability of this organization. This study aims to analyze the financial performance of OTS countries and identify the financial strengths and weaknesses of its member states. This study aims to highlight the issues in the financial structures of the countries, identify areas for improvement, and guide the Union's future economic strategies. The next steps of the study include introducing the OTS and its members, discussing the FSIs, and reviewing the literature on these indicators. The study's final phase involves conducting the practical implementation and assessing the outcomes.

OVERVIEW OF THE OTS

In 1992, a summit meeting took place involving Azerbaijan, Kazakhstan, Kyrgyzstan, Turkmenistan, Uzbekistan, and Türkiye. At the summit, the attendees discussed the need to strengthen cooperation between the countries, ensure economic coordination, make arrangements for free trade, and open up the high natural resource potential of the newly established Turkic states to Europe and the world through Türkiye. After the 1992 summit, this process matured and developed further with new summits. The Turkic Council, officially known as the Cooperation Council of Turkic-speaking States (CCTS), was

founded in 2009 through the Nakhchivan Agreement, which was signed by Azerbaijan, Kazakhstan, Kyrgyzstan, and Türkiye. This council serves as a platform for fostering cooperation among Turkic-speaking countries. With the 7th Summit taking place in Bakû in 2019, the Republic of Uzbekistan became a member of the CCTS. During the 8th Summit, the CCTS was officially rebranded as the *Organization of Turkic States*. The 9th, 10th, and 11th Summits of the OTS were held in Samarkand on November 11, 2022, Astana on November 3, 2023, and Bishkek on November 6, 2024, respectively. During the 9th Summit, leaders reaffirmed their commitment to Turkic integration and the Turkic World 2040 Vision. The 10th Summit, held under the motto "Turkic Era," focused on strengthening cooperation among Turkic States. The 11th Summit saw the adoption of the Turkic Green Vision and the Turkic World Charter, with Bishkek being designated as the 2025 Turkic World Digital Capital. At this summit, key agreements were signed on the digital economy, green finance, and space activities. The chairmanship was handed over to Kyrgyzstan, and it was decided that the 2025 Summit would be held in Azerbaijan, while an informal summit would take place in Hungary (Organization of Turkic States, 2024a).

Currently, OTS consists of five member countries: Azerbaijan, Kazakhstan, Kyrgyzstan, Uzbekistan, and Türkiye. In addition to its full members, the OTS has several observer states, including the Turkish Republic of Northern Cyprus, Hungary, Turkmenistan, and the Economic Cooperation Organization (ECO). The main objective of the OTS is to strengthen cooperation in social, political, economic, and cultural spheres among its member states. It aims to uphold security and stability in the region and to foster the development and growth of its member countries by leveraging the potential of the Turkic world (Organization of Turkic States, 2024b).

Table 1 presents the population statistics and some macroeconomic data for the OTS countries in 2023. Relevant data were obtained from the World Bank Data

Table 1. Statistics on OTS countries

	Population (Thousand \$)	Gdp (Million \$)	CPI %	Exports (Millions \$)	Imports (Millions \$)	EDS (Millions \$)	FDI (Thousand \$)
Azerbaijan	10.154	72.356	8.8	35.487	25.016	14.533	252.836
Kazakhstan	20.330	262.642	14.7	90.360	71.882	163.155	5.437.312
Kyrgyzstan	7.100	13.988	10.8	5.478	14.127	10.115	1.500
Uzbekistan	35.652	101.592	11.4*	24.067	41.335	59.184	2.156.721
Türkiye	85.326	1.118.253	53.9	356.900	384.240	499.842	10.951.000
World	8.061.876	106.171.668	5.6	31.134.686	30.247.168	-	867.176.687

Source: https://data.worldbank.org/*Uzbekistan inflation data is for 2022

Portal. OTS countries account for approximately 2% of the world's population and contribute about 1.5% of global GDP. In 2023, OTS countries' exports accounted for approximately 1.65% of global exports, while their imports represented 1.77% of the global total.

Azerbaijan gained independence in 1991 and has a population of 10,154 million with a gross domestic product (GDP) of \$72,36 billion as of 2023. In 2023, Azerbaijan's exports accounted for 0.11% of global exports, while its imports made up 0.08%. In 2023, Azerbaijan attracted US\$ 252,836 million in net Foreign Direct Investment (FDI), while its External Debt Stock (EDS) was US\$ 14,533 million.

Oil and gas are the locomotives of the economy of Azerbaijan. After gaining independence, financial liberalization became increasingly important in Azerbaijan. During this process, various financial institutions, especially banks, were allowed to operate. As of 2024, Azerbaijan is home to a total of 23 banks, with 2 state-owned and 21 privately-owned. 9 of the privately owned banks are foreign-owned. There are also 55 credit institutions and 39 credit unions operating in the country (Central Bank of the Republic of Azerbaijan, 2024).

Kazakhstan, Central Asian Turkic state, has a population of 20,33 million and a GDP of \$ 262,6 billion as of 2023. With an inflation rate of 14.7% in 2023, Kazakhstan has the second-highest inflation rate among the OTS countries. In 2023, Kazakhstan attracted US\$ 5.437 million in foreign investments, while its EDS stood at US\$ 163,155 billion. Kazakhstan's exports in 2023 accounted for 0.29% of global exports, while its imports totaled 0.24%.

The service and agriculture sectors play an important role in Kazakhstan's economy. Kazakhstan boasts abundant and robust mineral reserves. The country is one of the top producers of uranium in the world (Ozer et al., 2024: 19). Additionally, oil revenues are crucial for Kazakhstan's economy. From 2010 to 2021, around 65% of Kazakhstan's merchandise exports were oil-based. During this period, oil revenues accounted for approximately 35% of Kazakhstan's budget (World Bank, 2023: 13). Although relatively small, Kazakhstan's financial sector is open to development. Banks have largely dominated the financial sector. The Unified Accumulative Pension Fund (UAPF) stands as a key pillar within the non-banking financial sector, playing a crucial role in its overall structure (IMF, 2024).

Kyrgyzstan is categorized as a low- to middle-income nation situated in Central Asia. In 2023, its GDP reached approximately US\$ 14 billion, with a population of 7,1

million. Kyrgyzstan is rich in natural resources. However, there are also opportunities in terms of hydroelectricity generation, agriculture, and the tourism sector. In 2023, Kyrgyzstan's foreign trade balance showed a deficit of US\$ 8,6 billion, while its external debt stock stood at US\$ 10,1 billion. Kyrgyzstan has a relatively weak outlook in terms of foreign direct investment.

There are 23 commercial banks operating in Kyrgyzstan's financial sector. The country is home to 752 non-bank financial institutions. Additionally, the combined assets of banks, along with those of non-bank financial and credit institutions, account for approximately 57.3% of the nation's GDP (National Bank of the Kyrgyz Republic, 2023).

Uzbekistan is the newest member of the OTS. As of 2023, its population is 35.65 million, and its GDP is US\$ 101.59 billion. In 2023, Uzbekistan exported approximately US\$ 24 billion and imported US\$ 41 billion, resulting in a deficit in its foreign trade balance. The stock of external debt has reached US\$ 59.184 billion.

The privatization efforts and reforms implemented in recent years have had a positive impact on Uzbekistan's economy. The banking sector has a significant weight in Uzbekistan's financial sector. In 2023, the proportion of banking sector assets relative to GDP is estimated to be around 61%. In the non-bank financial sector, this ratio is approximately 1.6% (Central Bank of Uzbekistan, 2023: 26).

Türkiye, a member of the G-20 countries, is the 17th major economy globally. In 2023, its GDP is US\$ 1.118 trillion, and its population is 85.32 million. In this respect, Türkiye has the highest population and GDP in the OTS. Türkiye has been experiencing inflation problems in recent years, and the inflation rate in 2023 was 53.9%. This rate is significantly higher than the global average. In 2023, Türkiye's share of global exports and imports was 1.15% and 1.27%, respectively. In 2023, Türkiye attracted US\$ 10,951 million in net foreign direct investment, while its external debt stock reached US\$ 499.842 million.

Geographically and in terms of economic relations, Türkiye has a key position in the opening of the OTS countries to Europe and the transportation of natural resources in these countries. Türkiye has a well-established banking sector. As of March 2024, there are 63 banks in service. Banks' assets were 90% of the GDP in 2023 (BDDK, 2024).

FS AND INDICATORS REFLECTING FS

FS denotes the capacity of the financial system and its institutions to effectively manage and withstand financial

shocks or disruptions. The likelihood of disruption of intermediation services decreases as FS improves (Noman & Isa, 2021: 241). FSIs evaluate the financial sustainability and stability of both financial institutions and their clientele (San Jose & Georgiou, 2008: 277). These indicators are generated using information from financial institutions. Therefore, it has the ability to represent financial institutions and the markets in which they trade (Sundararajan et al., 2002: 2). The FSIs enable the identification of both the strengths and weaknesses within a financial system, facilitating a thorough evaluation across various countries and institutions.

FSIs were created to provide strong indicators and a reliable data set for early identification of financial risks and vulnerabilities, especially during frequent financial crises (San Jose & Georgiou, 2008: 277). The Asian financial crisis of 1997 served as a pivotal moment in the evolution of FSIs. In response to the crisis, both the World Bank and the IMF launched initiatives to create FSIs, aligning this effort with the ongoing Financial Sector Assessment Program (FSAP) at that time. Initiated in 1999, this project received support from other international organizations. After the study, a comprehensive guide was compiled and published in 2006 (Gersl & Hemanek, 2007: 69; San Jose & Georgiou, 2008: 277-278; Navajas & Thegeya, 2013: 5).

In the 2006 Compilation Guidelines, FSIs consist of two parts, a core set, and an incentivized set, and cover a total of 39 FSIs. The core set includes 12 FSIs, with key indicators for the banking sector. The incentivized framework encompasses a diverse array of entities, including non-financial corporations, households, the non-bank financial sector, securities, and real estate markets, alongside certain data from the banking sector, amounting to a total of 27 distinct indicators (Gersl & Hemanek, 2007: 69). Understanding these indicators is crucial for assessing financial well-being and stability (Sugiyarto, 2015: 1-2).

Efforts to develop FSIs are not limited to the IMF. International organizations such as the European Union are working to establish various FSIs. Some countries are also making individual efforts. The IMF's work also carries on in line with the 2006 compilation guidelines. A new guideline on FSIs was published in 2019 and then updated in 2022. In new studies, the number of FSIs increases, and their content is renewed to meet current requirements.

LITERATURE REVIEW

Research on FSIs typically focuses on individual countries or groups of countries. Arzova and Sahin (2024) with 17 countries; Bitetto et al. (2023) with 119

countries have tried to construct a valid FS index. Studies examining a single country have generally analyzed the FS and efficiency of the banking sector in that country. Some of these studies include the analyses conducted by Almahadin et al. (2020) on Jordan, Ahmed and Dogarawa (2021) on Nigeria, Sjaus and Žaja (2022) on Croatia, Salina et al. (2021) on Kazakhstan, and Ilgın (2024) on Türkiye. These studies assess the FS of the banking system in the respective countries using various FSIs.

Some authors like Seyedi and Abdoli (2019), have analyzed the factors affecting FSIs. In contrast, some authors have used FSIs to assess banks' FS or examine their changes over time. Masud and Haq (2016) conducted an analysis of the FS of banks in Bangladesh, employing a trend analysis approach covering the years 2006 to 2014. Rahman (2017) examined the financial stability of banks in Bangladesh, while Ouma and Kirori (2019) conducted a similar analysis in Kenya. They have used the Bankometer method. The FS of institutions can be investigated both on a sectoral basis and at a micro-level as a company. Suresh et al. (2019) conducted an in-depth analysis of the FS of both the Bank of Bhutan Limited and Tashi Bank at a micro-level.

Various models are used in studies that assess FS. Multi-Criteria Decision-Making (MCDM) models are also preferred in studies on FS. Below are some examples of studies that utilized these models:

Gaganis et al. (2006), have used the Utility Additives Discriminants (UTADIS) method to study 894 banks in 79 countries. By analyzing six financial and four non-financial indicators, they found that the primary factors influencing the classification of banks are asset quality, capital adequacy, and the specific market conditions in which the banks operate.

In their study, Ioannidis et al. (2010) examined 944 banks from 78 countries and determined that the UTADIS and Artificial Neural Networks (ANN) models were the most successful methods for bank classification on average.

Ginevičius and Podvieszko (2013), analysed Lithuanian banks for the period 2007-2009. In addition to methods such as SAW, TOPSIS, the COPRAS method developed in Lithuania and the PROMETHEE II technique have been used in this article. The results of the study indicate instability in the Lithuanian banking market and show significant fluctuations in banks' positions.

Doumpos et al. (2016), have examined 256 banks participating in the European Central Bank's stress tests in 2010, 2011, and 2014 using the FSIs with MCDM models. According to the study findings, capital adequacy is the

Table 2. Criteria evaluated in the study

Criteria	Definition	Explanations	References	Direction
TIER1	Tier1 Capital to risk-weighted assets	TIER1 Capital is a frequently used measure in stress tests as an indicator of the survival capacity of financial institutions. This ratio, which scales quality capital elements with risk-weighted assets, measures the sensitivity of financial institutions to risk.	Doumpos et al. (2016); Ginevičius and Podviekzo (2013); Okur et al. (2021)	Benefit
PRO	Provisions for nonperforming loans	This variable refers to the collateral allocated by banks and financial institutions for non-performing loans. It can also be expressed as reserves for losses arising from non-performing loans.	Marjanović and Popović (2020)	Benefit
ROA	Return on assets	The ROA ratio, used as a measure of the return on assets for financial institutions, assesses the impact of profitability generated by asset utilization on the health of the financial system	Doumpos et al. (2016); Marjanović and Popović (2020)	Benefit
ROE	Return on equity	ROE, as a measure of financial performance, indicates the efficiency of equity capital utilization. ROE is an important indicator for assessing financial health and profitability.	Radulescu et al. (2017); Roy and Das (2018)	Benefit
IM	Interest margin to gross income	This is the ratio of net interest margin to gross income. It helps us understand the proportion of interest income in total income. As this ratio increases, it is interpreted as higher income from interest-earning products and greater sensitivity to interest rates. In this case, the financial institution's interest rate risk may increase, and its financial health may deteriorate.	Ginevičius and Podviekzo (2013); Okur et al. (2021)	Benefit
LA	Liquid assets to short-term liabilities	This ratio shows the ability of liquid assets to cover short-term liabilities. A high ratio indicates that the financial institution is resilient to liquidity crises.	Radulescu et al. (2017)	Benefit
NPL	Nonperforming loans to total gross loans	This ratio, which shows the share of non-performing loans in total loans, reflects the asset quality of the financial institution. An increase in this ratio indicates that the asset quality of the financial institution has weakened and its risk has grown.	Doumpos et al. (2016); Okur et al. (2021); Radulescu et al. (2017);	Cost
OFX	Net open position in foreign exchange to capital	This ratio is calculated by scaling the difference between a financial institution's foreign currency denominated assets and liabilities by capital. A low level of this ratio, which measures a financial institution's foreign exchange risk and the extent to which this risk is covered by capital, indicates that the financial institution is more resilient to foreign exchange volatility.	Okur et al. (2021); Seyed and Abdoli (2019)	Cost

most robust indicator. While profitability and liquidity ratios are other important indicators, management efficiency is relatively weaker when measuring FS.

Radulescu et al. (2017) performed a comparative examination of the European banking system in the aftermath of Brexit, framed within the context of Basel III regulations. Their analysis employed the PROMETHEE II method combined with the entropy method across 28 EU member states. The results indicated that the banking sectors in Central and Eastern Europe demonstrated a remarkable level of efficiency and effectiveness. In contrast, more developed countries, including Germany, Italy, Britain, and France, demonstrated less favorable results.

Roy and Das (2018), analyzed the financial performance of 19 Bangladeshi banks from 2012-2013 using the TOPSIS method. Foreign commercial banks were more successful according to the findings.

Marjanović and Popović (2020) have analyzed banks in Serbia. The study period was 2012-2017 and used CRITIC and TOPSIS models. This study suggests that the influence of liquidity indicators and FSIs on bank performance is steadily growing.

Okur et al. (2021) evaluated the financial stability of 18 countries, specifically focusing on the Fragile 5 group. The TOPSIS method was utilized in this article and, examined the period from 2016 to 2018. The study's findings show that the countries defined as Fragile Five in the relevant period were not among those with poor financial performance. Accordingly, compared to other countries, it is observed that these countries performed better.

Yılmaz (2023) has examined the financial performance of US deposit banks with PARIS-ENTROPY methods from 2018 to 2022 by bank groups. It was determined that the best-performing group of banks in the relevant period were those with assets between \$100 million and \$1 billion. Using 10 indicators, the study concluded that the assets/equity ratio, which carries the highest weight under the ENTROPI, is the most significant criterion.

As far as we can tell from the literature, there is no research specifically focused on FS performance within the OTS. This enhances the importance of this study.

METHODOLOGY

Data set

In this article, the FSIs have been used for the analysis of the OTS member countries in the period 2018-2022. To this end, eight evaluation criteria have been determined in light of the relevant literature. The countries studied are Kazakhstan, Kyrgyzstan, Uzbekistan, and Türkiye. Azerbaijan, which did not have sufficient data during the relevant period, has been excluded from the analysis.

The data on the variables used in the study are obtained from the Financial Soundness Indicators (FSIs) published by the IMF. Table 2 presents the variables used in the study along with explanations for each variable. Additionally, the reference studies where these variables are used are provided in Table 2.

Methods

MCDM is used to select the best choice between multiple criteria. There are numerous studies in the literature concerning these methods. One of the preliminary steps in applying these methods has been determining the importance weights of the criteria. There are three primary approaches to criterion weighting: equal weighting, subjective weighting, and objective weighting methods. In this research, the significance weights assigned to the criteria were determined using two methodologies: the equal weighting approach and the Criteria Importance through Intercriteria Correlation (CRITIC) method, which is widely acknowledged in academic literature as a premier technique for objective criterion weighting. After the importance weights of the criteria were calculated, Grey Relational Analysis (GRA) and Simple Additive Weighting (SAW) methods were utilized to determine the rankings of financial institutions in the relevant countries. The implementation steps of these methods are presented in Table 3.

Table 3 provides the implementation steps of criterion weighting and performance ranking methods. All analyses conducted on the article have been performed by following the implementation steps of the respective analysis.

EMPIRICIAL FINDINGS

This study has assessed the financial performance of Kazakhstan (A1), Kyrgyzstan (A2), Uzbekistan (A3), and Türkiye (A4) using GRA and SAW methods. Defining the significance weights of the criteria used to evaluate the FS performance of the countries examined serves as

the initial. CRITIC and Equal Weighting methods were used for this purpose. Both weighting methods were separately implemented to the data of the four countries for each year from 2018 to 2022. The criteria whose importance weights were determined were analyzed by GRA and SAW methods and financial performance ranking has made among countries for each year. To avoid table pollution, only the implementation results of 2018 are shared in detail. Since the same procedure was followed in other years, only the results for these years are reported. Detailed results for the other years are presented in the appendices at the end of the study. Table 4 presents findings using the CRITIC Method for 2018.

The same procedures were used for 2019, 2020, 2021, and 2022. The final results for all years are displayed in Table 5. The significance weights of the criteria fluctuate annually, as illustrated in Table 5. However, when considering the average values for the relevant period, criteria NPL, IM, and TIER1 are the top three criteria in terms of importance weights.

Performance ranking for the year 2018 is conducted following the steps of the GRA Method as outlined in Table 3, using the importance weights obtained from the CRITIC Method. According to Table 6, the country with the best FS performance in 2018 is Kazakhstan. This is followed by Türkiye, Kyrgyzstan and Uzbekistan.

In Table 7, the GRA method, integrated with the Equal Weighting method, ranks the performance of countries for 2018. The findings reveal that the ranking of countries' performance for 2018 is as follows: Kazakhstan, Turkey, Kyrgyzstan, and Uzbekistan.

In Table 8, the SAW method is integrated with the CRITIC Weighting method for 2018.

In Table 9, the SAW method is integrated with the Equal Weighting method for 2018. In both methods, Kazakhstan is ranked first, with Kyrgyzstan following in last place. In the CRITIC Weighting - SAW method, Uzbekistan ranked second, but in the Equal Weighting - SAW method, it overtook Türkiye, taking the second spot.

Table 10 reports the results of GRA and SAW analyses according to both CRITIC Weighting and Equal Weighting methods. However, similar to some studies utilizing multiple MCDM techniques findings obtained through different methods in this study are consolidated using the Borda Count Method (Akyüz & Aka, 2017; Szymczyk et al., 2023). In this method, an alternative in the best condition among n alternatives is given $n-1$ points. The

Table 3. Application steps of analysis methods used in the study

CRITIC Method	GRA Method	SAW Method
Step 1: Decision Matrix (DM) $X = \begin{bmatrix} A_1 & x_{11} & x_{12} & \cdots & x_{1n} \\ A_2 & x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ A_m & x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (1.1)$ Step 2: Normalization of the DM $R_{ij} = \frac{x_{ij} - x_{j\min}}{x_{j\max} - x_{j\min}}, \dots, j = 1, 2, \dots, n \quad (1.2)$ $R_{ij} = \frac{x_{j\max} - x_{ij}}{x_{j\max} - x_{j\min}}, \dots, j = 1, 2, \dots, n \quad (1.3)$ Benefit-type criteria are normalized through Equation 1.2, while cost-type criteria are normalized using Equation 1.3. Step 3: Formation of the Correlation Coefficient Matrix $P_{jk} = \frac{\sum_{i=1}^m (r_{ij} - \bar{r}_j)(r_{ik} - \bar{r}_k)}{\sqrt{\sum_{i=1}^m (r_{ij} - \bar{r}_j)^2 \cdot \sum_{i=1}^m (r_{ik} - \bar{r}_k)^2}} \quad (1.4)$ Step 4: Computation of Cj Values $C_j = \sigma_j \cdot \sum_{k=1}^n (1 - p_{jk}) \quad (1.5)$ $j = 1, 2, \dots, n$ $\sigma_j = \sqrt{\frac{\sum_{i=1}^m (r_{ij} - \bar{r}_j)^2}{m-1}} \quad (1.6)$ Step 5: Computation of Criterion Weights $W_j = \frac{C_j}{\sum_{k=1}^n C_k} \quad (1.7)$	Step 1: Decision Matrix (DM) $X = \begin{bmatrix} A_1 & x_{11} & x_{12} & \cdots & x_{1n} \\ A_2 & x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ A_m & x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (2.1)$ Step 2: Determination of reference values depending on the orientation of the criteria Step 3: Normalization of the DM $X_i^* = \frac{x_{ij} - \min x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (2.2)$ $X_i^* = \frac{\max x_{ij} - x_{ij}}{\max x_{ij} - \min x_{ij}} \quad (2.3)$ Benefit-type criteria are normalized using Equation 2.2, while cost-type criteria follow Equation 2.3 for normalization. Step 4: Creating the Absolute Value (difference) Matrix $\Delta_{oi} = x_{ij} - x_{pj} \quad (2.4)$ $(i = 1, \dots, m \text{ and } j = 1 \dots n)$ $\Delta = \begin{bmatrix} \Delta_{11} & \Delta_{12} & \cdots & \Delta_{1n} \\ \Delta_{21} & \Delta_{22} & \cdots & \Delta_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ \Delta_{m1} & \Delta_{m2} & \cdots & \Delta_{mn} \end{bmatrix}$ Step 5: Creating the GRA Coefficient Matrix: $Y_{ij} = \frac{\Delta_{\min} + n\Delta_{\max}}{\Delta_{ij} + n\Delta_{\max}} \quad (2.5)$ The parameter denoted by n in the formula is referred to as the weighting coefficient, which must be between 0 and 1. In the literature, this value is commonly assigned as 0.5 $Y =$ $Y = \begin{bmatrix} Y_{11} & Y_{12} & \cdots & Y_{1n} \\ Y_{21} & Y_{22} & \cdots & Y_{2n} \\ \vdots & \vdots & \cdots & \vdots \\ Y_{m1} & Y_{m2} & \cdots & Y_{mn} \end{bmatrix}$ Step 6: Calculation of GRA Grades $r = \sum_{k=1}^n w_k Y_{ik} \quad (2.6)$	Step 1: Decision Matrix (DM) $X = \begin{bmatrix} A_1 & x_{11} & x_{12} & \cdots & x_{1n} \\ A_2 & x_{21} & x_{22} & \cdots & x_{2n} \\ \vdots & \vdots & \vdots & \cdots & \vdots \\ A_m & x_{m1} & x_{m2} & \cdots & x_{mn} \end{bmatrix} \quad (3.1)$ Step 2: Normalization of the DM $r_{ij} = \frac{x_{ij}}{\max x_{ij}} \quad (3.2)$ $i=1, \dots, m$ $j=1, \dots, n$ $r_{ij} = \frac{x_{ij}}{\min x_{ij}} \quad (3.3)$ $i=1, \dots, m$ $j=1, \dots, n$ Benefit-type criteria are normalized Equation 3.2, while cost-type criteria follow Equation 3.3. All values must be positive. When there are negative values, formula 3.4 should be followed to make the values positive. $r_{ij} = r_{ij} + \min r_{ij} + 1 \quad (3.4)$ Step 3: Calculation of Alternative Preference Values $S_j = \sum_{i=1}^m w_j r_{ij} \quad (3.5)$ $i=1, \dots, m$ $S_i^{\%} = \frac{S_j}{\sum_{j=1}^n S_j} \quad (3.6)$

second-best alternative takes $n-2$ points. The alternative in the last position takes 0 points, and these points are then added up to calculate the Borda score. The option with the maximum point is ranked first. The method is formulated as follows;

$$bi = \sum_{k=1}^n (M - r_{ik})$$

where r_{ik} represents the rank of alternative i under criterion k , and M indicates the total number of alternatives (Lansdowne & Woodward, 1996: 27).

Table 10 and Graph 1 presents the findings of the Borda Counting Technique. Accordingly, Kazakhstan is the optimal financial stability performance across the years. Türkiye demonstrates the most successful performance in 2022, while in the other years, it ranks second. Uzbekistan holds the third position in 2018 and 2020, second in 2019, and fourth in 2021 and 2022. Meanwhile, Kyrgyzstan ranks fourth in 2018, 2019, and 2020, and third in 2021 and 2022. When the country rankings are evaluated in general, the most financially sound country is Kazakhstan, while the weakest country is Kyrgyzstan. The decline in Uzbekistan's ranking in recent years is significant.

Table 4. Application of the CRITIC Method for 2018

Direction	B	B	B	B	B	B	C	C
Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	16,786	75,056	3,037	21,293	52,680	90,760	7,385	2,518
A2	19,627	54,640	1,612	7,988	64,608	66,927	7,297	3,582
A3	14,291	46,723	2,046	16,187	48,420	41,172	1,279	2,281
A4	13,993	68,345	1,797	13,498	68,888	64,010	3,687	1,522
Min	13,993	46,723	1,612	7,988	48,420	41,172	1,279	1,522
Max	19,627	75,056	3,037	21,293	68,888	90,760	7,385	3,582
Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,496	1,000	1,000	1,000	0,208	1,000	0,000	0,516
A2	1,000	0,279	0,000	0,000	0,791	0,519	0,014	0,000
A3	0,053	0,000	0,305	0,616	0,000	0,000	1,000	0,632
A4	0,000	0,763	0,130	0,414	1,000	0,461	0,606	1,000
Correlation Coefficient Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
TIER1	1,000	-0,025	-0,070	-0,443	0,182	0,436	-0,824	-0,941
PRO	-0,025	1,000	0,605	0,492	0,267	0,872	-0,545	0,325
ROA	-0,070	0,605	1,000	0,922	-0,600	0,640	-0,304	0,124
ROE	-0,443	0,492	0,922	1,000	-0,665	0,363	0,074	0,444
IM	0,182	0,267	-0,600	-0,665	1,000	0,155	-0,279	0,058
LA	0,436	0,872	0,640	0,363	0,155	1,000	-0,863	-0,170
NPL	-0,824	-0,545	-0,304	0,074	-0,279	-0,863	1,000	0,609
OFX	-0,941	0,325	0,124	0,444	0,058	-0,170	0,609	1,000
(1-p _{jk}) Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
TIER1	0,000	1,025	1,070	1,443	0,818	0,564	1,824	1,941
PRO	1,025	0,000	0,395	0,508	0,733	0,128	1,545	0,675
ROA	1,070	0,395	0,000	0,078	1,600	0,360	1,304	0,876
ROE	1,443	0,508	0,078	0,000	1,665	0,637	0,926	0,556
IM	0,818	0,733	1,600	1,665	0,000	0,845	1,279	0,942
LA	0,564	0,128	0,360	0,637	0,845	0,000	1,863	1,170
NPL	1,824	1,545	1,304	0,926	1,279	1,863	0,000	0,391
OFX	1,941	0,675	0,876	0,556	0,942	1,170	0,391	0,000
σ_j	0,465	0,454	0,445	0,417	0,473	0,409	0,487	0,413
C_j	4,040	2,272	2,532	2,421	3,724	2,277	4,446	2,707
w_j	0,165	0,093	0,104	0,099	0,153	0,093	0,182	0,111

Note: B: Benefit, C: Cost.**Table 5.** Importance weights of FSIs for all years according to CRITIC method

	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
2018	0,165	0,093	0,104	0,099	0,153	0,093	0,182	0,111
2019	0,152	0,094	0,102	0,088	0,193	0,085	0,176	0,110
2020	0,171	0,096	0,101	0,080	0,214	0,088	0,168	0,083
2021	0,161	0,082	0,107	0,094	0,126	0,179	0,155	0,096
2022	0,112	0,077	0,110	0,082	0,115	0,149	0,169	0,187
Average	0,152	0,088	0,105	0,088	0,160	0,119	0,170	0,117

Table 6. GRA method results for 2018 (CRITIC Weighting)

Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
Weights	0,165	0,093	0,104	0,099	0,153	0,093	0,182	0,111	
Direction	B	B	B	B	B	B	C	C	
References	19,627	75,056	3,037	21,293	68,888	90,760	1,279	1,522	
A1	16,786	75,056	3,037	21,293	52,680	90,760	7,385	2,518	
A2	19,627	54,640	1,612	7,988	64,608	66,927	7,297	3,582	
A3	14,291	46,723	2,046	16,187	48,420	41,172	1,279	2,281	
A4	13,993	68,345	1,797	13,498	68,888	64,010	3,687	1,522	
Min	13,993	46,723	1,612	7,988	48,420	41,172	1,279	1,522	
Max	19,627	75,056	3,037	21,293	68,888	90,760	7,385	3,582	
Max-Min	5,634	28,333	1,425	13,305	20,468	49,589	6,107	2,061	
Normalized Decision Matrix									
Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
Reference	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
A1	0,496	1,000	1,000	1,000	0,208	1,000	0,000	0,516	
A2	1,000	0,279	0,000	0,000	0,791	0,519	0,014	0,000	
A3	0,053	0,000	0,305	0,616	0,000	0,000	1,000	0,632	
A4	0,000	0,763	0,130	0,414	1,000	0,461	0,606	1,000	
Absolute Value (difference) Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,504	0,000	0,000	0,000	0,792	0,000	1,000	0,484	
A2	0,000	0,721	1,000	1,000	0,209	0,481	0,986	1,000	
A3	0,947	1,000	0,695	0,384	1,000	1,000	0,000	0,368	
A4	1,000	0,237	0,870	0,586	0,000	0,539	0,394	0,000	
Calculation of GRA Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,498	1,000	1,000	1,000	0,387	1,000	0,333	0,508	
A2	1,000	0,410	0,333	0,333	0,705	0,510	0,337	0,333	
A3	0,346	0,333	0,418	0,566	0,333	0,333	1,000	0,576	
A4	0,333	0,679	0,365	0,460	1,000	0,481	0,559	1,000	
$\Delta \max$	1,000								
$\Delta \min$	0,000								
n(gc)	0,50								
GRA Coefficients and Alternative Ranking Without Consideration of Significance Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,498	1,000	1,000	1,000	0,387	1,000	0,333	0,508	0,716
A2	1,000	0,410	0,333	0,333	0,705	0,510	0,337	0,333	0,495
A3	0,346	0,333	0,418	0,566	0,333	0,333	1,000	0,576	0,488
A4	0,333	0,679	0,365	0,460	1,000	0,481	0,559	1,000	0,610
Ranking Considering Importance Weights									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
Weights	0,165	0,093	0,104	0,099	0,153	0,093	0,182	0,111	
A1	0,498	1,000	1,000	1,000	0,387	1,000	0,333	0,508	0,648
A2	1,000	0,410	0,333	0,333	0,705	0,510	0,337	0,333	0,524
A3	0,346	0,333	0,418	0,566	0,333	0,333	1,000	0,576	0,515
A4	0,333	0,679	0,365	0,460	1,000	0,481	0,559	1,000	0,612

Note: B: Benefit, C: Cost.

Table 7. GRA method results for 2018 (Equal Weighting)

Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
Weights	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	
Direction	B	B	B	B	B	B	C	C	
References	19,627	75,056	3,037	21,293	68,888	90,760	1,279	1,522	
A1	16,786	75,056	3,037	21,293	52,680	90,760	7,385	2,518	
A2	19,627	54,640	1,612	7,988	64,608	66,927	7,297	3,582	
A3	14,291	46,723	2,046	16,187	48,420	41,172	1,279	2,281	
A4	13,993	68,345	1,797	13,498	68,888	64,010	3,687	1,522	
Min	13,993	46,723	1,612	7,988	48,420	41,172	1,279	1,522	
Max	19,627	75,056	3,037	21,293	68,888	90,760	7,385	3,582	
Max-Min	5,634	28,333	1,425	13,305	20,468	49,589	6,107	2,061	
Normalized Decision Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
Reference	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
A1	0,496	1,000	1,000	1,000	0,208	1,000	0,000	0,516	
A2	1,000	0,279	0,000	0,000	0,791	0,519	0,014	0,000	
A3	0,053	0,000	0,305	0,616	0,000	0,000	1,000	0,632	
A4	0,000	0,763	0,130	0,414	1,000	0,461	0,606	1,000	
Absolute Value (difference) Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,504	0,000	0,000	0,000	0,792	0,000	1,000	0,484	
A2	0,000	0,721	1,000	1,000	0,209	0,481	0,986	1,000	
A3	0,947	1,000	0,695	0,384	1,000	1,000	0,000	0,368	
A4	1,000	0,237	0,870	0,586	0,000	0,539	0,394	0,000	
Calculation of GRA Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,498	1,000	1,000	1,000	0,387	1,000	0,333	0,508	
A2	1,000	0,410	0,333	0,333	0,705	0,510	0,337	0,333	
A3	0,346	0,333	0,418	0,566	0,333	0,333	1,000	0,576	
A4	0,333	0,679	0,365	0,460	1,000	0,481	0,559	1,000	
Δ max	1,000								
Δ min	0,000								
n(gc)	0,50								
GRA Coefficients and Alternative Ranking Without Consideration of Significance Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,498	1,000	1,000	1,000	0,387	1,000	0,333	0,508	0,716
A2	1,000	0,410	0,333	0,333	0,705	0,510	0,337	0,333	0,495
A3	0,346	0,333	0,418	0,566	0,333	0,333	1,000	0,576	0,488
A4	0,333	0,679	0,365	0,460	1,000	0,481	0,559	1,000	0,610
Ranking Considering Importance Weights									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
Weights	0.125	0.125	0.125	0.125	0.125	0.125	0.125	0.125	
A1	0,498	1,000	1,000	1,000	0,387	1,000	0,333	0,508	0,716
A2	1,000	0,410	0,333	0,333	0,705	0,510	0,337	0,333	0,495
A3	0,346	0,333	0,418	0,566	0,333	0,333	1,000	0,576	0,488
A4	0,333	0,679	0,365	0,460	1,000	0,481	0,559	1,000	0,610

Note: B: Benefit, C: Cost

Table 8. SAW method results for 2018 (CRITIC Weighting)

Weights	0,165	0,093	0,104	0,099	0,153	0,093	0,182	0,111
Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
Direction	B	B	B	B	B	B	C	C
A1	16,786	75,056	3,037	21,293	52,680	90,760	7,385	2,518
A2	19,627	54,640	1,612	7,988	64,609	66,927	7,297	3,582
A3	14,291	46,723	2,046	16,187	48,420	41,172	1,279	2,281
A4	13,993	68,345	1,797	13,498	68,888	64,010	3,687	1,522
Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,855	1,000	1,000	1,000	0,765	1,000	0,173	0,604
A2	1,000	0,727	0,531	0,375	0,938	0,737	0,175	0,425
A3	0,728	0,623	0,674	0,760	0,703	0,454	1,000	0,667
A4	0,713	0,911	0,592	0,634	1,000	0,705	0,347	1,000
Weighting of Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
Weights	0,165	0,093	0,104	0,099	0,153	0,093	0,182	0,111
A1	0,141	0,093	0,104	0,099	0,117	0,093	0,032	0,067
A2	0,165	0,068	0,055	0,037	0,143	0,069	0,032	0,047
A3	0,120	0,058	0,070	0,075	0,107	0,042	0,182	0,074
A4	0,118	0,085	0,061	0,063	0,153	0,066	0,063	0,111
Si	Si%	Rank						
0,746	0,265	1						
0,616	0,219	4						
0,729	0,259	2						
0,719	0,256	3						

Note: B: Benefit, C: Cost**Table 9.** SAW method results for 2018 (Equal Weighting)

Weights	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125
Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
Direction	B	B	B	B	B	B	C	C
A1	16,786	75,056	3,037	21,293	52,680	90,760	7,385	2,518
A2	19,627	54,640	1,612	7,988	64,609	66,927	7,297	3,582
A3	14,291	46,723	2,046	16,187	48,420	41,172	1,279	2,281
A4	13,993	68,345	1,797	13,498	68,888	64,010	3,687	1,522
Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,855	1,000	1,000	1,000	0,765	1,000	0,173	0,604
A2	1,000	0,727	0,531	0,375	0,938	0,737	0,175	0,425
A3	0,728	0,623	0,674	0,760	0,703	0,454	1,000	0,667
A4	0,713	0,911	0,592	0,634	1,000	0,705	0,347	1,000
Weighting of Normalized Decision Matrix								
Weights	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,107	0,125	0,125	0,125	0,096	0,125	0,022	0,076
A2	0,125	0,091	0,066	0,047	0,117	0,092	0,022	0,053
A3	0,091	0,078	0,084	0,095	0,088	0,057	0,125	0,083
A4	0,089	0,114	0,074	0,079	0,125	0,088	0,043	0,125
Si	Si%	Rank						
0,800	0,280	1						
0,614	0,215	4						
0,701	0,246	3						
0,738	0,259	2						

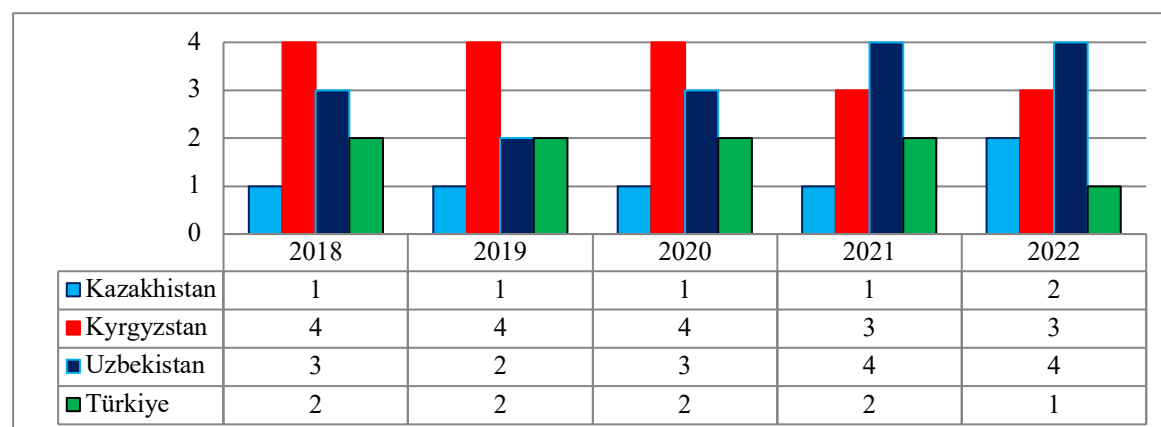
Note: B: Benefit, C: Cost

Table 10. Borda points for the 2018-2022 period

Borda Point According to GRA Method Results										
	2018		2019		2020		2021		2022	
	E.W	C.W	E.W	C.W	E.W	C.W	E.W	C.W	E.W	C.W
A1	3	3	3	3	3	3	3	3	2	2
A2	1	1	0	0	1	1	1	1	1	1
A3	0	0	1	2	0	0	0	0	0	0
A4	2	2	2	1	2	2	2	2	3	3
Borda Point According to SAW Method Results										
	2018		2019		2020		2021		2022	
	E.W	C.W	E.W	C.W	E.W	C.W	E.W	C.W	E.W	C.W
A1	3	3	3	3	3	3	3	3	2	2
A2	0	0	0	0	0	0	1	1	1	1
A3	1	2	1	2	2	2	0	0	0	0
A4	2	1	2	1	1	1	2	2	3	3
Borda Total Point						Borda Ranking				
	2018	2019	2020	2021	2022	2018	2019	2020	2021	2022
A1	12	12	12	12	8	1st	1st	1st	1st	2nd
A2	2	0	2	4	4	4th	4th	4th	3rd	3rd
A3	3	6	4	0	0	3rd	2nd	3rd	4th	4th
A4	7	6	6	8	12	2nd	2nd	2nd	2nd	1st

E.W: Equal Weighting

C.W: Weighting According to CRITIC Method

Graph 1. Financial soundness performance in OTS member countries in the 2018-2022 period**Source:** They were prepared by the authors.

EVALUATION OF FINDINGS

This study seeks to conduct a comparative assessment of the FS performance among the countries that are members of the OTS. First, in line with data availability, the four-member countries included in the sample were analyzed by MDCM methods with eight main evaluation criteria. Different weighting and ranking methods in MDCM can lead to varying results. Therefore, the Borda Counting Technique has been used, to integrate the findings and determine the final performance rankings.

According to the findings of the CRITIC Weighting method, the criteria with the highest importance weights are NPL in 2018, IM in 2019 and 2020, LA in 2021, and OFX in 2022. When evaluating the average importance weights of the research criteria over the years, it becomes evident that the criterion with the highest significance is the NPL. Criteria with the lowest importance weight according to equal mean value are PRO and ROE criteria.

When evaluating the FSIs of the countries included in the analysis, Kazakhstan is the most successful country

based on average for PRO, ROA, ROE, LA, and FX. Risk coverage capacity, asset utilization efficiency, and return on equity have increased in Kazakhstan's financial system from 2018 to 2022. IM decreased only in 2020 compared to other years. The decrease in NPL and FX are positive developments for the Kazakhstan financial system. These developments, which enhance the stability of Kazakhstan's financial system, could result in a greater interest from investors in Kazakhstan. Particularly, investments in natural resources, the energy sector, and infrastructure could present opportunities for potential investors. The ability to meet short-term obligations has decreased significantly after 2020. This is one of the most unfavorable aspects of the Kazakhstan financial system based on evaluation criteria. This must be considered for the stability of the financial system. Policymakers' measures to enhance the liquidity of financial institutions could be advantageous for the sustained stability of the financial system. Creating a reserve to guard against potential financial crises can be viewed as a measure to be taken in this context. Liquidity problems may also be regarded as a risk for investors adopting a short-term investment strategy in Kazakhstan. At this stage, a long-term investment strategy may be more suitable. Government bonds and bonds issued by strong private sector companies may be considered alternative investment options. Kazakhstan, which has ranked first in all years except 2022, has ranked second in the performance rankings in 2022. Overall, Kazakhstan's FS performance is better than other OTC countries.

An analysis of FSIs for Türkiye reveals that Türkiye's capacity to cover risks increased during the relevant period. This positive development in the financial system should be supported by policies that strengthen macroeconomic stability, such as disinflation, external debt management, and increasing reserves. The proportion of interest income in total revenues had been increasing until 2022, but there was a partial decrease in 2022 compared to the previous year. This rise in interest income is generally beneficial. However, financial diversification strategies could be promoted to boost non-interest income. Short-term debt repayment capacity has remained almost flat over time but increased significantly in 2022. The decline in both ROA and ROE and the increase in OFX are negative developments in terms of FS. Specifically, the increase in OFX poses a threat to Turkey's financial stability. Investors might choose to diversify their portfolios as a hedge against exchange rate fluctuations. To ensure the sustainability of financial stability, policymakers need to adopt measures to stabilize the FX position. Measures like enhancing foreign

exchange reserves and promoting trade in domestic currency can help mitigate foreign exchange risks. Türkiye consistently ranks among the top OTC countries for the soundness of its financial performance across all analyzed years. According to the ranking to performance results, Türkiye is ranked first in 2022 and second in all other years (in 2019, it has the same score as Uzbekistan). In 2022, the ROA, ROE, and LA criteria improved, while the NPL decreased. We believe that the improvement in the criteria has a significant impact on the change in ranking.

Uzbekistan hasn't experienced a significant change in its risk-absorbing capacity from 2018 to 2022. While the ROA experiences a slight increase, the ROE experiences a decrease. IM increased in 2019 and 2020 but fell below the 2018 level in 2022. This volatility in IM increases the sensitivity of financial institutions to interest rates. Financial institutions could use derivatives to hedge against interest rate risk. Furthermore, the decrease in interest income can be balanced by diversifying revenue sources. Investors should formulate sector-specific strategies, considering the decline in ROE and the fluctuations in IM. Non-bank sectors could offer an alternative for investors looking to mitigate interest rate risk. In 2019 and 2020, short-term debt repayment capacity had increased a partial. NPL has increased in all years compared to 2018. This has an adverse effect on financial soundness. Enhanced credit monitoring and evaluation processes, along with stricter supervision of financial institutions, can help decrease non-performing loans. Regulatory actions can be implemented to restructure distressed loans. There has not been a significant change in the net open position. Uzbekistan has ranked third among the OTC states in 2018. In 2019, it moved up to second place with the same score as Türkiye, but couldn't sustain this position and dropped to third place in 2020 and fourth place in 2021 and 2022.

No significant change in risk coverage capacity has been observed in Kyrgyzstan. PRO has increased slightly in the 2018-2022 period. Both profitability indicators have shown significant increases in 2022. IM has significantly decreased in 2022. In response to this development, which could negatively impact interest income, banks should consider diversifying their revenue streams and exploring alternative sources of income. The upward trend in NPL presents a substantial threat to the stability of Kyrgyzstan's financial system. At this stage, measures such as enhancing credit assessment and monitoring processes, as well as strengthening supervisory mechanisms, can be implemented. Measures

like restructuring or removing non-performing loans from the system can be considered. Among the country's rankings, Kyrgyzstan, which ranked fourth in 2018, 2019, and 2020, moved up one place to third place in 2021 and 2022. In 2021 and 2022, there was an improvement in the ROA and ROE profitability indicators, as well as the LA criterion. The decrease in OFX also supports this improvement. We believe that this positive change in the criteria has played a key role in Kyrgyzstan's improved ranking.

CONCLUSION

The analysis findings have significant implications for policymakers and regulatory authorities in the members of the OTS. Member countries should consider increasing their risk coverage capacity and short-term debt repayment capacity, as well as maximizing profit generation potential and interest income. At the same time, efforts should be made to reduce non-performing loans and net short positions in order to enhance FS and prevent potential financial crises. Based on the findings of the CRITIC weighting method and the final performance rankings of the countries, we strongly recommend that the authorities in Uzbekistan and Kyrgyzstan implement regulations to reduce the non-performing loan ratio. Because both countries saw an increase in the NPL ratio during the years under review. This situation jeopardizes the financial health of both countries and negatively impacts their financial performance.

Recently, the OTS countries have concluded joint industrial and trade agreements to facilitate trade. Steps are being taken to establish a special economic zone between member states to promote trade, create a council of central banks, and set up an investment fund to strengthen investment activities. The development of payment systems among member countries and the mutual sharing of knowledge in banking and financial technology will enhance the financial performance of OTS countries and contribute positively to financial stability.

Azerbaijan holds significant status as a member of this organization; however, it could not be included in this analysis due to insufficient data availability. This is one of the basic limitations of the article. In subsequent studies, if observer countries are included as members and data on Azerbaijan are shared within the scope of FSIs by the IMF, the issue can be investigated more comprehensively by including these countries. Additionally, country-specific academic research can be expanded in areas such as the rise in non-performing loans, the decline in

interest income, and foreign exchange needs highlighted in the study's findings. The results of new studies could provide valuable insights into identifying the sources of these issues and developing solutions.

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Appendix 1. Application of the CRITIC Method for 2019

Directions	B	B	B	B	B	B	C	C
Alternatives/ Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	19,108	75,056	3,037	21,293	52,680	95,866	8,143	1,649
A2	19,971	56,911	1,436	6,642	66,867	63,958	7,731	5,105
A3	20,368	56,651	2,126	13,046	50,715	40,322	1,479	11,280
A4	15,341	65,143	1,442	10,827	66,058	64,799	5,023	-0,997
Min	15,341	56,651	1,436	6,642	50,715	40,322	1,479	-0,997
Max	20,368	75,056	3,037	21,293	66,867	95,866	8,143	11,280
Normalized Decision Matrix								
Alternatives/ Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,749	1,000	1,000	1,000	0,122	1,000	0,000	0,784
A2	0,921	0,014	0,000	0,000	1,000	0,426	0,062	0,503
A3	1,000	0,000	0,431	0,437	0,000	0,000	1,000	0,000
A4	0,000	0,461	0,004	0,286	0,950	0,441	0,468	1,000
Correlation Coefficient Matrix								
Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
TIER1	1,000	-0,344	0,343	0,063	-0,510	-0,186	0,056	-0,803
PRO	-0,344	1,000	0,705	0,833	-0,253	0,897	-0,532	0,668
ROA	0,343	0,705	1,000	0,958	-0,821	0,571	-0,178	-0,052
ROE	0,063	0,833	0,958	1,000	-0,746	0,623	-0,152	0,156
IM	-0,510	-0,253	-0,821	-0,746	1,000	-0,001	-0,390	0,529
LA	-0,186	0,897	0,571	0,623	-0,001	1,000	-0,848	0,700
NPL	0,056	-0,532	-0,177	-0,152	-0,390	-0,848	1,000	-0,629
OFX	-0,803	0,668	-0,052	0,156	0,529	0,700	-0,629	1,000
(1-p _{jk}) Matrix								
Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
TIER1	0,000	1,344	0,657	0,937	1,510	1,186	0,944	1,803
PRO	1,344	0,000	0,295	0,167	1,253	0,103	1,532	0,332
ROA	0,657	0,295	0,000	0,042	1,821	0,429	1,178	1,052
ROE	0,937	0,167	0,042	0,000	1,746	0,378	1,152	0,844
IM	1,510	1,253	1,821	1,746	0,000	1,001	1,390	0,471
LA	1,186	0,103	0,429	0,378	1,001	0,000	1,848	0,301
NPL	0,944	1,532	1,178	1,152	1,390	1,848	0,000	1,629
OFX	1,803	0,332	1,052	0,844	0,471	0,301	1,629	0,000
σ_j	0,457	0,472	0,473	0,421	0,531	0,410	0,461	0,432
C _j	3,831	2,373	2,589	2,215	4,876	2,151	4,459	2,779
w _j	0,152	0,094	0,102	0,088	0,193	0,085	0,176	0,110

Note: B; Benefit, C; Cost

Appendix 2. GRA method results for 2019 (CRITIC Weighting)

Directions	B	B	B	B	B	B	C	C	
Weights	0,152	0,094	0,102	0,088	0,193	0,085	0,176	0,110	
Alternatives/Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	19,108	75,056	3,037	21,293	52,680	95,866	8,143	1,649	
A2	19,971	56,911	1,436	6,642	66,867	63,958	7,731	5,105	
A3	20,368	56,651	2,126	13,046	50,715	40,322	1,479	11,280	
A4	15,341	65,143	1,442	10,827	66,058	64,799	5,023	-0,997	
Min.	15,341	56,651	1,436	6,642	50,715	40,322	1,479	-0,997	
Max.	20,368	75,056	3,037	21,293	66,867	95,866	8,143	11,280	
Max. - Min	5,027	18,405	1,601	14,651	16,153	55,544	6,664	12,277	
Normalized Decision Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
Reference	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
A1	0,749	1,000	1,000	1,000	0,1217	1,000	0,000	0,784	
A2	0,921	0,014	0,000	0,000	1,000	0,426	0,062	0,503	
A3	1,000	0,000	0,431	0,437	0,000	0,000	1,000	0,000	
A4	0,000	0,461	0,004	0,286	0,950	0,441	0,468	1,000	
Absolute Value (difference) Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,251	0,000	0,000	0,000	0,878	0,000	1,000	0,216	
A2	0,079	0,986	1,000	1,000	0,000	0,575	0,938	0,497	
A3	0,000	1,000	0,569	0,563	1,000	1,000	0,000	1,000	
A4	1,000	0,539	0,996	0,714	0,050	0,559	0,532	0,000	
Calculation of GRA Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,666	1,000	1,000	1,000	0,363	1,000	0,333	0,699	
A2	0,864	0,337	0,333	0,333	1,000	0,465	0,348	0,502	
A3	1,000	0,333	0,468	0,470	0,333	0,333	1,000	0,333	
A4	0,333	0,481	0,334	0,412	0,909	0,472	0,485	1,000	
$\Delta \max$	1,000								
$\Delta \min$	0,000								
n(gc)	0,500								
GRA Coefficients and Alternative Ranking Without Consideration of Significance Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,666	1,000	1,000	1,000	0,363	1,000	0,333	0,699	0,758
A2	0,864	0,337	0,333	0,333	1,000	0,465	0,348	0,502	0,523
A3	1,000	0,333	0,468	0,470	0,333	0,333	1,000	0,333	0,534
A4	0,333	0,481	0,334	0,412	0,909	0,472	0,485	1,000	0,553
Ranking Considering Importance Weights									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,666	1,000	1,000	1,000	0,363	1,000	0,333	0,699	0,676
A2	0,864	0,337	0,333	0,333	1,000	0,465	0,348	0,502	0,575
A3	1,000	0,333	0,468	0,470	0,333	0,333	1,000	0,333	0,578
A4	0,333	0,481	0,334	0,412	0,909	0,472	0,485	1,000	0,577

Appendix 3. GRA method results for 2019 (Equal Weighting)

Directions	B	B	B	B	B	B	C	C	
Weights	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125	
Alternatives / Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	19,108	75,056	3,037	21,293	52,680	95,866	8,143	1,649	
A2	19,971	56,911	1,436	6,642	66,867	63,958	7,731	5,105	
A3	20,368	56,651	2,126	13,046	50,715	40,322	1,479	11,280	
A4	15,341	65,143	1,442	10,827	66,058	64,799	5,023	-0,997	
Min.	15,341	56,651	1,436	6,642	50,715	40,322	1,479	-0,997	
Max.	20,368	75,056	3,037	21,293	66,867	95,866	8,143	11,280	
Max. - Min	5,027	18,405	1,601	14,651	16,153	55,544	6,664	12,277	
Normalized Decision Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
Reference	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
A1	0,749	1,000	1,000	1,000	0.1217	1,000	0,000	0,784	
A2	0,921	0,014	0,000	0,000	1,000	0,426	0,062	0,503	
A3	1,000	0,000	0,431	0,437	0,000	0,000	1,000	0,000	
A4	0,000	0,461	0,004	0,286	0,950	0,441	0,468	1,000	
Absolute Value (difference) Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,251	0,000	0,000	0,000	0,878	0,000	1,000	0,216	
A2	0,079	0,986	1,000	1,000	0,000	0,575	0,938	0,497	
A3	0,000	1,000	0,569	0,563	1,000	1,000	0,000	1,000	
A4	1,000	0,539	0,996	0,714	0,050	0,559	0,532	0,000	
Calculation of GRA Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,666	1,000	1,000	1,000	0,363	1,000	0,333	0,699	
A2	0,864	0,337	0,333	0,333	1,000	0,465	0,348	0,502	
A3	1,000	0,333	0,468	0,470	0,333	0,333	1,000	0,333	
A4	0,333	0,481	0,334	0,412	0,909	0,472	0,485	1,000	
$\Delta \max$	1,000								
$\Delta \min$	0,000								
n(gc)	0,500								
GRA Coefficients and Alternative Ranking Without Consideration of Significance Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,666	1,000	1,000	1,000	0,363	1,000	0,333	0,699	0,758
A2	0,864	0,337	0,333	0,333	1,000	0,465	0,348	0,502	0,523
A3	1,000	0,333	0,468	0,470	0,333	0,333	1,000	0,333	0,534
A4	0,333	0,481	0,334	0,412	0,909	0,472	0,485	1,000	0,553
Ranking Considering Importance Weights									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,666	1,000	1,000	1,000	0,363	1,000	0,333	0,699	0,758
A2	0,864	0,337	0,333	0,333	1,000	0,465	0,348	0,502	0,523
A3	1,000	0,333	0,468	0,470	0,333	0,333	1,000	0,333	0,534
A4	0,333	0,481	0,334	0,412	0,909	0,472	0,485	1,000	0,553

Appendix 4. SAW method results for 2019 (CRITIC Weighting)

Directions	Max	Max	Max	Max	Max	Max	Min	Min
Weights	0,152	0,094	0,102	0,088	0,193	0,085	0,176	0,110
Alternatives / Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	19,108	75,056	3,037	21,293	52,680	95,866	8,143	1,649
A2	19,971	56,911	1,436	6,642	66,867	63,958	7,731	5,105
A3	20,368	56,651	2,126	13,046	50,715	40,322	1,479	11,280
A4	15,341	65,143	1,442	10,827	66,058	64,799	5,023	-0,997
Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,938	1,000	1,000	1,000	0,788	1,000	0,182	0,274
A2	0,981	0,758	0,473	0,312	1,000	0,667	0,191	0,141
A3	1,000	0,755	0,700	0,613	0,758	0,421	1,000	0,075
A4	0,753	0,868	0,475	0,508	0,988	0,676	0,294	1,000
Weighting of Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,142	0,094	0,102	0,088	0,152	0,085	0,032	0,030
A2	0,149	0,071	0,048	0,027	0,193	0,057	0,034	0,015
A3	0,152	0,071	0,072	0,054	0,146	0,036	0,176	0,008
A4	0,114	0,081	0,049	0,045	0,191	0,058	0,052	0,110
Si	Si%	Rank						
0,725	0,265	1						
0,595	0,217	4						
0,715	0,261	2						
0,699	0,256	3						

Appendix 5. SAW method results for 2019 (Equal Weighting)

Weighting of Normalized Decision Matrix								
Directions	Max	Max	Max	Max	Max	Max	Min	Min
Weights	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125
Alternatives /Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,117	0,125	0,125	0,125	0,098	0,125	0,023	0,034
A2	0,123	0,095	0,059	0,039	0,125	0,083	0,024	0,018
A3	0,125	0,094	0,087	0,077	0,095	0,053	0,125	0,009
A4	0,094	0,108	0,059	0,064	0,123	0,084	0,037	0,125
Si	Si%	Rank						
0,773	0,286	1						
0,565	0,209	4						
0,665	0,247	3						
0,695	0,258	2						

Note: In the analyses performed using the Critic Weighting and Equal Weighting methods within the SAW model, the results diverge solely in the 'Weighting of Normalized Decision Matrix' step. To prevent redundancy, repeated results have not been included in Appendix 5, as they are already presented in Appendix 4.

Appendix 6. Application of the CRITIC Method for 2020

Directions	B	B	B	B	B	B	C	C
Alternatives/ Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	21,288	77,699	3,061	19,277	45,529	103,636	6,868	0,316
A2	21,650	59,149	0,995	4,607	65,483	64,866	10,094	2,805
A3	15,196	63,728	2,189	10,202	54,346	39,856	2,061	4,038
A4	15,676	74,937	1,414	10,758	71,941	58,521	3,890	2,664
Min	15,196	59,149	0,995	4,607	45,529	39,856	2,061	0,316
Max	21,650	77,699	3,061	19,277	71,941	103,636	10,094	4,038
Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,944	1,000	1,000	1,000	0,000	1,000	0,402	1,000
A2	1,000	0,000	0,000	0,000	0,756	0,392	0,000	0,332
A3	0,000	0,247	0,578	0,381	0,334	0,000	1,000	0,000
A4	0,074	0,851	0,202	0,419	1,000	0,293	0,772	0,369
Correlation Coefficient Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
TIER1	1,000	-0,066	0,085	0,099	-0,312	0,744	-0,928	0,656
PRO	-0,066	1,000	0,603	0,857	-0,255	0,607	0,263	0,705
ROA	0,085	0,603	1,000	0,924	-0,911	0,557	0,290	0,576
ROE	0,099	0,857	0,924	1,000	-0,717	0,700	0,236	0,753
IM	-0,312	-0,255	-0,911	-0,717	1,000	-0,520	-0,050	-0,483
LA	0,744	0,607	0,557	0,700	-0,520	1,000	-0,521	0,991
NPL	-0,928	0,263	0,290	0,236	-0,050	-0,521	1,000	-0,433
OFX	0,656	0,705	0,576	0,753	-0,483	0,991	-0,433	1,000
(1-p _{jk}) Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
TIER1	0,000	1,066	0,915	0,901	1,312	0,256	1,928	0,344
PRO	1,066	0,000	0,397	0,144	1,255	0,393	0,737	0,295
ROA	0,915	0,397	0,000	0,076	1,911	0,443	0,710	0,424
ROE	0,901	0,144	0,076	0,000	1,717	0,300	0,764	0,247
IM	1,312	1,255	1,911	1,717	0,000	1,520	1,050	1,483
LA	0,256	0,393	0,443	0,300	1,520	0,000	1,521	0,009
NPL	1,928	0,737	0,710	0,764	1,050	1,521	0,000	1,433
OFX	0,344	0,295	0,424	0,247	1,483	0,009	1,433	0,000
σ_j	0,541	0,478	0,441	0,413	0,444	0,420	0,438	0,418
C_j	3,636	2,048	2,149	1,711	4,549	1,867	3,569	1,768
w_j	0,171	0,096	0,101	0,080	0,214	0,088	0,168	0,083

Note: B: Benefit, C: Cost

Appendix 7. GRA method results for 2020 (CRITIC Weighting)

Directions	B	B	B	B	B	B	C	C	
Weights	0,171	0,096	0,101	0,080	0,214	0,088	0,168	0,083	
Alternatives / Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	21,288	77,699	3,061	19,277	45,529	103,636	6,868	0,316	
A2	21,650	59,149	0,995	4,607	65,483	64,866	10,094	2,805	
A3	15,196	63,728	2,189	10,202	54,346	39,856	2,061	4,038	
A4	15,676	74,937	1,414	10,758	71,941	58,521	3,890	2,664	
Min.	15,196	59,149	0,995	4,607	45,529	39,856	2,061	0,316	
Max.	21,650	77,699	3,061	19,277	71,941	103,636	10,094	4,038	
Max. - Min	6,453	18,550	2,066	14,669	26,412	63,780	8,033	3,722	
Normalized Decision Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
Reference	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
A1	0,944	1,000	1,000	1,000	0,000	1,000	0,402	1,000	
A2	1,000	0,000	0,000	0,000	0,756	0,392	0,000	0,332	
A3	0,000	0,247	0,578	0,381	0,334	0,000	1,000	0,000	
A4	0,074	0,851	0,202	0,419	1,000	0,293	0,772	0,369	
Absolute Value (difference) Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,056	0,000	0,000	0,000	1,000	0,000	0,599	0,000	
A2	0,000	1,000	1,000	1,000	0,245	0,608	1,000	0,669	
A3	1,000	0,753	0,422	0,619	0,666	1,000	0,000	1,000	
A4	0,926	0,149	0,798	0,581	0,000	0,707	0,228	0,631	
Calculation of GRA Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,899	1,000	1,000	1,000	0,333	1,000	0,455	1,000	
A2	1,000	0,333	0,333	0,333	0,672	0,451	0,333	0,428	
A3	0,333	0,399	0,542	0,447	0,429	0,333	1,000	0,333	
A4	0,351	0,771	0,385	0,463	1,000	0,414	0,687	0,442	
$\Delta \max$	1,000								
$\Delta \min$	0,000								
n(gc)	0,500								
GRA Coefficients and Alternative Ranking Without Consideration of Significance Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,899	1,000	1,000	1,000	0,333	1,000	0,455	1,000	0,836
A2	1,000	0,333	0,333	0,333	0,672	0,451	0,333	0,428	0,486
A3	0,333	0,399	0,542	0,447	0,429	0,333	1,000	0,333	0,477
A4	0,351	0,771	0,385	0,463	1,000	0,414	0,687	0,442	0,564
Ranking Considering Importance Weights									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,899	1,000	1,000	1,000	0,333	1,000	0,455	1,000	0,749
A2	1,000	0,333	0,333	0,333	0,672	0,451	0,333	0,428	0,538
A3	0,333	0,399	0,542	0,447	0,429	0,333	1,000	0,333	0,502
A4	0,351	0,771	0,385	0,463	1,000	0,414	0,687	0,442	0,611

Appendix 8. GRA method results for 2020 (Equal Weighting)

Directions	B	B	B	B	B	B	C	C	
Weights	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125	
Alternatives / Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	21,288	77,699	3,061	19,277	45,529	103,636	6,868	0,316	
A2	21,650	59,149	0,995	4,607	65,483	64,866	10,094	2,805	
A3	15,196	63,728	2,189	10,202	54,346	39,856	2,061	4,038	
A4	15,676	74,937	1,414	10,758	71,941	58,521	3,890	2,664	
Min.	15,196	59,149	0,995	4,607	45,529	39,856	2,061	0,316	
Max.	21,650	77,699	3,061	19,277	71,941	103,636	10,094	4,038	
Max. - Min	6,453	18,550	2,066	14,669	26,412	63,780	8,033	3,722	
Normalized Decision Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
References	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
A1	0,944	1,000	1,000	1,000	0,000	1,000	0,402	1,000	
A2	1,000	0,000	0,000	0,000	0,756	0,392	0,000	0,332	
A3	0,000	0,247	0,578	0,381	0,334	0,000	1,000	0,000	
A4	0,074	0,851	0,202	0,419	1,000	0,293	0,772	0,369	
Absolute Value (difference) Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,056	0,000	0,000	0,000	1,000	0,000	0,599	0,000	
A2	0,000	1,000	1,000	1,000	0,245	0,608	1,000	0,669	
A3	1,000	0,753	0,422	0,619	0,666	1,000	0,000	1,000	
A4	0,926	0,149	0,798	0,581	0,000	0,707	0,228	0,631	
Calculation of GRA Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,899	1,000	1,000	1,000	0,333	1,000	0,455	1,000	
A2	1,000	0,333	0,333	0,333	0,672	0,451	0,333	0,428	
A3	0,333	0,399	0,542	0,447	0,429	0,333	1,000	0,333	
A4	0,351	0,771	0,385	0,463	1,000	0,414	0,687	0,442	
$\Delta \max$	1,000								
$\Delta \min$	0,000								
n(gc)	0,500								
GRA Coefficients and Alternative Ranking Without Consideration of Significance Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,899	1,000	1,000	1,000	0,333	1,000	0,455	1,000	0,836
A2	1,000	0,333	0,333	0,333	0,672	0,451	0,333	0,428	0,486
A3	0,333	0,399	0,542	0,447	0,429	0,333	1,000	0,333	0,477
A4	0,351	0,771	0,385	0,463	1,000	0,414	0,687	0,442	0,564
Ranking Considering Importance Weights									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,899	1,000	1,000	1,000	0,333	1,000	0,455	1,000	0,836
A2	1,000	0,333	0,333	0,333	0,672	0,451	0,333	0,428	0,486
A3	0,333	0,399	0,542	0,447	0,429	0,333	1,000	0,333	0,477
A4	0,351	0,771	0,385	0,463	1,000	0,414	0,687	0,442	0,564

Appendix 9. SAW method results for 2020 (CRITIC Weighting)

Directions	Max	Max	Max	Max	Max	Max	Min	Min
Weights	0,171	0,096	0,101	0,080	0,214	0,088	0,168	0,083
Alternatives / Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	21,288	77,699	3,061	19,277	45,529	103,636	6,868	0,316
A2	21,650	59,149	0,995	4,607	65,483	64,866	10,094	2,805
A3	15,196	63,728	2,189	10,202	54,346	39,856	2,061	4,038
A4	15,676	74,937	1,414	10,758	71,941	58,521	3,890	2,664
Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,983	1,000	1,000	1,000	0,633	1,000	0,300	1,000
A2	1,000	0,761	0,325	0,239	0,910	0,626	0,204	0,113
A3	0,702	0,820	0,715	0,529	0,755	0,385	1,000	0,078
A4	0,724	0,964	0,462	0,558	1,000	0,564	0,527	0,119
Weighting of Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,168	0,096	0,101	0,080	0,135	0,088	0,050	0,083
A2	0,171	0,073	0,033	0,019	0,194	0,055	0,034	0,009
A3	0,120	0,079	0,072	0,043	0,161	0,034	0,168	0,007
A4	0,124	0,093	0,047	0,045	0,214	0,049	0,089	0,010
Si	Si%	Rank						
0,801	0,292	1						
0,589	0,215	4						
0,683	0,249	2						
0,670	0,244	3						

Appendix 10. SAW method results for 2020 (Equal Weighting)

Weighting of Normalized Decision Matrix								
Directions	Max	Max	Max	Max	Max	Max	Min	Min
Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
Weights	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125
A1	0,123	0,125	0,125	0,125	0,079	0,125	0,038	0,125
A2	0,125	0,095	0,041	0,030	0,114	0,078	0,026	0,014
A3	0,088	0,103	0,089	0,066	0,094	0,048	0,125	0,010
A4	0,091	0,121	0,058	0,070	0,125	0,071	0,066	0,015
Si	Si%	Rank						
0,865	0,329	1						
0,522	0,199	4						
0,623	0,237	2						
0,615	0,234	3						

Note: In the analyses performed using the Critic Weighting and Equal Weighting methods within the SAW model, the results diverge solely in the 'Weighting of Normalized Decision Matrix' step. To prevent redundancy, repeated results have not been included in Appendix 10, as they are already presented in Appendix 9.

Appendix 11. Application of the CRITIC Method for 2021

Directions	B	B	B	B	B	B	C	C
Alternatives/ Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	19,300	75,614	4,229	30,646	57,694	50,526	3,318	2,026
A2	19,188	63,389	1,276	6,458	63,222	71,272	10,819	5,188
A3	14,616	45,881	1,346	6,103	49,032	46,916	5,130	6,034
A4	14,999	79,520	1,665	13,337	65,643	84,647	2,976	5,461
Min	14,616	45,881	1,276	6,103	49,032	46,916	2,976	2,026
Max	19,300	79,520	4,229	30,646	65,643	84,647	10,819	6,034
Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	1,000	0,884	1,000	1,000	0,522	0,096	0,956	1,000
A2	0,976	0,521	0,000	0,015	0,854	0,646	0,000	0,211
A3	0,000	0,000	0,024	0,000	0,000	0,000	0,725	0,000
A4	0,082	1,000	0,132	0,295	1,000	1,000	1,000	0,143
Correlation Coefficient Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
TIER1	1,000	0,320	0,530	0,474	0,295	-0,114	-0,449	0,705
PRO	0,320	1,000	0,498	0,631	0,798	0,587	0,374	0,532
ROA	0,530	0,498	1,000	0,984	-0,052	-0,408	0,499	0,974
ROE	0,474	0,631	0,984	1,000	0,082	-0,257	0,574	0,953
IM	0,295	0,798	-0,052	0,082	1,000	0,903	-0,153	0,068
LA	-0,114	0,587	-0,408	-0,257	0,903	1,000	-0,116	-0,337
NPL	-0,449	0,374	0,499	0,574	-0,153	-0,116	1,000	0,307
OFX	0,705	0,532	0,974	0,953	0,068	-0,337	0,307	1,000
(1-p _{jk}) Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
TIER1	0,000	0,680	0,470	0,526	0,706	1,114	1,449	0,295
PRO	0,680	0,000	0,502	0,369	0,203	0,413	0,626	0,468
ROA	0,470	0,502	0,000	0,016	1,052	1,408	0,501	0,026
ROE	0,526	0,369	0,016	0,000	0,918	1,257	0,426	0,048
IM	0,706	0,203	1,052	0,918	0,000	0,097	1,153	0,932
LA	1,114	0,413	1,408	1,257	0,097	0,000	1,116	1,337
NPL	1,449	0,626	0,501	0,426	1,153	1,116	0,000	0,693
OFX	0,295	0,468	0,026	0,048	0,932	1,337	0,693	0,000
σ_j	0,548	0,450	0,478	0,469	0,444	0,472	0,463	0,450
C_j	2,871	1,466	1,898	1,668	2,245	3,180	2,761	1,708
w_j	0,161	0,082	0,107	0,094	0,126	0,179	0,155	0,096

Note: B: Benefit, C: Cost

Appendix 12. GRA method results for 2021 (CRITIC Weighting)

Directions	B	B	B	B	B	B	C	C	
Weights	0,161	0,082	0,107	0,094	0,126	0,179	0,155	0,096	
Alternatives / Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	19,300	75,614	4,229	30,646	57,694	50,526	3,318	2,026	
A2	19,188	63,389	1,276	6,458	63,222	71,272	10,819	5,188	
A3	14,616	45,881	1,346	6,103	49,032	46,916	5,130	6,034	
A4	14,999	79,520	1,665	13,337	65,643	84,647	2,976	5,461	
Min.	14,616	45,881	1,276	6,103	49,032	46,916	2,976	2,026	
Max.	19,300	79,520	4,229	30,646	65,643	84,647	10,819	6,034	
Max. - Min	4,685	33,639	2,953	24,543	16,611	37,731	7,843	4,008	
Normalized Decision Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
Reference	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
A1	1,000	0,884	1,000	1,000	0,522	0,096	0,956	1,000	
A2	0,976	0,521	0,000	0,015	0,854	0,646	0,000	0,211	
A3	0,000	0,000	0,024	0,000	0,000	0,000	0,725	0,000	
A4	0,082	1,000	0,132	0,295	1,000	1,000	1,000	0,143	
Absolute Value (difference) Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,000	0,116	0,000	0,000	0,479	0,904	0,044	0,000	
A2	0,024	0,480	1,000	0,986	0,146	0,355	1,000	0,789	
A3	1,000	1,000	0,976	1,000	1,000	1,000	0,275	1,000	
A4	0,918	0,000	0,868	0,705	0,000	0,000	0,000	0,857	
Calculation of GRA Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	1,000	0,812	1,000	1,000	0,511	0,356	0,920	1,000	
A2	0,954	0,510	0,333	0,337	0,774	0,585	0,333	0,388	
A3	0,333	0,333	0,339	0,333	0,333	0,333	0,645	0,333	
A4	0,3525	1,000	0,365	0,415	1,000	1,000	1,000	0,369	
Δ max	1,000								
Δ min	0,000								
n(gc)	0,500								
GRA Coefficients and Alternative Ranking Without Consideration of Significance Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	1,000	0,812	1,000	1,000	0,511	0,356	0,920	1,000	0,825
A2	0,954	0,510	0,333	0,337	0,774	0,585	0,333	0,388	0,527
A3	0,333	0,333	0,339	0,333	0,333	0,333	0,645	0,333	0,373
A4	0,3525	1,000	0,365	0,415	1,000	1,000	1,000	0,369	0,688
Ranking Considering Importance Weights									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	1,000	0,812	1,000	1,000	0,511	0,356	0,920	1,000	0,795
A2	0,954	0,510	0,333	0,337	0,774	0,585	0,333	0,388	0,554
A3	0,333	0,333	0,339	0,333	0,333	0,333	0,645	0,333	0,382
A4	0,3525	1,000	0,365	0,415	1,000	1,000	1,000	0,369	0,712

Appendix 13. GRA method results for 2021 (Equal Weighting)

Directions	B	B	B	B	B	B	C	C	
Weights	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125	
Alternatives / Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	19,300	75,614	4,229	30,646	57,694	50,526	3,318	2,026	
A2	19,188	63,389	1,276	6,458	63,222	71,272	10,819	5,188	
A3	14,616	45,881	1,346	6,103	49,032	46,916	5,130	6,034	
A4	14,999	79,520	1,665	13,337	65,643	84,647	2,976	5,461	
Min.	14,616	45,881	1,276	6,103	49,032	46,916	2,976	2,026	
Max.	19,300	79,520	4,229	30,646	65,643	84,647	10,819	6,034	
Max. - Min	4,685	33,639	2,953	24,543	16,611	37,731	7,843	4,008	
Normalized Decision Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
Reference	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
A1	1,000	0,884	1,000	1,000	0,522	0,096	0,956	1,000	
A2	0,976	0,521	0,000	0,015	0,854	0,646	0,000	0,211	
A3	0,000	0,000	0,024	0,000	0,000	0,000	0,725	0,000	
A4	0,082	1,000	0,132	0,295	1,000	1,000	1,000	0,143	
Absolute Value (difference) Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,000	0,116	0,000	0,000	0,479	0,904	0,044	0,000	
A2	0,024	0,480	1,000	0,986	0,146	0,355	1,000	0,789	
A3	1,000	1,000	0,976	1,000	1,000	1,000	0,275	1,000	
A4	0,918	0,000	0,868	0,705	0,000	0,000	0,000	0,857	
Calculation of GRA Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	1,000	0,812	1,000	1,000	0,511	0,356	0,920	1,000	
A2	0,954	0,510	0,333	0,337	0,774	0,585	0,333	0,388	
A3	0,333	0,333	0,339	0,333	0,333	0,333	0,645	0,333	
A4	0,3525	1,000	0,365	0,415	1,000	1,000	1,000	0,369	
Δ max	1,000								
Δ min	0,000								
n(gc)	0,500								
GRA Coefficients and Alternative Ranking Without Consideration of Significance Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	1,000	0,812	1,000	1,000	0,511	0,356	0,920	1,000	0,825
A2	0,954	0,510	0,333	0,337	0,774	0,585	0,333	0,388	0,527
A3	0,333	0,333	0,339	0,333	0,333	0,333	0,645	0,333	0,373
A4	0,3525	1,000	0,365	0,415	1,000	1,000	1,000	0,369	0,688
Ranking Considering Importance Weights									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	1,000	0,812	1,000	1,000	0,511	0,356	0,920	1,000	0,825
A2	0,954	0,510	0,333	0,337	0,774	0,585	0,333	0,388	0,527
A3	0,333	0,333	0,339	0,333	0,333	0,333	0,645	0,333	0,373
A4	0,3525	1,000	0,365	0,415	1,000	1,000	1,000	0,369	0,688

Appendix 14. SAW method results for 2021 (CRITIC Weighting)

Directions	Max	Max	Max	Max	Max	Max	Min	Min
Weights	0,161	0,082	0,107	0,094	0,126	0,179	0,155	0,096
Alternatives / Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	19,300	75,614	4,229	30,646	57,694	50,526	3,318	2,026
A2	19,188	63,389	1,276	6,458	63,222	71,272	10,819	5,188
A3	14,616	45,881	1,346	6,103	49,032	46,916	5,130	6,034
A4	14,999	79,520	1,665	13,337	65,643	84,647	2,976	5,461
Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	1,000	0,951	1,000	1,000	0,879	0,597	0,897	1,000
A2	0,994	0,797	0,302	0,211	0,963	0,842	0,275	0,391
A3	0,757	0,577	0,318	0,199	0,747	0,554	0,580	0,336
A4	0,777	1,000	0,394	0,435	1,000	1,000	1,000	0,371
Weighting of Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,161	0,078	0,107	0,094	0,111	0,107	0,139	0,096
A2	0,160	0,066	0,032	0,020	0,122	0,150	0,043	0,037
A3	0,122	0,048	0,034	0,019	0,094	0,099	0,090	0,032
A4	0,125	0,082	0,042	0,041	0,126	0,179	0,155	0,036
Si	Si%	Rank						
0,893	0,314	1						
0,630	0,221	3						
0,538	0,189	4						
0,786	0,276	2						

Appendix 15. SAW method results for 2021 (Equal Weighting)

Weighting of Normalized Decision Matrix								
Directions	Max	Max	Max	Max	Max	Max	Min	Min
Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
Weights	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125
A1	0,125	0,119	0,125	0,125	0,110	0,075	0,112	0,125
A2	0,124	0,100	0,038	0,026	0,120	0,105	0,034	0,049
A3	0,095	0,072	0,040	0,025	0,093	0,069	0,073	0,042
A4	0,097	0,125	0,049	0,054	0,125	0,125	0,125	0,046
Si	Si%	Rank						
0,915	0,331	1						
0,597	0,216	3						
0,509	0,184	4						
0,747	0,270	2						

Note: In the analyses performed using the Critic Weighting and Equal Weighting methods within the SAW model, the results diverge solely in the 'Weighting of Normalized Decision Matrix' step. To prevent redundancy, repeated results have not been included in Appendix 15, as they are already presented in Appendix 14.

Appendix 16. Application of the CRITIC Method for 2022

Directions	B	B	B	B	B	B	C	C
Alternatives/ Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	18,556	76,898	4,197	30,723	61,520	47,034	3,365	0,514
A2	19,166	67,260	6,390	32,617	35,365	82,786	12,455	2,658
A3	14,486	46,637	2,529	13,344	42,135	47,309	3,532	1,695
A4	16,794	86,701	4,904	37,875	66,525	90,865	1,979	3,120
Min	14,486	46,637	2,529	13,344	35,365	47,034	1,979	0,514
Max	19,166	86,701	6,390	37,875	66,525	90,864	12,455	3.120
Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,870	0,755	0,432	0,708	0,839	0,000	0,868	1,000
A2	1,000	0,515	1,000	0,786	0,000	0,816	0,000	0,177
A3	0,000	0,000	0,000	0,000	0,217	0,006	0,852	0,547
A4	0,493	1,000	0,615	1,000	1,000	1,000	1,000	0,000
Correlation Coefficient Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
TIER1	1,000	0,563	0,841	0,723	0,013	0,328	-0,582	0,048
PRO	0,563	1,000	0,553	0,943	0,757	0,571	0,191	-0,233
ROA	0,841	0,553	1,000	0,797	-0,125	0,758	-0,704	-0,497
ROE	0,723	0,943	0,797	1,000	0,499	0,735	-0,136	-0,395
IM	0,013	0,757	-0,125	0,499	1,000	0,085	0,779	0,113
LA	0,328	0,571	0,758	0,735	0,085	1,000	-0,322	-0,910
NPL	-0,582	0,191	-0,704	-0,136	0,779	-0,322	1,000	0,266
OFX	0,048	-0,233	-0,496	-0,395	0,113	-0,910	0,266	1,000
(1-p _{jk}) Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
TIER1	0,000	0,437	0,159	0,277	0,987	0,672	1,582	0,953
PRO	0,437	0,000	0,447	0,057	0,243	0,429	0,809	1,233
ROA	0,159	0,447	0,000	0,203	1,125	0,242	1,704	1,496
ROE	0,277	0,057	0,203	0,000	0,501	0,265	1,136	1,395
IM	0,987	0,243	1,125	0,501	0,000	0,915	0,221	0,888
LA	0,672	0,429	0,242	0,265	0,915	0,000	1,322	1,910
NPL	1,582	0,809	1,704	1,136	0,221	1,322	0,000	0,735
OFX	0,953	1,233	1,496	1,395	0,888	1,910	0,735	0,000
σ_j	0,449	0,427	0,415	0,434	0,481	0,528	0,458	0,443
C_j	2,273	1,560	2,232	1,662	2,347	3,037	3,439	3,809
w_j	0,112	0,077	0,110	0,082	0,115	0,149	0,169	0,187

Note: B: Benefit, C: Cost

Appendix 17. GRA method results for 2022 (CRITIC Weighting)

Directions	B	B	B	B	B	B	C	C	
Weights	0,116	0,077	0,110	0,082	0,115	0,149	0,169	0,187	
Alternatives / Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	18,556	76,898	4,197	30,723	61,520	47,034	3,365	0,514	
A2	19,166	67,260	6,390	32,617	35,365	82,786	12,455	2,658	
A3	14,486	46,637	2,529	13,344	42,135	47,309	3,532	1,695	
A4	16,794	86,701	4,904	37,875	66,525	90,865	1,979	3,120	
Min.	14,486	46,637	2,529	13,344	35,365	47,034	1,979	0,514	
Max.	19,166	86,701	6,390	37,875	66,525	90,864	12,455	3,120	
Max. - Min	4,680	40,064	3,861	24,531	31,160	43,831	10,476	2,606	
Normalized Decision Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
Reference	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
A1	0,870	0,755	0,432	0,708	0,839	0,000	0,868	1,000	
A2	1,000	0,515	1,000	0,786	0,000	0,816	0,000	0,177	
A3	0,000	0,000	0,000	0,000	0,217	0,006	0,852	0,547	
A4	0,493	1,000	0,615	1,000	1,000	1,000	1,000	0,000	
Absolute Value (difference) Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,130	0,245	0,568	0,292	0,161	1,000	0,132	0,000	
A2	0,000	0,485	0,000	0,214	1,000	0,184	1,000	0,823	
A3	1,000	1,000	1,000	1,000	0,783	0,994	0,148	0,453	
A4	0,507	0,000	0,385	0,000	0,000	0,000	0,000	1,000	
Calculation of GRA Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,793	0,671	0,468	0,632	0,757	0,333	0,791	1,000	
A2	1,000	0,508	1,000	0,700	0,333	0,731	0,333	0,378	
A3	0,333	0,333	0,333	0,333	0,390	0,335	0,771	0,525	
A4	0,497	1,000	0,565	1,000	1,000	1,000	1,000	0,333	
$\Delta \max$	1,000								
$\Delta \min$	0,000								
n(gc)	0,500								
GRA Coefficients and Alternative Ranking Without Consideration of Significance Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,793	0,671	0,468	0,632	0,757	0,333	0,791	1,000	0,681
A2	1,000	0,508	1,000	0,700	0,333	0,731	0,333	0,378	0,623
A3	0,333	0,333	0,333	0,333	0,390	0,335	0,771	0,525	0,419
A4	0,497	1,000	0,565	1,000	1,000	1,000	1,000	0,333	0,799
Ranking Considering Importance Weights									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,793	0,671	0,468	0,632	0,757	0,333	0,791	1,000	0,701
A2	1,000	0,508	1,000	0,700	0,333	0,731	0,333	0,378	0,592
A3	0,333	0,333	0,333	0,333	0,390	0,335	0,771	0,525	0,450
A4	0,497	1,000	0,565	1,000	1,000	1,000	1,000	0,333	0,771

Appendix 18. GRA method results for 2022 (Equal Weighting)

Directions	B	B	B	B	B	B	C	C	
Weights	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125	
Alternatives / Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	18,556	76,898	4,197	30,723	61,520	47,034	3,365	0,514	
A2	19,166	67,260	6,390	32,617	35,365	82,786	12,455	2,658	
A3	14,486	46,637	2,529	13,344	42,135	47,309	3,532	1,695	
A4	16,794	86,701	4,904	37,875	66,525	90,865	1,979	3,120	
Min.	14,486	46,637	2,529	13,344	35,365	47,034	1,979	0,514	
Max.	19,166	86,701	6,390	37,875	66,525	90,864	12,455	3,120	
Max. - Min	4,680	40,064	3,861	24,531	31,160	43,831	10,476	2,606	
Normalized Decision Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
Reference	1,000	1,000	1,000	1,000	1,000	1,000	1,000	1,000	
A1	0,870	0,755	0,432	0,708	0,839	0,000	0,868	1,000	
A2	1,000	0,515	1,000	0,786	0,000	0,816	0,000	0,177	
A3	0,000	0,000	0,000	0,000	0,217	0,006	0,852	0,547	
A4	0,493	1,000	0,615	1,000	1,000	1,000	1,000	0,000	
Absolute Value (difference) Matrix									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,130	0,245	0,568	0,292	0,161	1,000	0,132	0,000	
A2	0,000	0,485	0,000	0,214	1,000	0,184	1,000	0,823	
A3	1,000	1,000	1,000	1,000	0,783	0,994	0,148	0,453	
A4	0,507	0,000	0,385	0,000	0,000	0,000	0,000	1,000	
Calculation of GRA Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	
A1	0,793	0,671	0,468	0,632	0,757	0,333	0,791	1,000	
A2	1,000	0,508	1,000	0,700	0,333	0,731	0,333	0,378	
A3	0,333	0,333	0,333	0,333	0,390	0,335	0,771	0,525	
A4	0,497	1,000	0,565	1,000	1,000	1,000	1,000	0,333	
$\Delta \max$	1,000								
$\Delta \min$	0,000								
n(gc)	0,500								
GRA Coefficients and Alternative Ranking Without Consideration of Significance Coefficients									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,793	0,671	0,468	0,632	0,757	0,333	0,791	1,000	0,681
A2	1,000	0,508	1,000	0,700	0,333	0,731	0,333	0,378	0,623
A3	0,333	0,333	0,333	0,333	0,390	0,335	0,771	0,525	0,419
A4	0,497	1,000	0,565	1,000	1,000	1,000	1,000	0,333	0,799
Ranking Considering Importance Weights									
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX	R _{oi}
A1	0,793	0,671	0,468	0,632	0,757	0,333	0,791	1,000	0,681
A2	1,000	0,508	1,000	0,700	0,333	0,731	0,333	0,378	0,623
A3	0,333	0,333	0,333	0,333	0,390	0,335	0,771	0,525	0,419
A4	0,497	1,000	0,565	1,000	1,000	1,000	1,000	0,333	0,799

Appendix 19. SAW method results for 2022 (CRITIC Weighting)

Directions	Max	Max	Max	Max	Max	Max	Min	Min
Weights	0,111	0,077	0,110	0,082	0,115	0,149	0,169	0,187
Alternatives / Criteria	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	18,556	76,898	4,197	30,723	61,520	47,034	3,365	0,514
A2	19,166	67,260	6,390	32,617	35,365	82,786	12,455	2,658
A3	14,486	46,637	2,529	13,344	42,135	47,309	3,532	1,695
A4	16,794	86,701	4,904	37,875	66,525	90,865	1,979	3,120
Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,968	0,887	0,657	0,811	0,925	0,518	0,588	1,000
A2	1,000	0,776	1,000	0,861	0,532	0,911	0,159	0,193
A3	0,756	0,538	0,396	0,352	0,633	0,521	0,560	0,303
A4	0,876	1,000	0,767	1,000	1,000	1,000	1,000	0,165
Weighting of Normalized Decision Matrix								
	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,108	0,068	0,072	0,066	0,107	0,077	0,099	0,187
A2	0,112	0,059	0,110	0,070	0,061	0,136	0,027	0,036
A3	0,084	0,041	0,043	0,029	0,073	0,078	0,095	0,057
A4	0,098	0,077	0,084	0,082	0,115	0,149	0,169	0,031
Si	Si%	Rank						
0,785	0,291	2						
0,611	0,226	3						
0,500	0,185	4						
0,804	0,298	1						

Appendix 20. SAW method results for 2022 (Equal Weighting)

Weighting of Normalized Decision Matrix								
Directions	Max	Max	Max	Max	Max	Max	Min	Min
Criteria	0,125	0,125	0,125	0,125	0,125	0,125	0,125	0,125
Weights	TIER1	PRO	ROA	ROE	IM	LA	NPL	OFX
A1	0,121	0,111	0,082	0,101	0,116	0,065	0,074	0,125
A2	0,125	0,097	0,125	0,108	0,066	0,114	0,020	0,024
A3	0,094	0,067	0,049	0,044	0,079	0,065	0,070	0,038
A4	0,110	0,125	0,096	0,125	0,125	0,125	0,125	0,021
Si	Si%	Rank						
0,794	0,280	2						
0,679	0,240	3						
0,507	0,179	4						
0,851	0,301	1						

Note: In the analyses performed using the Critic Weighting and Equal Weighting methods within the SAW model, the results diverge solely in the 'Weighting of Normalized Decision Matrix' step. To prevent redundancy, repeated results have not been included in Appendix 20, as they are already presented in Appendix 19.

The Effect of Environmental Concern and Brand Hate on Purchase Intention: Mediating Role of Greenwashing and Moderating Role of Consumer Captivity in Airline Industry

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ABSTRACT

This research examines the impacts of greenwashing (GW) and brand hate (BH) on purchase intention (PI) in the airline sector. It addresses Turkish consumers with an airline transportation purchase experience. Based on the data set of 445 respondents from an online survey, the observations demonstrate that BH partially mediates the relationship between GW and PI; GW and BH negatively affect PI. Therefore, our study suggests that airlines eliminate their GW behaviors and diminish or moderate their BH to improve their consumers' PI. Airlines need to understand how greenwashing contributes to brand hate, which in turn influences the purchase intentions of their consumers.

The hypothesized relationships were confirmed, and the model proposed in this paper is applicable. The findings indicate that BH is a partial mediator between GW and PI. This research enhances current knowledge by assessing GW, BH, and BH as mediators of GW and PI in the air transportation of Turkish passengers.

Keywords: Greenwashing, Brand Hate, Purchase Intention.

JEL Classification Codes: M30, M3

Referencing Style: APA 7

INTRODUCTION

The climate crisis, carbon footprints, increasing global warming, and air pollution have caused consumers to worry about environmental issues. Regulatory authorities like IATA (International Air Transport Association), the UN (United Nations), non-governmental environmental organizations, and consumers' environmental concerns exert pressure on airlines.

As a member state of ICAO (The International Civil Aviation Organization), IATA, and the UN, Türkiye has initiated carbon offset programs in the airline sector. Airlines use claims about sustainability, eco-friendliness, greener choices, and carbon offset offerings, and conduct programs to manage environmental impacts. These programs will attract consumers' environmental concerns. Despite airlines' degradation of the environment and their becoming more environmentally conscious, consumers still desire air travel because of its relevance to vacation and freedom.

Airlines use so-called greenwashing strategies to conceal or deemphasize the negative environmental

effects of flying (de Freitas Netto et al., 2020) while publishing their pro-environmental performance when confronted with the normative pressure of society (Naderer et al., 2017).

Studies on airline passengers' attitudes and behavior toward green practices are under-researched, limited, and require further investigation (Wong et al., 2020). Aziz & Rahman (2022) compel scholars to investigate brand hate in various contexts, such as products, services, and cultural dimensions. Greenwashing, concerned consumers, or social decision-making (Santos et al., 2024) has become popular among marketing scholars. However, greenwashing has not been studied much concerning environmentally harmful services such as airlines (Neureiter & Matthes, 2023).

These research gaps are addressed in this study by investigating airline passengers' greenwashing perceptions of purchase intention through brand hate. Our study makes this contribution by studying air transport services purchased by Turkish consumers. Airlines can gain significant advantages by understanding passengers' attitudes and behaviors regarding

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sustainable practices. This insight can inform the creation of marketing strategies to promote environmental conservation efforts while appealing to environmentally conscious travelers (Wong et al., 2020).

We will cover the literature review, methodology, analysis, conclusion, constraints of the study, and recommendations for further studies in the respective order.

LITERATURE REVIEW

Purchase Intention

Research indicates that individuals seeking an environmentally sustainable society and lifestyle are more inclined to purchase green services. As environmental concerns become more important to consumers, they increasingly replace traditional purchases with environmentally friendly options. Consumers' decisions on green purchasing are directed by their understanding of the connection between consumption behavior and environmental degradation (Kumar & Ghodeswar, 2015). Schultz (2001) proposed that concern for the biosphere is one of the correlated factors contributing to environmental concern. Consumers lean toward green purchases due to the harmful effects of consumption (McIntosh, 1991). As consumers become more conscious, their intention for green purchases may increase. However, ecological awareness may not always lead to green consumption. Consumers do not prioritize environmental concerns over other product features (Ginsberg & Bloom, 2004). A consumer with a positive attitude toward air transportation who can afford the service may still avoid purchasing due to environmental concerns, or vice versa. All the constraints, like cost, convenience of location, service loss, service consumption linked to a friend or relative, the nature of the service, and the lack of alternatives, may cause consumers to acquire the services without questioning their environmental friendliness.

Mainieri et al. (1997) suggested that consumer beliefs affect environmentally conscious consumerism more than demographics, confusion over environmental marketing claims, and participation in other pro-environment behaviors. Airline passengers now question "sustainable," "eco-responsible," and "green" advertising as being "carbon neutral", encouraging the payment of premiums for carbon offsetting and charging to contribute to the development of "sustainable aviation fuels," even though the real case is very different.

Some authors have argued that environmental concerns can strongly influence individuals' motivation to change their behaviors to address ecological issues (Mostafa, 2007). However, consumers facing the bulk of ambiguous information may have difficulty identifying sustainable products or services (Chen & Chang, 2013). The false environmental attributes can be construed as asymmetric information signals by airlines to recipient flyers. This may lead to skepticism regarding the performance and functionality of such products and services, and reluctance to budget more towards them.

Greenwashing

Greenwashing has been described as misleading environmental communication (Lyon & Montgomery, 2015) and making deceptive or exaggerated claims about environmentalism in advertisements while performing minimal actual environmental efforts (Delmas & Burbano, 2011). Global warming affects airlines' communications about their ecological practices and consumers' environmental concerns (Santos et al., 2024). Airlines may exaggerate and mislead communication to give an environmentally friendly impression (Delmas & Burbano, 2011).

The expectancy violations theory (EVT) posits that companies may face severe consequences for violating consumers' high-level expectations with negative information (Sohn & Lariscy, 2015). Depending on how a consumer evaluates the violation, in our case, the greenwashing attempt, the airline receives approval or disapproval (Burgoon, 2015). Consumers' expectations of ethical acting, responsibility, and honesty shape their perceptions, information processing, and subsequent behavior. The evaluation of environmental marketing claims may change the positive perceptions about brands to negative ones. These negative perceptions may influence consumers' feelings for the brand. Consumers' environmental expectations through greenwashing may lead to brand hate towards airlines.

Romani et al. (2012) state that consumers are exposed to different triggers about brands controlled by marketers or others. Delmas & Burbano (2011) identified the drivers of greenwashing at non-market external, market external, and organizational levels by employing the institutional theory framework. Non-market drivers include the regulatory and monitoring environment, such as laws, regulations, sanctions, NGOs, environmental activists, and media pressure, which shape firms' policies towards greenwashing. Market drivers encompass consumer and investor demands and competitive pressure.

As member states of ICAO, IATA, and the UN, commercial airlines have started implementing carbon reduction practices in Türkiye. In the aviation sector, regulatory authorities like IATA and the UN, along with non-governmental environmental organizations and consumers' environmental concerns, exert pressure on airlines, unintentionally leading them to engage in greenwashing.

From a consumer psychology perspective, perceived greenwashing refers to consumers' skepticism about the discrepancy between a company's promises and practices for a contribution to a sustainable environment (Nyilasy et al., 2014). Lyon & Montgomery (2015) stated that as consumers become more aware of corporate environmental claims, they become more suspicious. When consumers find environmental claims unreliable, they may disregard all environmental claims to avoid being misled. Consumers develop a brand aversion, and their purchase intention for sustainable services changes adversely. Consequently, their brand love may be damaged.

Thus, the hypothesized relationships are:

H1: Greenwashing positively influences brand hate.

H2: Greenwashing negatively influences purchase intention.

Brand Hate

Hate is an emotional response triggered by a breach of moral principles (Sternberg, 2003). The determinants for brand hate are classified threefold by Hegner et al. (2017). The first classification is for products and services representing failures, dissatisfaction, or unfavorable associations. Carbon emissions by air transportation can be considered product-related antecedents of brand hate. When the brand's image conflicts with the consumer's desired identity, as greenwashing demonstrates,

consumers experience a symbolic incongruity with the brand, which causes consumer-related classification. Negative feelings and distance from a brand may arise from a non-compliance between the brand's image, values, ethics, and consumers. Airlines' greenwashing efforts may not match consumers' environmental concerns. Greenwashing may cause brand hate as an adverse behavioral outcome (Santos et al., 2024).

The third classification is for contextual factors. This classification stems from perceived ideological mismatches with the brand due to corporate misconduct and can be exemplified by environmentally conscious consumers' negative sentiments toward greenwashing. Consumers prefer brands to attain objectives like environmental protection. In case of greenwashing, consumers may demonstrate their brand hate by avoidance behavior (Curina et al., 2020).

Attachment and aversion were explained by Park et al. (2013) as a means of self-expansion and self-contraction in the Attachment-Aversion Relationship (AAR) Model. Attachment, with a strong connection and closeness to a brand, provides personal growth; aversion, on the other hand, creates a distance from a brand.

Consumers' perceptions of airlines engaged in greenwashing may influence their attitudes toward airline brands as passengers. Passengers review their purchase intentions, comparing airlines' environmental efforts against their environmental concerns. The incongruity resulting from this comparison may affect the degree of avoidance or attachment.

The next hypotheses of our research are:

H3: Brand hate negatively influences purchase intention.

H4: Brand hate is a mediator between greenwashing and purchase intention.

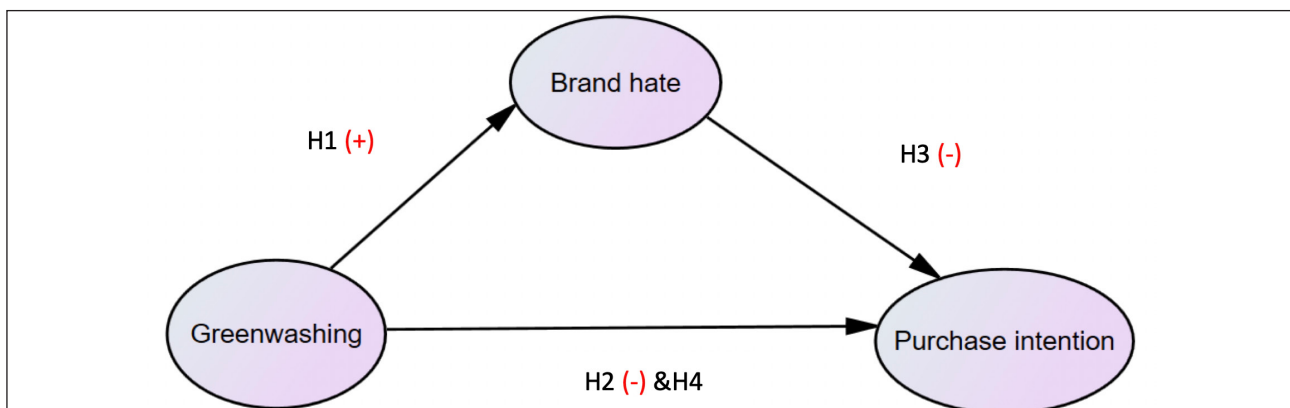


Figure 1: The hypothesis of the research model

Table 1: Demographics and other statistics of participants

Demographics

	Categories	Frequency (N=445)	Percentage (%)
Age	over 65	6	1.35
	61-65	3	.70
	56-60	10	2.20
	51-55	16	3.60
	41-50	72	16.20
	31-40	155	34.80
	26-30	86	19.30
	18-25	96	21.60
	under 18	1	.20
Gender	Female	230	51.7
	Male	214	48.1
Education	PhD	41	9.21
	Master's degree	2	.45
	Bachelor's degree	197	44.27
	Associate	67	15.06
	Secondary	26	5.84
	Elementary	112	25.17
Marital status	Single	223	50.10
	Married	222	49.90
Employment	Unemployed	81	18.20
	Retired	21	4.72
	Non-worker	22	4.94
	Entrepreneur	24	5.39
	Public sector employee	108	24.27
	Private sector employee	189	42.47
Average monthly income	under 11.400 TRY	100	22.47
	11.400-25.000 TRY	80	17.98
	25.001-35.000 TRY	95	21.35
	35.001-45.000 TRY	55	12.36
	45.001-55.000 TRY	44	9.89
	over 55.001 TRY	71	15.96
Other statistics			
Airline preference	THY	224	50.3
	Pegasus	144	32.4
	AJET	59	13.3
	Other	18	4
Number of flights	Once a month	6	1.3
	10 or more times a month	1	.2
	2-4 times a month	11	2.5
	5-10 times a month	2	.4
	Once a year	127	28.5
	2-6 times a year	222	49.9
	7-11 times in a year	76	17.1

RESEARCH MODEL

The proposed model for this research is constructed as follows.

METHODOLOGY

Measurement and Sample

The survey was implemented based on scales (Chen & Chang, 2013; Murad et al., 2022; Bruner, 2012) validated in prior research. The number of items and factors for each scale is as follows: 5 items with 1 factor for greenwashing, 6 items with 1 factor for brand hate, and 3 items with 1 factor for purchase intention. The scales were originally in English. When designing survey tools available in the literature for people of different ethnicities, faiths, or nationalities, the proper translation into the target language is crucial (Harkness & Schoua-Glusberg, 1998). For this reason, the scales were first translated into Turkish and then retranslated into English. Translations were reviewed by marketing scholars to determine whether there was a change in the meaning of the expressions. The survey featured multiple-choice items formatted on a Likert scale, with the highest score of 7 indicating strong agreement. The questionnaire was formed on Google Forms, and answering all questions was mandatory

to prevent data loss. 60 participants were given a pilot application to test the scales' reliability and the Turkish terms' comprehensibility. In this context, an effort was made to gather verbal feedback from participants during the pilot study. After the evaluations, the scale items were reviewed, and the questionnaire was finalized.

The survey was conducted in Türkiye. Since air travel is available to everyone, participants were not restricted by sociodemographic factors. Turkish passengers who had flight experience with one of the Turkish airlines during the last twelve-month period comprised the research population (General Directorate of State Airports Authority, 2025). The number of domestic passengers exceeded ninety million by the end of 2023. The sample size of 445 is compatible with DeVaus (1992)'s statement for a suitable sample size of 385 within a 95% confidence level for more than 10,000 participants. The questionnaire was delivered to a sample of Turkish consumers (N=445) via youreply.com.tr and LinkedIn.com. The main survey was initiated on October 5, 2023, and remained available until December 11th, 2023.

Participants were asked to consider the airline with which they most frequently fly to prevent bias in the statements' sequence. The respondents completed

Table 2: Cronbach's alpha (α) values and factor loadings (λ).

Variable	Items	λ	Cronbach's α
GW	GW1	.735	.920
	GW2	.769	
	GW3	.800	
	GW4	.736	
	GW5	.767	
BH	BH1	.756	.957
	BH2	.842	
	BH3	.895	
	BH4	.913	
	BH5	.888	
PI	PI1	.855	.833
	PI3	.859	

Table 3: Analysis of confirmatory factor

model fit indices	criteria	obtained
χ^2		154.395
df		48
χ^2/df	< 5.0	3.217
NFI	> .95	.969
RFI	> .95	.958
CFI	> .95	.979
IFI	> .95	.979
TLI	> .95	.970
GFI	> .95	.946
RMSEA	< .08	.071

the survey in ten minutes on average. The survey is presented in three strands. The first strand investigates individuals' reasons for flying and whether they are

frequent travelers. Participants were asked how many flights they had taken during the 12 months. The second strand covers scale items on greenwashing, brand hate, and purchase intention.

DATA ANALYSIS

Test of Normality

The values of normality range between -1.499 and +1.062 for skewness and 2.915 and +2.490 for kurtosis. The results are considered normal in line with Kline (2023)'s statement of ± 3 for the skewness coefficient and ± 10 for the kurtosis coefficient.

Factor Analysis

The sample's adequacy is sufficient for factor analysis with a KMO value of .874. The sample's suitability is supported by Bartlett's test, as the p-value is less than .05.

The total variances explained by the three components are 48.175%, 15.678%, and 13.731%. The eigenvalues for each component are: 6.263, 2.038, and 1.785. The three extracted factors account for 77.585% of the total variance. All variables are unidimensional, and the factor analysis is appropriate for these variables.

Table 2 represents Cronbach's alpha values and the factor loadings. The factor loadings of the PI scale were improved by omitting the second item (PI2). The item

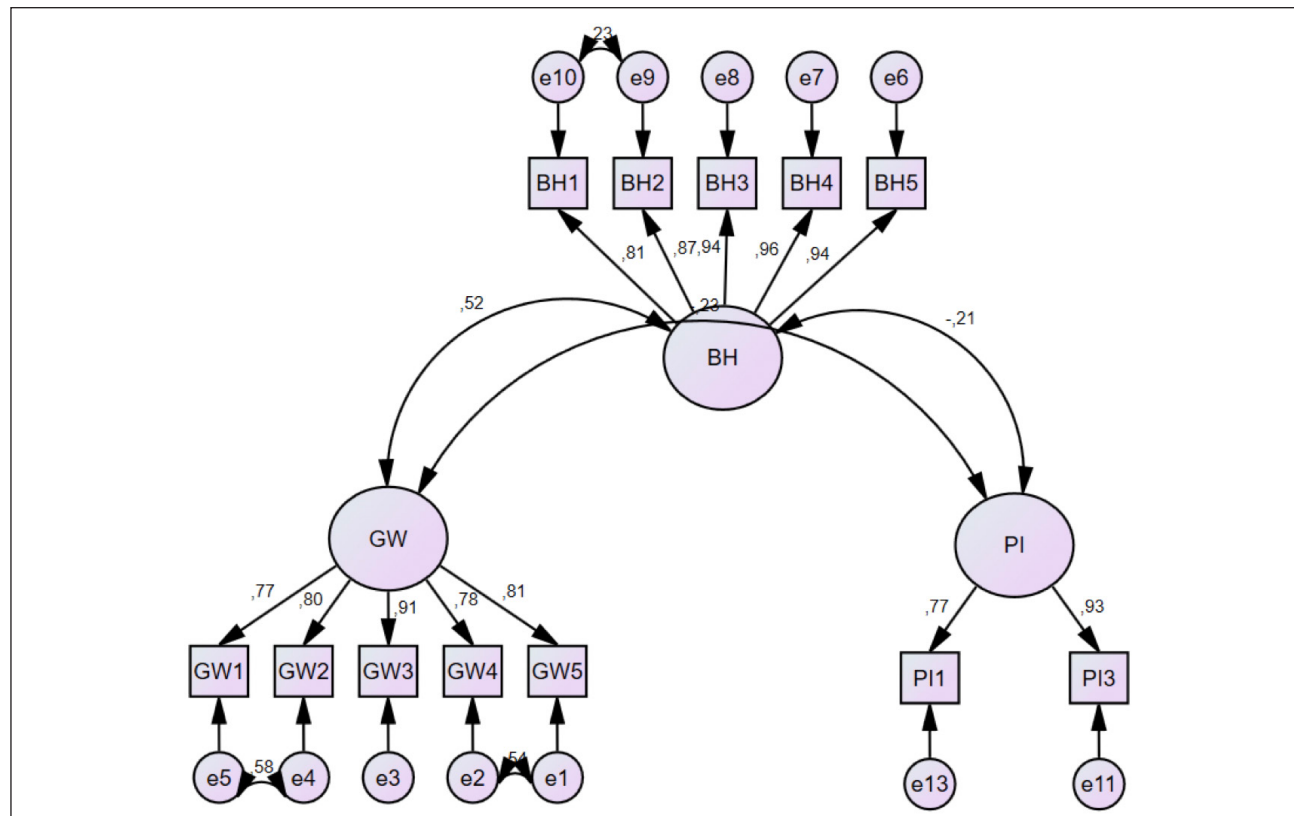
**Figure 2:** Confirmatory Factor Analysis

Table 4: Reliability Results.

CR	AVE	MSV	MaxR(H)	GW	BH	PI
.908	.664	.270	.919	.815		
.957	.817	.270	.968	.520***	.904	
.840	.726	.054	.883	-.232***	-.212***	.852

Correlations Significance: *** $p < .001$

Table 5: HTMT Analysis

	GW	BH	PI
GW			
BH	.550		
PI	.236	.215	

Table 6: Results of model fit

model fit indices	criteria	obtained
χ^2		154.395
df		48
χ^2/df	< 5.0	3.217
CFI	> .95	.979
IFI	> .95	.979
TLI	> .95	.970
NFI	> .95	.969
RFI	> .95	.958
GFI	> .95	.946
RMSEA	< .08	.071

factor loadings represent a strong relationship with values varying between .735 and .895.

The estimated values of the confirmatory factor analysis are demonstrated in Table 3 and illustrated in Figure 2. Model fit indices (CFI of .979, NFI of .969, TLI of

.970, IFI of .979, and RMSEA of .071 represent a good fit in conformity with criteria suggested by McDonald & Ho (2002).

Principal component analysis is an appropriate method for investigating the fundamental factor framework of indicators. Once the construct indicators are established for one-dimensionality, additional evaluation is needed to ensure reliability and validity.

Reliability and Validity

The model reliability indicated by Cronbach's alphas in Table 2 was over 0.7 for all three scales. Cronbach's alpha coefficients for GW, BH, and PI are .920, .957 and .833, respectively, demonstrating strong internal consistency and good reliability.

The AVE (Average Variance Explained) and CR (Construct Reliability) values with values closer to 1 indicate higher reliability. The CR value should exceed the cut point of .60 for the construct's convergent validity with low AVE values as stated by Fornell & Larcker (1981). In our model, the CR is greater than .70 for all scales (CR values are .908 for GW, .957 for BH, .840 for PI), and discriminant validity is greater than .50 (AVE values are .664 for GW, .817 for BH, and .726 for PI) as stated in Table 4.

Values of HTMT (.550, .236, and .215) in Table 5 for discriminant validity are below the threshold (.85) and establish discriminant validity.

SEM (Structural Equation Modeling) and Hypothesis Testing

AMOS 24.0 was used to derive empirical results through maximum likelihood estimation (MLE) and test hypotheses through structural equation modeling (SEM) at a 95% confidence level with the bootstrapping method. Our data stemmed from a questionnaire containing three constructs and 13 items. Table 6 and Figure 3 illustrate the model fit results and the path coefficients. Model fit indices (χ^2/df of 3.217, CFI of .979, NFI of .969, TLI of .970, IFI of .979, and RMSEA of .071) represent a good fit in conformity with the criteria suggested by McDonald & Ho (2002).

Hypothesis 1 predicted a relationship between GW and BH, revealing that GW positively and significantly affects BH ($\beta=.597$, $p < .05$ and C.R.= 10.681). The increase in brand hate is directly proportional to the increase in greenwashing. Hypothesis 2 further predicted that GW is negatively related to PI ($\beta=-.134$, $p < .05$ and C.R.= -2.675). The decrease in PI is inversely proportional to the increase in GW. Hypothesis 3 posits BH's statistically significant

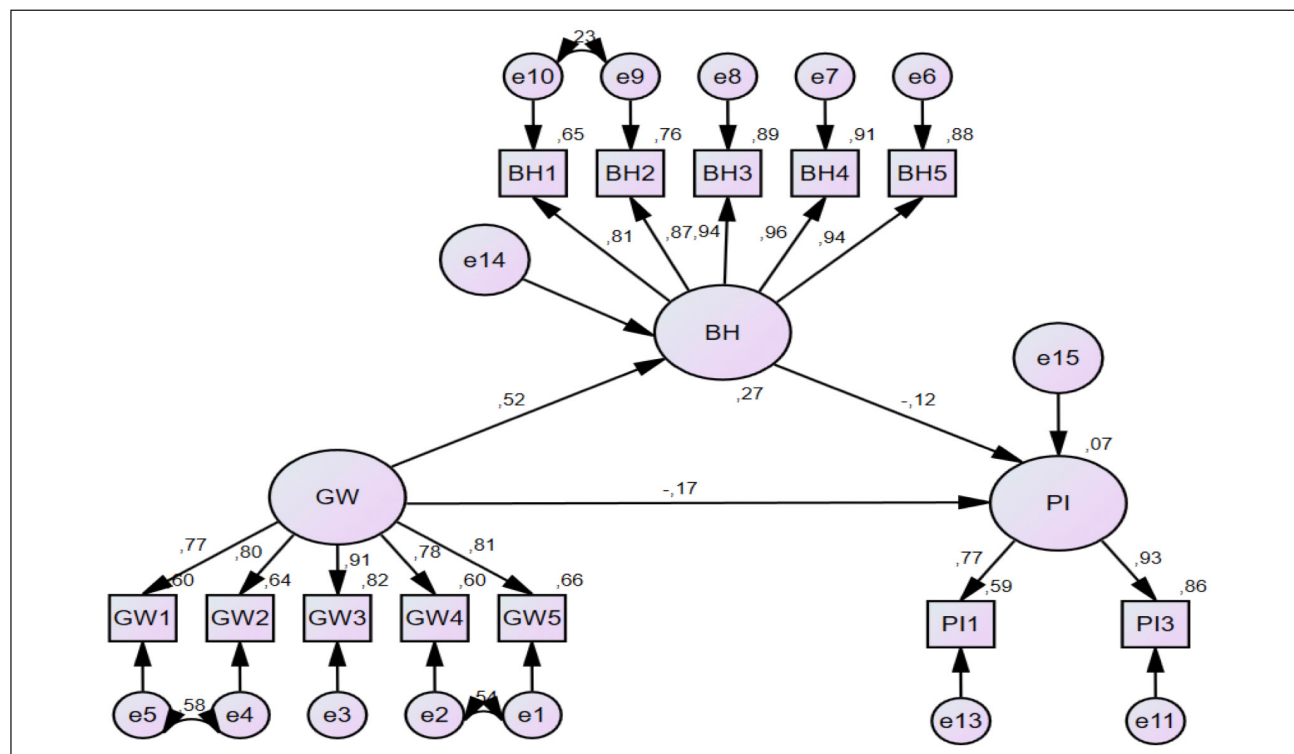


Figure 3: Structural Equation Model

and negative effect on PI ($\beta = -.087$, $p < .05$ and C.R. = -2.074). The decrease in PI is inversely proportional to the increase in BH. Thus, H1 through H3 are all supported.

The mediation analysis reveals that brand hate partially mediates purchase intention. and greenwashing. The total effect of greenwashing on purchase intention with brand hate ($\beta = -.232$, $p < .05$) and the standardized direct effect ($\beta = -.167$, $p < .05$), the indirect effect ($\beta = -.065$, $p < .05$, CIUL-LL = -.006, -.127) are statistically significant. Thus, Hypothesis 4 is supported.

CONCLUSION

This study examined how greenwashing and brand hate affect Turkish consumers' purchase intention for air transportation. It extends sustainability literature by focusing on the airline sector in a specific cultural context and highlights the importance of sustainability practices for service-oriented businesses. This contribution is important for marketing and management strategies for the airline sector, which serves millions of passengers and consumes a vast amount of fuel.

As sustainability becomes a growing concern, the importance of carbon offset programs is increasing. Judging from air traffic and fuel consumption, airline passengers' attitudes and behaviors toward green practices are crucial for the airline transportation sector. In earlier research, Kumar and Ghodeswar (2015) found

that sellers' environmental concern affects consumers' purchase decisions. Environmentally conscious consumers expect brands to demonstrate genuine sustainability practices. Studies revealed that purchase intentions are affected by consumers' perceptions of greenwashing (More, 2019; Jog & Singhal, 2024). Supporting prior research, our study demonstrated that Turkish passengers' purchase intention was adversely affected by greenwashing.

Airlines may benefit from targeting the green market by offering real and transparent environmental approaches rather than relying on greenwashing. Nyilasy et al. (2014); Naderer et al. (2017) argued that greenwashing may harm consumers' brand appraisal. Consequently, brand hate harms purchase intention (Hegner et al. 2017).

Companies jeopardize their brand reputation by greenwashing (Marciniak, 2009; Delmas & Burbano, 2011). Murad et al. (2022) revealed that greenwashing leads to an increase in brand hate. Santos et al. (2024) suggested that greenwashing positively and directly affects brand hate. Our findings confirm that greenwashing evokes the brand hate expressed by Turkish consumers.

When organizations violate stakeholders' high expectations, the negative consequences are more severe than if they had low or neutral reputations (Sohn & Lariscy, 2015). Consumers' disappointment about expectations may lead to brand hate. Passengers may

react with brand hate to disappointment resulting from unmet environmental expectations (Romani et al., 2012). In line with these suggestions, our study supports brand hate's negative effects on purchase intention.

Regarding the importance of sustainability in designing consumer behaviors within the airline sector, our findings reveal that greenwashing can significantly damage brand reputation, foster brand hate, and ultimately reduce purchase intention. Airlines can build consumer loyalty in terms of repurchase and contribute to efforts to tackle carbon emissions by applying genuine sustainability practices and avoiding deceptive green practices. These insights offer valuable guidance for marketing and management strategies in the airline industry. Future research could further explore cultural variations in consumer responses to greenwashing and examine strategies to rebuild loyalty in cases where sustainability expectations have been violated.

Future Research and Limitations

Several limitations for future research are addressed. First, the sample consisted of randomly selected Turkish consumers, with 50% between the ages of 31 and 50. Future research can involve more homogeneous participant groups to reduce the potential common method variance.

Another limitation is that greenwashing is a relatively new concept, and sanctions in Turkey have not supported it. Consumers may either be unaware of greenwashing and its use by corporations, or perceive it differently depending on the product, service, or its significance in daily life. As a result, consumer reactions may differ from those in more regulated regions. Future research may include a comparison of the effects of greenwashing across specific sectors in the region with different levels of regulations.

Perceptions of greenwashing and brand hate may vary across cultures. Therefore, testing the model in other countries may be valuable for determining the universality of the findings. Additionally, greenwashing and brand hate can be analyzed from the perspective of service providers to understand environmental concerns on brand perceptions.

Future research can also adopt a longitudinal or experimental plan to examine the causality between brand hate and greenwashing with a control group. Longitudinal studies provide a methodological approach for examining how attitudes and behaviors evolve, while experimental studies could help identify the

sequence and strength of causal relationships between greenwashing and brand hate. This would allow researchers to test whether the effects of greenwashing and brand hate are sequential or simultaneous.

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Health Tourism Potential of Turkey under the Different Regimes: Macroeconomic Factors Affecting the International Competitiveness

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ABSTRACT

This study focuses on the macroeconomic determinants of international health tourism revenues in Turkey from 2003Q1 to 2023Q1 with a nonlinear approach, a Markov Regime Switching model. Empirical findings show that two regimes are identified, and there is a clear-cut transition from the low to the high regime in 2016Q1. Most economic factors are statistically insignificant in the low regime, whereas almost all variables have a statistically significant impact on international health tourism revenues in the high regime. In the high regime, increases in relative prices, real effective exchange rates, and oil prices lead to a decrease in international health tourism revenues, while health sector stock returns positively impact the revenues. As a global factor, the effect of the uncertainty index is statistically insignificant in both regimes. The empirical findings highlight Turkey's dependence on price competition in the health tourism market and underline the need for sustainable public incentives to enhance the long-term viability of the sector.

Keywords: Health Tourism, Macroeconomic Factors, International Competitiveness, Markov Regime Switching.

JEL Classification Codes: Z30, Z38, C34

Referencing Style: APA 7

INTRODUCTION

Health tourism has recently emerged as a fast-expanding global market. The worldwide healthcare market is projected to increase annually by 5.1 % from 2023 to 2027, driven by the growing older population, prevalence of chronic diseases, escalating healthcare spending, and advancements in healthcare technology. In developing countries specifically, sectoral growth is also being supported by improvements in healthcare infrastructure (Global Healthcare Market, 2024).

The future of the health services sector in Turkey, a growing nation, is significantly influenced by existing infrastructure, rising private sector investments, and expanding health insurance coverage with government assistance. The sector's operational effectiveness and level of patient care are also being improved through new technology like big data analytics, telemedicine, and artificial intelligence (Turkey Healthcare Market, 2024). Since the 1980s, health policy in Turkey has been influenced by the promotion of more active involvement by the private sector and the creation of a

market-dominated system (Fedai, 2019: 2024). In 1990, a master plan was created for health services. This covered key issues, such as making inspections and planning more effective by restructuring the Ministry of Health, prioritizing protective health services, granting autonomy to hospitals, and developing the scope of family practice (Sülkü, 2011: 5). In the 2000s, an emergency action plan, to be implemented in 2002, established basic principles under the title of Health for All. Accordingly, the Ministry of Health launched the Health Transformation Program (HTP) in 2003 (Çavmak and Çavmak, 2017: 51-52; Ministry of Health, 2008). This program led to a rapid expansion in the number of hospitals in Turkey between 2003 and 2013, prompting the need for rules to restrict the establishment of new private hospitals across all provinces during the 2000s. Consequently, the growth of private hospitals slowed during the 2010s. Instead, the private hospital market continued to expand through mergers of smaller hospitals or their acquisition by institutionalized hospital groups. Meanwhile, state City Hospitals, structured as comprehensive health campuses equipped with substantial capacity and sophisticated medical technology, reduced disparities in service

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provision between private and public hospitals (Boyacı, 2024: 1029-1030).

Today, in Turkey, health sector institutions have begun leveraging information technologies and health information systems to enhance healthcare decision-making. A new initiative within the Ministry of Health's Health Transformation Program promoted the digitalization of healthcare institutions. Internationally, the level of hospital digitalization is evaluated by the Healthcare Information and Management Systems Society (HIMSS), with Turkey having HIMSS-accredited hospitals in 35 provinces (Peker et al., 2018). The improved quality and reliability of Turkish healthcare services are also reflected in the certification that healthcare facilities have gained from various healthcare accreditation bodies. One of them is the Joint Commission International (JCI), which evaluates and accredits international healthcare organizations' compliance with standards. Finally, the quality and efficiency of healthcare services in Turkey have also been enhanced by implementing advanced artificial intelligence-supported diagnostic systems, robotic surgery, and other cutting-edge technologies. Overall, these developments have strengthened Turkey's competitiveness in the international health tourism market.

Considering the global competition in terms of infrastructure and technology, Turkey's performance in health tourism still lags behind that of developed countries. The medical tourism index and its sub-indexes (Country Environment, Medical Tourism Industry, and Facility and Services) provide significant insights as quantitative indicators in assessing Turkey's health tourism potential. This potential can be considered both regionally and globally. Being located at the crossroads of Europe and Asia, Turkey has a significant geographical advantage because of easy access to both continents. This gives it the potential to become a regional leader in health tourism depending on its competitiveness compared to neighboring countries. More specifically, according to the 2020-2021 overall global ranking of the Medical Tourism Index, calculated by the International Health Research Center (2024), Turkey ranks 30th, slightly ahead of Greece at 34th, and significantly ahead of Iran at 46th. However, while Greece and Turkey rank similarly in fields like cosmetic surgery, dental care, cardiology, and orthopedics, Greece (24th) ranks well ahead of Turkey (35th) on the country environment sub-index, which includes the economy, safety, image, and culture sub-components. Considering the broader region around Turkey, Israel ranks well ahead at 8th globally in the

overall medical tourism index, particularly in robotic surgery. Similarly, considering the Mediterranean basin, Italy is another significant medical tourism destination, and ranks 18th on the overall index, well above Turkey (Medical Tourism Destinations, 2024). While Turkey has the potential to surpass these regional competitors in terms of costs, it faces international competition from countries like Mexico, Thailand, and India, which are ahead of Turkey on the overall index ranking. Therefore, for Turkey to become a global player, it needs to create strong policies at both the macro and micro levels. When formulating policies, uncertainties should be considered alongside the effects of price competition and the development of health institutions.

Given this background, this study is a novel attempt to examine how Turkey's health tourism responds to global shocks. As such, it seeks to address a significant gap in the literature by examining the macroeconomic factors influencing health tourism demand. Turkey was chosen as the sample for this study because it is rapidly becoming a global health tourism hub, attracting patients from all over the world. Turkey offers a wide range of medical services, from high-tech surgery to alternative treatments, at prices well below the costs in many other countries (Medical Tourism, 2024). Our study is distinct in that it provides inferences for health tourism policy development and uses a nonlinear methodology to enhance the robustness of the results. To the best of our knowledge, this is the first study to use the Markov Regime Switching (MS) model to analyze the determinants of health tourism earnings.

The layout of the paper is structured as follows. The second section reviews the literature investigating the demand for health tourism. The third section introduces the data set and analysis method, namely the MS model. The fourth section presents the analysis results. The final section discusses and evaluates the results.

LITERATURE REVIEW

To understand the factors that determine international health tourism demand, it is first necessary to understand the motivations behind medical tourist behavior. Given that price competition is the main factor in the tourism services market (Vetitnev et al., 2016), the cost is an essential motivation (Arellano, 2007; Burkett, 2007; Connell, 2006; Smith and Forgione, 2007). Health tourists also choose destinations based on cultural proximity (Yu and Ko, 2012), although others may choose based on factors other than cultural, religious, or linguistic proximity (Ahmed et al., 2018). One such key determinant of health

tourism demand is the reliability of the healthcare team in the host country (Prasetyo et al., 2020). Finally, health tourists may also be motivated to seek healthcare in a popular tourist destination, where they can enjoy their trip during their treatment (Turner, 2007).

In today's rapidly changing world, health tourism trends are also evolving quickly. One powerful new trend is the search for well-being along with the emergence of new destinations and the behavior of insurance companies (Papp and Lőrincz, 2016). Today, people are willing to travel the world to engage in wellness practices and achieve their medical and aesthetic goals (Wright and Zascerinska, 2023). In Europe especially, health tourism trends are moving towards preventative health care activities rather than medical treatments (Smith and Puczkó, 2010). Health tourism is a niche sector within the increasing global demand for healthcare services. In particular, emerging countries offering advanced healthcare services can increase the inflow of medical tourists if located close to developed countries (Malhotra and Dave, 2024). Four key factors influence the tendency toward medical tourism, namely economic, social, and cultural, healthcare infrastructure and quality standards, and marketing and promotion strategies (Mandagi and Tappy, 2024).

Regarding the motivation of tourists in health tourism, various push and pull factors have been identified. Push factors include age, gender, economic status, cultural background, health insurance coverage, and individual health conditions. Pull factors include medical costs, exchange rates, infrastructure, accreditation of medical facilities, service quality, political and social stability, regulatory environments, and hospital reputation (Ha et al., 2021: 770-771). Pull factors also include accessibility (minimizing waiting periods), cost-effective treatment alternatives, and the possibility of higher quality and/or responsiveness from international healthcare providers (Manna et al., 2020).

Regarding the macroeconomic determinants of health tourism demand, studies have used comparable explanatory variables. For instance, Kadir and Nayan (2021) considered health tourism prices, travel costs, real income per capita, exchange rate, inflation (difference between host and origin country), and health spending. Mageswari et al. (2014) examined six macroeconomic factors: inflation rate, crude oil price, money supply, industrial production index, stock index, and exchange rate. Tang and Lau (2017) included medical quality and facilities, health tourism pricing, tourist revenues, exchange rates, safety, and the severe acute respiratory syndrome (SARS) epidemic.

While the international literature provides a strong foundation regarding the macroeconomic factors affecting health tourism, studies focusing on Turkey reveal a complex interplay of factors, such as exchange rates and healthcare quality (Büyüközkan et al., 2021; Çeti and Ünlüöner, 2020). Medical operations in Turkey are generally cheaper than in Western industrialized nations, thereby attracting consumers due to the financial advantage (Ateş and Sunar, 2024; Işıklı et al., 2020). Accordingly, a number of studies focused on Turkey have specifically considered the impact of changing exchange rates on costs and revenues. Biri (2021) and Ağazade and Ergün (2022), for example, both demonstrated that Turkey's health tourism revenues are significantly sensitive to changes in real exchange rates.

Other factors influencing Turkey's health tourism revenues include tourist income, prices in competing destinations, geographical and cultural distance between countries, security, the host country's legal conditions, the prevalence of health insurance in tourists' countries of origin, quality of health care, promotional and marketing activities. However, few studies have investigated these determinants of health tourism demand in Turkey (Ağazade and Ergün, 2022: 3). Indeed, Ağazade and Ergün (2023) identified only two studies analyzing variables influencing the demand for health and medical tourism in Turkey, namely Gündüz et al. (2019) and Işıklı et al. (2020). Furthermore, while Koyuncu (2016) examined the relationship between Turkey's total tourism sector revenues and health tourism revenues, studies on Turkey have generally focused more on the total demand in the tourism sector rather than the demand for health tourism.

Finally, to the best of our knowledge, no study has investigated the impact of health tourism in Turkey with various uncertainties, which is the focus of our study. Previous studies have only examined the effects of risk indicators like political and economic uncertainties (İrani et al., 2022; Tekin, 2015) or economic crises (Çınar and Şener, 2021) on Turkey's overall tourism sector.

METHODOLOGY, DATA SET, AND MODEL

Early work on MS models, popularized by Hamilton (1994), focused on cyclical fluctuations. These models allow researchers to examine the dynamic behavior of variables depending on each regime (Baharumshah et al., 2017). These models also reveal regime differences through the specific situation or regime variable (Koç and Akgül, 2013; Yağcıbaşı and Yıldırım, 2019).

Table 1: Variable Definitions and Sources

Variables	Data Sources
International Health Tourism Revenues (<i>health_tourism_t</i>)	Turkish Statistical Institute (TUIK)
Real Effective Exchange Rate (<i>reer_t</i>)	Federal Reserve Economic Data (FRED)
Inflation Differences (<i>inf_t</i>)	Federal Reserve Economic Data (FRED)
Healthcare Sector Stock Price Index (<i>share_t</i>)	Datastream
Uncertainty Index (<i>unc_t</i>)	Federal Reserve Economic Data (FRED)
Oil Price (<i>oil_t</i>)	Federal Reserve Economic Data (FRED)
Financial Stress Index (<i>fsi_t</i>) ¹	Federal Reserve Economic Data (FRED)

Krolzig (1997) developed model definitions incorporating various features that enable the mean, intercept, and variance of residuals to be modified across regimes via an unknown state variable. One specific model, the Markov Regime Switching Intercept Autoregressive Heteroskedasticity (MSIAH) model, takes into account changes in the variance of the error terms in the system and allows all parameter changes (Çatık and Önder, 2011). In the MSIAH model, the state or regime variable, represented by the symbol s_t , takes an integer value. The unobservable variable in the model allows different regime probabilities to be calculated for the observable variables. The transition probabilities of the Markov model are expressed through the following model:

$$P\{s_t = j | s_{t-1} = i, s_{t-2} = k, \dots\} = P\{s_t = j | s_{t-1} = i\} = p_{ij} \quad (1)$$

Here, p_{ij} reflects the transition probabilities from state i to state j , and under the assumption $p_{i1} + p_{i2} + \dots + p_{iM} = 1$, the matrix of transition probabilities P in size $M \times M$ is defined as follows (Hamilton, 1994; Krolzig, 1997):

$$P = \begin{bmatrix} P_{11} & P_{12} & \dots & P_{1M} \\ P_{21} & P_{22} & \dots & P_{2M} \\ \vdots & \vdots & \ddots & \vdots \\ P_{M1} & P_{M2} & \dots & P_{MM} \end{bmatrix} \quad (2)$$

The MSIAH model is estimated using the maximum likelihood estimator, which is based on the expectation-maximization algorithm.

In the present study, we analyzed the macroeconomic determinants of international health tourism revenues in the Turkish economy for the period 2003Q1-2023Q1 depending on the availability of the data set. Table 1 presents the symbols used for the variables and their data sources.

The model of the determinants of international health tourism demand for Turkey is as follows:

$$health_tourism_t = \alpha_1 + \beta_1 reer_t + \delta_1 inf_t + \theta_1 share_t + \omega_1 unc_t + \varphi_1 oil_t + \varepsilon_t \quad (3)$$

The dependent variable (*health_tourism_t*) was calculated as the percentage ratio of international health tourism revenue to total international tourism revenue. Two explanatory variables, real effective exchange rate (*reer_t*) and financial stress index (*fsi_t*), were included in the analysis at their level values. To compare prices in the Turkish market and global markets, we calculated the differences (*inf_t*) in the annual percentage changes of the consumer price index of the Turkish and US economies regarding health spending, using it as a measure of relative price. The health sector stock price index (*share_t*), uncertainty index (*unc_t*), and oil price (*oil_t*) variables were included in terms of the annual percentage change. The expressions α_1 and ε_t reflect the constant term and the error term, respectively. In addition to the MS model, we expressed the model in linear form, estimated using the Ordinary Least Squares (OLS) estimator. This estimation provided an opportunity to compare linear and non-linear model predictions.

We can express equation (3) in linear form as a two-regime MSIAH system as follows:

$$health_tourism_t = \begin{cases} \alpha_1 + \beta_1 reer_t + \delta_1 inf_t + \theta_1 share_t + \omega_1 unc_t + \varphi_1 oil_t + \varepsilon_t, & s_t = 1 \\ \alpha_2 + \beta_2 reer_t + \delta_2 inf_t + \theta_2 share_t + \omega_2 unc_t + \varphi_2 oil_t + \varepsilon_t, & s_t = 2 \end{cases} \quad (4)$$

In this system, s_t represents the regime variable that takes integer values 1 or 2, as stated before. The two values, $s_t = 1$ and $s_t = 2$ reflect regimes where international health tourism revenues are low and high, respectively.

EMPIRICAL FINDINGS

The trends of the macroeconomic variables in regime shifts were analyzed through the MSIAH model estimation to reveal the different regimes of international health tourism revenues. Linear model estimation was given priority to enable comparison with the MSIAH

Table 2: Unit Root Test (ADF with Structural Break: Innovative Outlier)

Variable	Test Statistics	Breaking Point	Probability
<i>health_tourism_t</i>	-12.9425	2020Q1	0.000
<i>reer_t</i>	-5.2614	2011Q3	0.0399
<i>inf_t</i>	-5.1226	2021Q1	0.0582
<i>share_t</i>	-5.6615	2018Q3	0.0127
<i>unc_t</i>	-7.7112	2020Q1	0.000
<i>oil_t</i>	-4.9716	2020Q4	0.0830
<i>fsi_t</i>	-5.2598	2009Q2	0.0400

Table 3: OLS Estimation Results

Variable	Coefficient	Standard Error	t-statistics	Prob.
<i>c_t</i>	13.27894	1.1349	11.6997	0.0000
<i>reer_t</i>	-0.07025	0.0073	-9.5798	0.0000
<i>inf_t</i>	-0.08606	0.0188	-4.5633	0.0000
<i>share_t</i>	0.00911	0.0024	3.7762	0.0003
<i>unc_t</i>	-0.00190	0.0025	-0.7348	0.4647
<i>oil_t</i>	-0.00846	0.0035	-2.3669	0.0205
R-Square: 0.6340		F-Statistics: 25.9880		

model's results. Before model estimation, the final data were subjected to unit root testing to determine the stationarity properties of the time series. Given that the sample period was characterized by various local and global financial crises, structural changes, and potential effects of the COVID-19 pandemic, the Augmented Dickey-Fuller (ADF) test was used to allow structural breaks, based on the work of Vogelsang and Perron (1998)¹. Table 2 presents the results of the unit root test with structural breaks.²

The test results indicated that the series are stationary at the level. Revenue from international health tourism and the economic uncertainty variables were stationary at the 1% significance level. Other variables remained stationary at a significance level of at least 10%. There

were breaks in both the international health tourism revenue series and economic uncertainty index coinciding with the COVID-19 pandemic period, that is, 2020Q1. A break was also observed in the relative price series in 2021Q1, presumably because policymakers implemented expansionary policies to reduce the pandemic's economic effects, thereby raising the overall level of prices in all economies. The real effective exchange rate series also showed a break in 2011Q3. This can be explained by increased capital inflows during this period, which pushed the nominal exchange rate down, thereby leading to the Turkish Lira appreciation (İlhan, 2022). Finally, there was also a significant break in the robustness check model's financial stress index variable following the 2008 Global Financial Crisis.

The drivers of international health tourism revenue for the Turkish economy were estimated after the series' stationarity features were determined. Before estimating the MSIAH model, equation (3) was estimated using a linear estimator. Table 3 shows the results obtained from model (3) using the OLS estimator.

¹ There are two specific choices regarding the type of break: additive and innovative outlier. This distinction was first introduced by Fox (1972). The effect of innovative outlier observation is not limited to the t moment when the event occurs but can also cause changes in the following process (Yorulmaz, 2010). For this reason, an innovative outlier was preferred for the present study.

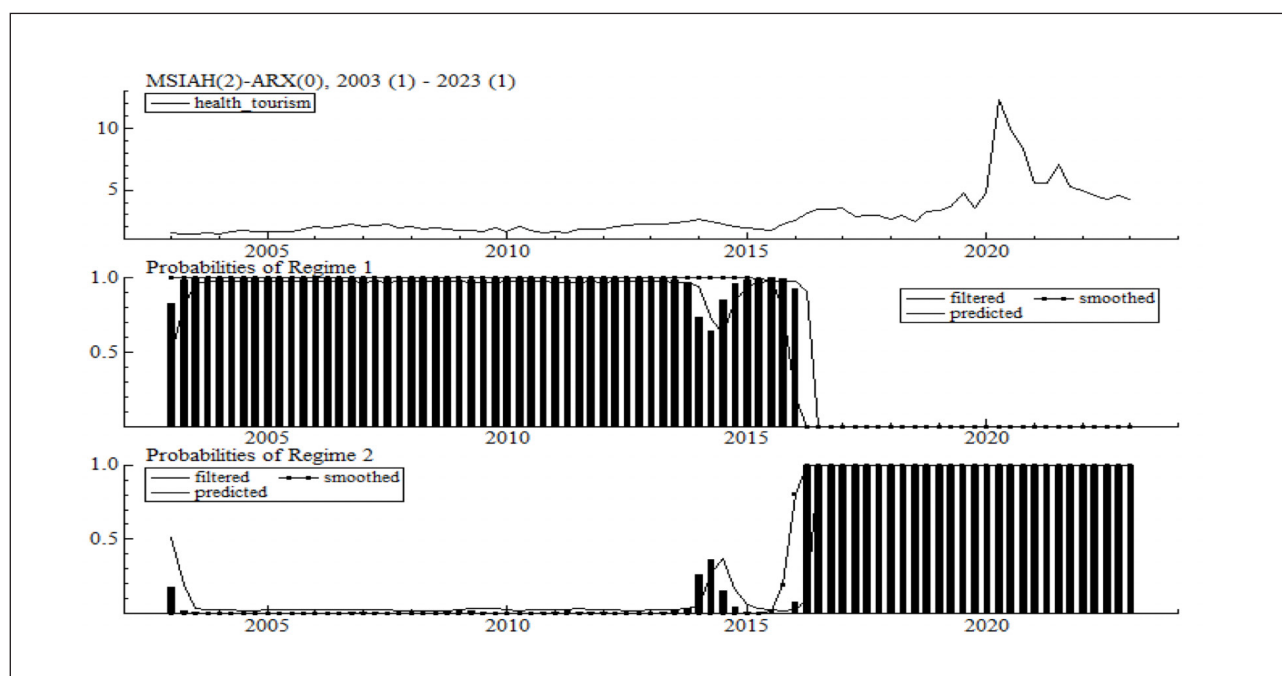
² The maximum number of lags in the ADF unit root test with structural breaks was determined as four because the series were quarterly in frequency. The optimal number of lags was calculated according to the Schwarz Information Criteria.

Table 4. Transition Matrix and Classification of the Regimes

Transition Matrix		
	Regime-1	Regime-2
Regime-1	0.6445	0.3555
Regime-2	0.0282	0.9718
Regime Classification		
Regime-1: 2003:1-2015:4 [0.9957]	Regime-2: 2016:1-2023:1 [0.9934]	

The OLS estimate results show that all variables are statistically significant; except for economic uncertainty. International health tourism revenues were negatively affected by all of the explanatory factors, with the exception of the health sector stock price index. Among the significant variables, the relative price had the highest coefficient while oil prices had the lowest.

observations associated with the low regime as with the high regime. While there was a 97.18% chance of a high regime change in the period after the high regime, there was only a 2.82% chance of a transition from the high to the low regime. It was unlikely that the high regime would change to a low regime. Figure 2 displays the regime probabilities between the low regime and the high regime.

**Figure 2.** Regime Probabilities

Before estimating the MSIAH model, it is necessary to define the regimes. Two different regimes were determined for the dependent variable: low and high international health tourism revenues (Regime-1 and Regime-2). Table 4 shows the transition matrix and classification of the regimes.

As Table 4 shows, the low regime dominated between 2003Q1 and 2015Q4, whereas the high international health tourism revenue regime dominated between 2016Q1 and 2023Q1. There were almost twice as many

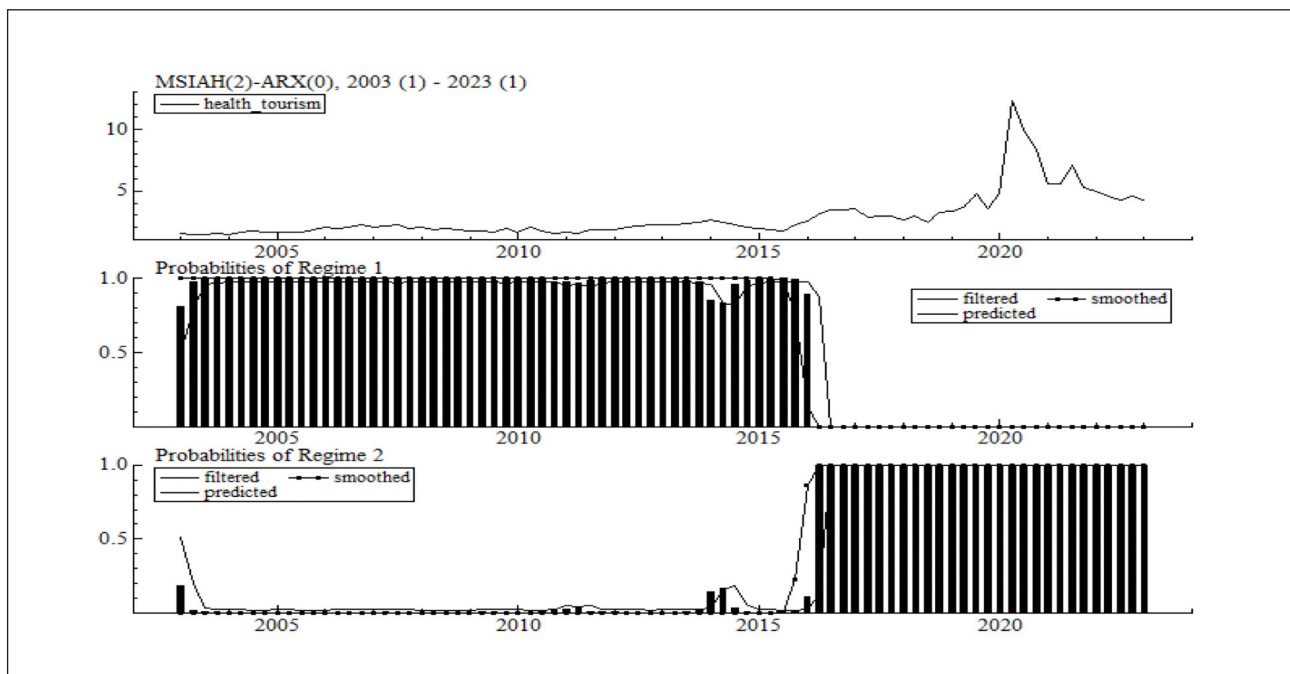
The MSIAH estimator results for equation (4) are reported in Table 5. The likelihood ratio (LR) test proves whether the linear model is valid (İlhan et al., 2022). LR test results suggest that the linear model is invalid and the estimator that uncovers regime changes should be used.

The estimation results indicate that, as the difference between relative prices rises, international health tourism revenue in the low regime decreases. No other variables were statistically significant in this regime. In contrast, in

Table 5. MSIAH Model Estimation Results

Low Regime			
Variable	Coefficient	Standard Error	t-statistics
c_t	2.3125***	0.6609	3.4991
$reer_t$	-0.0020	0.0041	-0.4781
inf_t	-0.0145*	0.0074	-1.9678
$share_t$	-0.0010	0.0007	-1.3535
unc_t	0.0003	0.0008	0.3464
oil_t	-0.0016	0.0012	-1.3256
High Regime			
Variable	Coefficient	Standard Error	t-statistics
c_t	17.0665***	1.8461	9.2444
$reer_t$	-0.0963***	0.0142	-6.7617
inf_t	-0.1471***	0.0287	-5.1322
$share_t$	0.0187***	0.0046	4.1079
unc_t	-0.0056	0.0044	-1.2863
oil_t	-0.0133*	0.0068	-1.9444
LR Linearity Test: 137.5370		Chi(7): 0.0000***	Chi(9): 0.0000***

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

**Figure 3.** Alternative Model Regime Shifts

the high regime, all variables were statistically significant, except economic uncertainty. The results from the high

regime are parallel to the linear model. As in the linear model, the relative price has the highest impact.

To check the robustness of the MSIAH model findings, the main model was preserved and the financial stress index variable was used instead of economic uncertainty. There were substantial increases for this variable, especially during crisis periods, which indicates that the risk in global markets increased. Figure 3 shows the regimes revealed by the MSIAH model estimated for the robustness analysis. The high and low regimes obtained in the robustness analysis are almost identical to the main model.

most substantial variable, as in the linear and main model MSIAH estimations. An increase in the difference between relative prices reduced international health tourism revenue. The most significant variable in the high regime was relative price increases in the healthcare sector, consistent with the previous estimation results. The fact that Turkey's health sector has become relatively expensive reduces its international health tourism revenue. Another notable finding regarding the high regime is that a rise in health sector stock returns caused an increase in international health tourism revenues. The

Table 6: Alternative MSIAH Model Estimation Results

Low Regime			
Variable	Coefficient	Standard Error	t-statistics
c_t	1.6870***	0.5982	2.8199
$reer_t$	0.0022	0.0037	0.5858
inf_t	-0.0110*	0.0067	-1.6412
$share_t$	-0.0019***	0.0007	-2.5776
fsi_t	-0.1001***	0.0326	-3.0723
oil_t	-0.0020*	0.0011	-1.8589
High Regime			
Variable	Coefficient	Standard Error	t-statistics
c_t	17.4343***	1.8899	9.2249
$reer_t$	-0.0990***	0.0145	-6.8244
inf_t	-0.1604***	0.0275	-5.8320
$share_t$	0.0207***	0.0044	4.7544
fsi_t	-0.1728	0.2526	-0.6840
oil_t	-0.0151***	0.0078	-1.9234
LR Linearity Test: 143.4507		Chi(7): 0.0000***	Chi(9): 0.0000***

Note: ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6 shows the alternative model estimation results. The findings support the linear model.

The findings show that the real effective exchange rate had no statistically significant impact on international health tourism revenue, whereas the other variables were statistically significant in the low regime. In this state, international health tourism revenue was reduced by the relative prices of tourism sector products and services, oil prices, and the financial stress index. In the high regime, the relative prices of tourism sector products were the

financial stress index shows no statistically significant impact on this model, whereas increases in oil prices lead to a decline in international health tourism revenues.

CONCLUSION

This study examined international health tourism revenues in a non-linear structure for the Turkish economy. Health tourism represents a significant area of interest that engages policymakers within the spectrum of alternative tourism. Given its infrastructure

facilities and qualified healthcare personnel, Turkey has significant potential. Health tourism, which has shown significant development, especially in the last twenty years, will become one of the most important sectors of the future. Hence, public incentives and subsidies should be implemented for this sector, which has a positive externality.

The present study analyzed the period 2003Q1-2023Q1 according to the availability of the data set. The findings obtained from the MSIAH model indicated that there are two different regimes for international health tourism income in Turkey. The periods of the low and high regimes are 2003Q1-2015Q4 and 2016Q1-2023Q1, respectively. During the low regime dominance, nearly all the coefficients were statistically insignificant. On the other hand, during the high regime, the relative prices of tourism sector products were the most substantial variable. An increase in the difference between relative prices reduced international health tourism revenue. The fact that Turkey's health sector has become relatively expensive reduces its international health tourism revenue. Also, a rise in the real effective exchange rate, which signifies local currency appreciation, reduced international health tourism income.

These empirical findings regarding the effect of national currency on health tourism are parallel to those of Biri (2021), Ağazade and Ergün (2022), and Canbay et al. (2023). In the high regime, Turkey's international health tourism income increased in line with health sector stock returns, which was included in the analysis to reveal the development of the health sector. This result partially supports the findings reported by Işıklı et al. (2020) and Biri (2021). Regarding the uncertainty index and oil prices, used to analyze the effects of global factors, the uncertainty index was not statistically significant. Oil prices reduced international health tourism income due to an increase in transportation costs by their transfer to the general price level. During the high regime, the transmission mechanism of the tourism sector to the economy worked effectively. Here, pricing level and the local currency were the most crucial factors determining international health tourism earnings. In Turkey's case, global economic developments had only a limited effect on health tourism income.

These results provide clear evidence that Turkey has been integrated into international health tourism through price competition. However, the strategy of competing by providing relatively cheap healthcare may be difficult to sustain in the long term. Policymakers should therefore continue to increase public subsidies for health tourism

development to establish a sustainable competitive long-term strategy. In this sense, international practices that can be an example for Turkey are noteworthy. For instance, the Thai government has strengthened health tourism by implementing targeted subsidies for medical facilities serving international patients. Similarly, South Korea's approach to promoting medical tourism through special health packages and partnerships with travel agencies could serve as a reference for Turkey. Additionally, the establishment of a national health tourism board, along with strengthening public-private partnerships, could be substantial concrete policy steps for Turkey.

The study has several limitations, of which the first is the exclusion of human capital elements in the model. Future studies should therefore include health sector employees in the analysis as a human capital element. The reason why human capital cannot be included in the analysis is that no data representing human capital and equipment is maintained in the health sector. The available human capital data refers to macro-scale capital within the entire economy. Therefore, it could not be included in the model in this study. Human capital is a critical determinant of international health tourism demand. Thus, if such data were available, future research could examine variables such as the number of accredited health professionals, patient satisfaction scores, and the language proficiency of medical staff. Overcoming these limitations depends on expanding the range of data collected within the health sector, which would provide a more detailed perspective on Turkey's competitiveness in health tourism. The second limitation is that the study mostly relied on annual data, which makes it harder to implement a time series analysis. If future studies can avoid this data adaptation problem, then they can examine the macroeconomic determinants of international health tourism revenues using panel data analysis for different country groups, including human capital elements.

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An Exploratory Study on the Reconceptualization of Inclusivity as a Management Practice in the Turkish Institutional Context

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ABSTRACT

In this study, the concept of inclusivity, which originated in the European context, is evaluated through the lens of the translation approach, with the aim of discovering the dimensions of inclusivity specific to the Turkish context. In-depth interviews were conducted with individuals actively engaged in the workforce. The concept of inclusivity is examined on three levels: general perception of inclusivity, inclusivity at the organizational level, and inclusivity among colleagues. Using a phenomenological design, one of the qualitative research methods, inclusivity is analyzed based on participants' experiences. According to the study's findings, inclusivity is defined through dimensions of ignoring differences, high similarity, acceptance/rejection, and respect. At the organizational level, inclusivity is perceived through the inclusion of diversity, meritocracy, participation in decision-making processes, and openness to ideas and suggestions. Inclusivity among colleagues is reflected in cooperation and solidarity, communication within the group, and socialization. These findings support the institutional perspective, which argues that management knowledge and practices are not universal but are restructured according to the specific contexts in which they are transferred. Therefore, the discovery of Turkey-specific inclusivity dimensions in this study demonstrates that management practices vary contextually and are reshaped based on the unique cultural and institutional dynamics of each country.

Keywords: Inclusivity, Dimensions of Inclusivity, Perception of Inclusivity, Rational Perspective, Institutional Perspective.

JEL Classification Codes: M10, M12, M14

Referencing Style: APA 7

INTRODUCTION

Sturdy (2004) suggests that the spread of management knowledge can be understood from rational, psychodynamic, dramaturgical, political, cultural, and institutional perspectives (Sturdy, 2004). Of these, the rational and institutional perspectives are especially prominent for explaining how management knowledge spreads (Edwards & Rees, 2006; Kipping & Engwall, 2002; Pfeffer & Fong, 2002; Sturdy et al., 2009). The rational perspective suggests that management knowledge and practices are universal and functional, while the institutional approach explores how knowledge and practices circulate, focusing on three main viewpoints (Gooderham et al., 1999; Dirlik, 2024). One viewpoint, Scandinavian institutionalism, emphasizes the process of translation as management knowledge and practices move between countries. The translation approach (Czarniawska & Sevón, 1996; Sahlin-Anderson, 1996; Sahlin-Anderson & Engwall, 2002; Frenkel, 2005; Morris

& Lancaster, 2006; Özen & Berkman, 2007; Özen, 2013; Cassell & Lee, 2017) explains how local actors reinterpret and adapt management knowledge and practices to fit their specific settings (Dirlik, 2023). This approach, which forms the basis of the current study, views the transfer of management knowledge and practices as a "translation" that occurs through social interactions (Czarniawska & Jeorges, 1996; Sahlin & Wedlin, 2008). Sahlin and Wedlin (2008) describe translation as an "editing process" with three key stages: recontextualizing, reconstructing logic, and reformulating. Through these stages, management knowledge and practices are restructured (Sahlin & Wedlin, 2008). This emphasizes that as management knowledge and practices are translated to different contexts, they change in content and meaning, making a direct transfer impossible (Sahlin & Wedlin, 2008; Wasti, 1998; Czarniawska & Joerges, 1996; Jones et al., 2000; Boxenbaum & Battilana, 2005).

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This article is derived from the doctoral thesis titled, "Bir Yönetim Uygulaması Olarak Kapsayıcılığın Türkiye Kurumsal Bağlamında Yeniden Kavramsallaştırılmasına Yönelik Keşfedici Bir Araştırma" conducted under the supervision of Yücel SAYILAR by Koray KARTALKAYA at the Institute of Social Sciences, Uludağ University."

The concept of inclusivity is defined as an outcome of the spread of diversity management practices—which are thought to provide a competitive advantage at the business level in the United States (Kochan et al., 2003)—to Europe, where it has been adapted to cultural differences and local needs (Boxenbaum, 2006; Risberg & Soderberg, 2008; Omanovic, 2009; Klarsfeld, 2009; Heres & Benchop, 2010) and framed within a moral and ethical context (Oswick & Noon, 2014). In this context, Shore et al. (2011) conceptualized inclusivity in Europe based on Brewer's (1991) optimal distinctiveness theory, incorporating dimensions of high belongingness and high uniqueness (Shore et al., 2011). These dimensions are considered to align with Europe's political, cultural, and sociological landscape. However, Turkey may have contextual differences from Europe in these respects. From an institutional perspective, it seems necessary to reassess the concept of inclusivity within Turkey's local context. This study accepts the transfer of inclusivity from Europe to Turkey and focuses on the process of recontextualizing inclusivity as a business and management practice within the translation process.

This theoretical framework forms the basis for exploring how inclusivity is defined and perceived by individuals in businesses in Turkey. Additionally, it investigates whether there are any context-specific dimensions of inclusivity in Turkey. Therefore, when inclusivity is considered as a sociological phenomenon and a management practice, it can be assumed that it may acquire meanings and dimensions unique to the Turkish context when evaluated from an institutional perspective. This assumption forms the foundation of this study. The main objective of the study is to explore the dimensions of inclusivity specific to Turkey. In this way, it is believed that revealing how the concept of inclusivity as a management practice is understood and shaped in Turkey, a context distinct from Europe, will make a unique contribution to the relevant literature. Furthermore, this study is significant in terms of understanding inclusivity from an institutional perspective, identifying its sociological dimensions specific to Turkey, and providing a scientific basis for inclusivity practices as a business practice. The study employs a qualitative research method, and the data obtained from in-depth interviews with white-collar and blue-collar employees actively working in Turkey were coded to identify the main themes related to the context-specific dimensions of inclusivity.

LITERATURE REVIEW

From an institutional perspective, the diffusion of management knowledge is addressed through three

different perspectives (Dirlik, 2023). According to the first perspective, management knowledge and practices are in continuous interaction with the institutional environment, which includes structures, rules, norms, beliefs, and myths (Özen, 2007). This knowledge and these practices carry the distinctive characteristics of the context they belong to (Sturdy, 2001), and during diffusion processes, they are shaped by coercive, normative, and mimetic mechanisms found in the economic, political, and legal contexts of the recipient countries (Meyer & Rowan, 1977). The second perspective emphasizes that management knowledge and practices adapt to the existing institutional order or environment of the local context where they are transferred, resulting in different versions of the original practice (Dirlik, 2023). Both of these perspectives highlight the importance of social and societal influences in the diffusion process of management knowledge. The third perspective in the diffusion of management knowledge from an institutional perspective is the translation approach, also known as the Scandinavian approach (e.g., Czarniawska & Sevón, 1996; Sahlin-Anderson, 1996; Sahlin-Anderson & Engwall, 2002; Frenkel, 2005; Morris & Lancaster, 2006; Özen & Berkman, 2007; Özen, 2013; Cassell & Lee, 2017; Erçek, 2004, 2016; Erçek & İşeri Say, 2009) (Dirlik, 2023). This approach explains how management knowledge is interpreted and reshaped by local actors in the context. This raises the question of how legitimized management knowledge can be transferred to different cultural, legal, and political contexts (Sanders & Tuschke, 2007). The dependence of management knowledge on humans and context is considered one of the factors that complicates this transfer process, as knowledge carries the characteristics of the institutional context in which it was produced (Kostova & Zaheer, 1999). Therefore, it is expected that management knowledge formed in a socio-cultural context will not have the same effect in a different context (Wasti, 1998). As a result, the meaning and effectiveness of management knowledge in a different context can only be achieved through various adaptations and modifications (Ansari et al., 2014; Lam, 1997; Tayeb, 1998).

The translation phenomenon, which forms the basis of the Scandinavian approach, refers to the process by which management knowledge adapts to new contexts. To achieve this adaptation, it is argued that management knowledge and practices need to be reshaped according to local cultural differences and requirements. The interaction of management knowledge with the elements of the context in which it exists initiates a process where this knowledge acquires a new context-

specific meaning (Boxenbaum & Pedersen, 2009). In this context, it is emphasized that management knowledge will inevitably undergo change (Czarniawska & Joerges, 1996). Management knowledge, when transferred to a different environment, interacts with the local elements of that environment, leading to reinterpretation and reshaping. As a result, management knowledge acquires context-specific qualities, becoming a version of its original form. This process is defined as the "translation" of management knowledge, and it is emphasized that it will gain different meanings in each context (Sahlin & Wedlin, 2008; Czarniawska & Joerges, 1996). Legal, social, economic, and political factors are considered context-specific influences in the translation process of management knowledge (Gooderham et al., 1999; Alvarez & Mazza, 1998; Sahlin-Andersson & Engwall, 2002). It is stated that these factors vary across contexts and therefore do not possess universal characteristics (Sahlin & Wedlin, 2008). Various critical studies conducted in Europe, particularly in countries such as the United Kingdom (Ferner, 2005; Jack & Lorbiecki, 2007; Lorbiecki & Jack, 2000), the Netherlands (Boxenbaum, 2006; Heres & Benschop, 2010), Finland (Sippola & Smale, 2007), Denmark (Risberg & Soderberg, 2008), Sweden (Omanovic, 2009), France (Klarsfeld, 2009), and Belgium (Janssens & Zanoni, 2005), conclude that management knowledge is not a universal phenomenon (Omanovic, 2009).

The individual's perception of themselves as part of organizational processes (such as access to information and resources, participation in workgroups, and involvement in decision-making processes) forms the definition of inclusivity at the business level (Mor-Barak & Cherin, 1998). Inclusivity emerged from the restructuring of diversity management knowledge to align with the macro-institutional dynamics of the European context. In this framework, all studies and definitions developed regarding inclusivity (e.g., Pelled et al., 1999; Roberson, 2006; Miller, 1998; Mor-Barak & Cherin, 1998) show that they share a common foundation on the dimensions of uniqueness and belonging, as proposed by Shore et al. (2011). Shore et al. (2011) theorize inclusivity based on Brewer's (1991) optimal distinctiveness theory, which posits that inclusivity encompasses behaviors that satisfy both the need for uniqueness and belonging (Shore et al., 2011). The optimal distinctiveness theory suggests that inclusivity occurs at the point where assimilation and differentiation are optimal. Within this theory, when inclusivity is at its highest, differentiation is at its peak, and assimilation is at its lowest. Conversely, when inclusivity is at its lowest, the process of assimilating individuals is at

its highest, and individual differences are minimized. In this context, inclusivity is said to occur at an optimal level where assimilation and differentiation are equal (Brewer, 1991). At the point defined as optimal, individuals feel high belonging and high uniqueness, while at the assimilation point, where inclusivity is lowest, they experience high belonging and low uniqueness. Shore et al. (2011) suggest that individuals seek to balance their need for similarity and belonging with others while also maintaining a unique identity, based on the principles of optimal distinctiveness theory.

In this regard, Shore et al. (2011) explain that inclusivity occurs when both high uniqueness and high belonging are present. They state that low uniqueness and low belonging lead to exclusion, high uniqueness and low belonging lead to differentiation, and low uniqueness and high belonging lead to assimilation (Shore et al., 2011). These defined dimensions of inclusivity can be said to become prominent and defined within a European-specific framework. Therefore, from an institutional perspective, it is emphasized that the dimensions of inclusivity must be restructured according to the value system of the country in question. However, studies on this topic remain limited. Nevertheless, in their work focused on translating and recontextualizing inclusivity, Tang et al. (2015) identified the concept of tolerance as a China-specific dimension, in addition to the dimensions of belonging and uniqueness. As inclusivity was transferred to China, expressed through high uniqueness and high belonging, it was redefined with the context-specific dimension of tolerance during the process of translation and recontextualization.

From an institutional perspective, it is expected that inclusivity will acquire new dimensions and contents within the context of Turkey due to contextual differences. In other words, as a management practice and organizational phenomenon, inclusivity is likely to be reinterpreted and framed by actors in Turkey, with new meanings reflecting the characteristics of the local context. In this regard, under the heading of "Turkish Institutionalism," the unique institutional characteristics of Turkey that may influence the perception of inclusivity will be evaluated.

Syed and Özbilgin (2009) address the differences between contexts through a relational framework of macro, meso, and micro factors, along with the historical process. In this framework, the macro level includes laws, institutions, religion, culture, and political and economic structures; the meso level focuses on interorganizational relationships and their effects; and the micro level covers

individual identity, roles, and actions (Syed & Özbilgin, 2009). According to the relational framework, the historical process is viewed as the most general factor that determines the differences between contexts. In other words, while the macro, meso, and micro levels are interrelated, the events that occur in the historical background of the context are considered the foundation of this relationship (Syed & Özbilgin, 2009).

Each context has its own historical process and the macro, meso, and micro factors that shape this process, and therefore, the interaction of these factors shapes the context. When management knowledge is transferred to a context, it aligns with these factors and is reinterpreted in a context-specific way (Sahlin & Wedlin, 2008). For this reason, it is expected that management knowledge will differ in each context. The concept of inclusivity is also an outcome of the translation of diversity management within the European context. In the European context, inclusivity has been conceptualized through the dimensions of high belonging and high uniqueness. From this perspective, it can be stated that Turkey differs from Europe in terms of its legal, political, economic, religious, and socio-cultural aspects.

In the context of Turkey, religious influences are particularly prominent. The Islamic religion and established cultural motifs define a different social structure in terms of gender roles, family structure, and workforce participation (Bakıcı & Aydın, 2020). The religion, culture, and beliefs of societies assign different roles to men and women (Terzioğlu & Taşkın, 2008). It can be stated that the values established by Islam in society have a significant influence on shaping gender roles, with expectations for women to take on domestic responsibilities and child care duties. Due to gender-based stereotypes, women are often excluded from education and are associated with domestic duties and child care (Beydili et al., 2013; Zavalıç & Ateş, 2021). Men, on the other hand, are responsible for managing both the home and the external, public spheres.

The patriarchal structure plays a significant role in the formation of gender roles (Bakıcı & Aydın, 2020). This patriarchal system causes women to take on multiple roles, which results in their unequal access to education and economic resources (Bakıcı & Aydın, 2020). The impact of the patriarchal structure on the labor market limits women's access to resources, thereby hindering their participation in the workforce (Bakıcı & Aydın, 2020). As a consequence, women face discrimination in areas such as politics, economics, and social life (Yıldırım, 2021). Discrimination against women in the

business world is categorized into horizontal and vertical discrimination. Horizontal discrimination refers to the distinction between male and female professions and wage inequalities even in equivalent jobs, while vertical discrimination refers to the barriers women face in accessing decision-making processes (Yıldırım, 2021).

It is emphasized that in Turkey, women lag behind men in terms of labor force participation and compensation, particularly being limited to lower levels in management positions (Yıldırım, 2021). Traditional male norms and values dominate the management hierarchy in the workplace. It has been observed that during women's career advancement and promotions, there is a higher level of trust placed in men, and prejudices play a significant role (Kutanis & Ulu, 2016). The lower representation of women in top-level positions indicates that social prejudices are also present in these areas (Yıldız, 2014). Although Article 10 of the Constitution and Articles 5 and 18 of the Labor Law provide a legal basis against discrimination, some legal regulations still limit women's participation in the workforce (Dedeoğlu, 2009).

As a result, it is expected that the concept of inclusivity, which emerged from the reinterpretation of diversity management in Europe, will be understood and applied in Turkey in accordance with the historical and social characteristics of the local context.

RESEARCH DESIGN

When an issue or topic needs to be examined in depth, when the goal is to address a complex situation in detail, when it is important to clarify the context in which a problem is evaluated, and during the process of theory development, qualitative research is preferred (Creswell, 2021). Therefore, in this study, which investigates how the concept of inclusivity is defined and perceived within the Turkish context, qualitative research methods have been used both due to the research question and because they provide the opportunity for in-depth definition and interpretation of the inclusivity concept in the Turkish context.

Qualitative research includes designs such as narrative inquiry, theory building, ethnography, case study, and phenomenology (Tekindal & Uguz Arsu, 2020). In the phenomenological design, the focus is on studying the experiences that people are aware of in their daily lives, aiming to understand how a particular phenomenon or concept is experienced (Schram, 2003). This design seeks to explain how a relatively unknown phenomenon manifests in people's lives (Yıldırım & Şimşek, 2018).

In this study, the aim is to understand what kind of knowledge individuals have about inclusivity and how they experience and interpret it. Since the focus of the research is on personal meanings and experiences related to inclusivity, the phenomenological design has been considered appropriate.

There are different views regarding the number of participants chosen for a study. Research shows that the number of participants can range from 1 to 325 (Creswell, 2021). Some sources suggest that the number of participants can be limited to a maximum of 10 (Yıldırım & Şimşek, 2018), while others indicate that the range can be between 6 and 20 (Wilson, 2015). In the sample selection phase, maximum diversity and snowball sampling methods were preferred. Maximum diversity sampling involves including different individuals or situations, while snowball sampling involves current participants recommending other potential participants (Creswell, 2021). In this context, participants from various industries were included, and data was collected based on the recommendations of the participants. The study focused on participants actively working in Bursa. The aim was to select participants from different sectors. The study sample consists of 21 participants aged 35-45 from white and blue-collar workers in the tourism, education, healthcare, logistics, food, public, and manufacturing sectors. The participants were asked the following questions during the interviews: "What does inclusivity, being inclusive, and being included mean? Can you explain?" "What factors make a business an inclusive company?" "What situations show that your coworkers are inclusive?" The participants' identities were kept confidential, and each participant was coded according to the order of the interview as P1, P2, and so on (P1=Participant1, P2=Participant2).

In the study, the data were analyzed using both content analysis and descriptive analysis methods. In content analysis, the data are first coded, then themes are created, and the codes and themes are organized to interpret the findings. Descriptive analysis, on the other hand, involves interpreting and providing explanations based on direct quotations from the participants' statements within the established themes (Yıldırım & Şimşek, 2018).

In this study, the data were coded using the in vivo method. The in vivo method refers to the process in which the researcher uses the participants' own words and expressions, rather than the researcher's own terminology, for coding (Saldana, 2019). In the open coding phase, participants' statements were

directly assigned as codes to identify the context-specific dimensions of inclusivity. During the axial coding process, categories were created based on the participants' statements. In the selective coding phase, themes from the literature were taken into account. As a result, codes, categories, and themes were developed using the in vivo method. The goal was to achieve clear codes after several rounds of coding, followed by the identification of categories and themes (Saldana, 2019:9). In this process, participant statements with similar meanings were grouped together, and categories were created from these codes. Categories were considered as elements that add meaning to the data (Dey, 1999). The resulting categories were interpreted as dimensions that demonstrate how the concept of inclusivity is understood, and to clarify this interpretation process, a descriptive analysis was conducted based on the relevant participant statements.

In quantitative research, validity and reliability can be determined through measurement methods, whereas in qualitative research, it is difficult to fully define these concepts (Baltacı, 2019). The qualitative researcher must take appropriate precautions to obtain accurate information (validity) and provide a detailed explanation of the research process, allowing others to examine it (reliability). In this study, various steps have been taken to ensure validity and reliability (Yıldırım & Şimşek, 2018).

Internal Validity: Expert opinions were sought, and participant diversity was prioritized. Comprehensive explanations were provided to participants before the interviews, and an environment of trust was established. The interviews lasted 20-25 minutes, and participant confirmation was carefully ensured. The participants' responses are directly quoted in the findings section.

External Validity: To ensure external validity, the study model, data collection methods, selection of the study group, employed techniques, data analysis, and findings have been clearly stated.

Internal Reliability: The same questions were asked to each participant, in the same order and with the same approach. The interviews were recorded with the participants' consent to prevent data loss.

External Reliability: The results obtained were continuously verified and updated with newly collected data.

FINDINGS

Main Theme of Inclusivity

Participants were asked to provide information in response to the question, "What does inclusivity, being inclusive, and being included mean? Can you explain?" The codes, categories, and themes derived from the participants' responses are presented in Table 1. Participants defined inclusivity through the concepts of disregarding differences, high similarity, acceptance, belonging, and respect. Below, the findings for each category are explained sequentially, along with the participants' perspectives.

Descriptive Analysis of Statements Regarding the Setting Aside Differences - High Similarity Dimension

The participants provided the following responses to the question: "What does inclusivity, being inclusive, and being included mean? Can you explain?"

P3: *Inclusivity is the ability for people to be together. It means simply existing as a human being when being together, where everything else becomes irrelevant.*

P5: *What I'm actually trying to say is to see the things that are not like me, the things that are different from me, as the same as me. I believe that inclusivity is being part of the whole.*

Table 1: Categories and Codes Related to the Question "What does Inclusivity, Being Inclusive, and Being Included Mean? Can You Explain?"

Theme: Inclusivity	
Categories	Codes
Setting Aside Differences - Similarity	Regardless of differences, Breaking external, Stereotypes, Setting aside differences, Your being as a human, Despite differences, See as the same, Overlooking different circumstances, "Not saying 'Why are you like this?'," Putting aside differences, Not separating people, Not considering any differences
Acceptance/Being Accepted – Belonging	Being accepted as I am, Being accepted as they are, Accepting what exists, Making them feel like one of them, Accepting despite their differences, Accepting as they are, To accept, Accepting everyone as they are, Accepting as it is, Accepting with all their characteristics, Accepting as they are, Not being left out, Being accepted, We must accept their existence, If they accept with your thoughts
Respect	You need to show respect, You must show respect, By showing respect, If they include respect among their values, Respectful communication, I associate it with respect, I must show respect, If they show respect, I show respect, If they show respect to me, Show respect, You must show respect, One who shows respect, Move forward with respect, Respecting each other, If there is respect, The respect I receive, First, you must show respect, They must show respect, You will learn to be respectful, I want them to show respect, Respect for my personality, If they respected my lesson, By showing respect, Essentially, respect, If you show respect, Just show respect, They must show respect, If they show respect, They should show respect, In respect, We must respect each other, They will show respect, Respect is the foundation of everything

P13: *I believe it's about not saying, "Why are you like this?"*

P17: *Keeping people within the circle. Not separating them. Being able to be together without dividing people for reasons like "this is a woman, this is a man," etc.*

From the participants' statements, it can be seen that the concept of inclusivity is understood around the idea of disregarding or setting aside people's differences. In this context, the participants essentially define a "difference-blind" approach. The act of disregarding people's differences does not imply the meanings of not perceiving, ignoring, denying, dismissing, or overlooking those differences. In a difference-blind approach, the goal is for individuals' differences to be disregarded in a way that does not affect their value or relationships. In the case of disregarding people's differences, the expected outcome is a sense of similarity or the expectation to become like one of them. Participants express a high level of similarity and explain inclusivity based on this idea. Inclusivity is considered equivalent to similarity based on "being human." The participants' statements in this regard are as follows:

P21: *It is something like the teaching of Mevlana: "Come as you are, regardless of who you are, without considering anything about the people, without looking at their differences, and without seeing that situation."*

P14: *It involves transcending things such as where a person is from, where they come from, who their father is, ethnicity, gender, LGBT status, etc., setting aside their differences, and disregarding their differences.*

P2: *Regardless of the differences, no matter how many superior aspects the other person may have, it means being able to professionally accept that person without getting stuck in their traditions, political views, or any conflicting opinions.*

From the above explanations, it can be concluded that the understanding of difference is comprehensive. Difference is considered not only as visible characteristics but also as deep features such as people's different experiences, abilities, and views. The understanding of inclusivity is evaluated as the acceptance of people's differences being disregarded, based on similarity, being alike, and as the opposite of exclusion.

Descriptive Analysis of Expressions Related to the Dimension of Acceptance/Being Accepted

When examining the codes related to the acceptance/being accepted category, it can be concluded that the common meaning of these codes is the necessity

of accepting people as they are and disregarding the differences individuals may possess. The main emphasis in these codes is that people need to fully accept themselves and others, and this acceptance should occur regardless of the individual's characteristics, thoughts, identity, or existence. In the acceptance/being accepted category, it is emphasized that everyone is equal and valuable, and that individuals should be accepted for their unique characteristics. Additionally, it is highlighted that in order to prevent feelings of exclusion, individuals should be accepted by disregarding their differences.

The expressions of participants regarding acceptance/being accepted in inclusivity are as follows:

P8: *Accepting everything and everyone, with all their characteristics, as they are.*

P9: *Accepting a person regardless of what they are or how they are.*

P13: *To be inclusive means to first accept everyone as they are.*

P4: *It feels like opening your arms. Accepting what exists, reaching the whole through the part. It is about embracing and being embraced.*

P18: *It is about accepting a person as they are and helping them grow in whichever area they want to succeed within your own space.*

Upon examining the expressions, it is observed that inclusivity is generally shaped within the dimensions of acceptance/being accepted, by disregarding individuals' differences. The frequently used expressions by the participants, such as "accepting as they are," "accepting the person as they are," and "accepting everyone as they are," highlight the necessity of accepting differences and inclusivity. While these expressions emphasize the importance of unconditionally accepting individuals' identities, characteristics, or differences, it is understood that inclusivity is not considered as a process of creating or fostering a sense of belonging. Inclusivity refers to the acceptance of individuals while disregarding their differences and the process of inclusion. In this context, disregarding individuals' differences may support a sense of belonging. However, it is evident that participants do not use the concepts of acceptance/being accepted and belonging interchangeably. Therefore, while participants emphasize the necessity of accepting differences and inclusivity, it is concluded that they do not perceive it as a process of creating a sense of belonging.

Descriptive Analysis of Expressions Related to the Dimension of Respect

Participants express that factors such as not judging, being unbiased, and being tolerant facilitate individuals' ability to accept and respect each other's differences. These elements promote mutual understanding and empathy, and they also play a role in the processes of acceptance and similarity. Not judging allows individuals to control their biases and maintain an open-minded attitude. Being unbiased makes it easier to approach others with greater understanding, while being tolerant encourages respect for different perspectives and helps individuals recognize differences. These factors are complementary to respect; not judging, being unbiased, and being tolerant play a critical role in the acceptance of individuals with their differences. Respect is closely linked to seeing, understanding, and valuing differences. Therefore, the presence of respect, in combination with these factors, increases the tendency to accept differences by disregarding them and reduces feelings of alienation. The participants' explanations are as follows:

P16: *This view is about respecting differences. Not judging the other person based on their different characteristics. Not seeing these differences. Simply evaluating them as a human individual. Listening, being able to listen.*

P17: *You have to respect them. Now, just because there is respect, everything doesn't disappear at once. If someone is still a woman, or if someone is still disabled, but when there is respect, no intervention is made, do you understand what I mean? This way, everyone will be within the circle. You don't judge, you don't interfere, you don't seek reasons, you accept them as they are. Thus, the outcome won't lead to division.*

P18: *If there is respect, they will accept things as they are, and the problem will be solved. You shouldn't judge. You need to listen to people's stories. You could be in the same situation, and once you think that, you feel that you have to respect them.*

P15: *Basically, I am talking about respecting. I am like this. If everyone respected everything about everyone, every difference, the problem would disappear. Then you will start to include, you will become inclusive.*

The above statements show that a respect-based understanding plays a significant role in the formation of inclusivity. This understanding comprehensively addresses both the internal (character, values, emotions) and external (physical appearance, gender, place of residence) attributes of an individual. Achieving inclusivity is possible when both of these characteristics are respected. Respecting people's differences and

Table 2: Categories and Codes Related to the Question "What Are the Factors That Make a Business an Inclusive Business?"

Theme: Business Inclusivity	
Categories	Codes
Incorporating Diversity	Regardless of who or what I am, Embracing diversity, Embracing difference, By ensuring diversity, They will want female employees, They will want employees with disabilities, They will want employees with different sexual orientations, Including everyone, Embracing everyone, If it does not lead to segregation
Ensuring Merit	Based on their qualifications, Ensuring they are in a position where they can emerge, To an area where they are competent, Evaluating in terms of job potential, Based on job performance, Assigning the job to the right person, By employing according to their qualifications, By positioning them correctly in the right place, Looking at the work the employee does, Does he/she do the job well?, Does he/she know the job?, Is he/she suitable for the job?, You are the expert, Hiring according to the job, If he/she can do the job in the best way, Focus on the job he/she is doing, An unrelated person has been promoted, Having competent people, If he/she does the job properly, He/she is doing the job well,
Participation in Decisions with Ideas and Suggestions	Being able to have ideas listened to, Being given the right to speak, My opinion should be heard, Being able to present ideas, Making decisions together, Should be open to every idea, He/she should provide an explanation, Ensuring finding common ground, Acceptance of suggestions, Feedback, Ask for my opinion as well, Why isn't my opinion being asked?, Listening to that idea, He/she asks me too, Ideas should be evaluated (feedback), My opinion is not being asked, Decision-making mechanisms If my opinion is taken as well

being free from prejudice supports the creation of an inclusive environment. Showing respect for differences without prejudice facilitates the integration process of individuals. Respect forms the foundation of the aspects of ignoring and accepting individuals' differences, which constitute the definition of inclusivity. It is understood that these three dimensions are interconnected and that respect is effective in both the processes of ignoring individuals' differences and the process of acceptance. While inclusivity is seen as the process of accepting and being accepted, the dimension of respect plays a crucial role in realizing these processes. Additionally, it is stated that these three dimensions, which define inclusivity, are also connected to inclusivity in business and among colleagues. This connection will be explained in more detail below.

Main Theme of the Business's Inclusivity

The question "What are the factors that make a business an inclusive business?" was asked regarding the inclusivity of the business, and the participants explained the business's inclusivity through the dimensions of ensuring diversity, merit and performance, and participation in decisions through ideas and suggestions. The categories and codes related to this theme are shown in Table 2.

Descriptive Analysis of Statements Regarding the Inclusion of Diversity Dimension

Participants express that the understanding of diversity plays a critical role in business inclusivity. They emphasize that promoting diversity within companies forms the foundation of inclusivity. Within this framework, essential components of inclusivity include overlooking differences, acceptance, and respect. Diversity encompasses the processes through which individuals within a business feel accepted and valued despite their differences; this process is facilitated by respecting differences and providing opportunities for participation. Participants also define business inclusivity in contrast with concepts like discrimination and exclusion. An organization is considered inclusive if it prevents discrimination and avoids exclusion. Participants' statements are as follows:

P3: "A company is inclusive if it accommodates all the differences I mentioned earlier, and if people with diverse backgrounds can still be there despite their differences."

P4: "It should be able to include diversity without distinguishing between religion, language, race, or gender and be able to work with everyone."

P7: "If they don't want female employees, they should want them; if they don't want employees with disabilities, they should want them; or if they don't want an employee with a different sexual orientation, they should still want them. Even if they don't want to, they should be obligated to hire them."

P15: "As long as they accept everyone and everything as they are, and as long as they include them in the work process normally. This is how it should be. The attitude of the employer who is at the head of the company, who hires... If the employer says, 'we can't hire this person because they are a certain way,' or if they say no to someone else, then it won't be inclusive."

Descriptive Analysis of Statements Regarding the Merit-Based Dimension

Participants state that companies should focus solely on job performance and qualifications when evaluating employees. They emphasize that personal and external factors, such as gender, age, ethnicity, or religious beliefs, should not be considered in the evaluation process. To ensure merit, participants highlight the importance of establishing an objective evaluation process based on criteria designed to fairly assess job performance. Additionally, they express that a fair work environment, where everyone has equal opportunities and experiences no discrimination, supports meritocracy. Participants' perspectives are as follows:

P20: "My perspective is this: if a person is doing their job properly, then what they believe in, wear, or choose to express should not matter. It's quite ridiculous to interfere in any of that."

P1: "People can have different characteristics; they could be women, men, or have any kind of personal preferences, but that doesn't matter. In my view, inclusivity means accepting people based on their qualifications, without looking at personal traits."

P15: "The same should go for workplaces. Don't pass over someone for being different during the hiring process. Focus on the job they're doing; other personal details shouldn't concern you."

Descriptive Analysis of Statements on Participation in Decision-Making through Ideas and Suggestions

In corporate inclusivity, considering employees' ideas and suggestions emerges as a critical factor that enhances their satisfaction. Gathering employees' views indicates that their presence and contributions are valued. Participants expressed their thoughts on

participation in decision-making through ideas and suggestions as follows:

P6: “That workplace should make me feel like I exist. For example, my opinion should be heard as well. Whether it’s accepted or not, I should still be listened to. If it’s not accepted, the reasons for that decision should be explained to me.”

P15: “They ask me, for example, what should we do, and they take my opinion—this makes me very happy. I feel good; I feel like I am somebody in that company.”

P7: “Employees should be able to present their ideas to management. They should create an environment by working and thinking together, and by making decisions collectively.”

Main Theme of Inclusiveness Among Colleagues

In response to the question, “What situations show that your colleagues are inclusive?” participants associated inclusiveness among colleagues with aspects such as collaboration, solidarity, and intra-group communication and socialization. Table 3 presents the codes and categories that illustrate the inclusiveness of colleagues.

Descriptive Analysis of Expressions Related to the Collaboration and Solidarity Dimension

The analysis of the codes related to collaboration and solidarity emphasizes the importance of mutual help in the inclusivity of coworkers. It is understood that support and mutual assistance between employees are fundamental elements of inclusivity. Due to the connections between the tasks employees perform, there is a high expectation for mutual help and support. Furthermore, the ability to share aspects of their personal

lives outside of work and assist one another in these matters clearly illustrates how inclusivity is achieved. The participants’ views are as follows:

P4: “There are tasks that need to be done, and without saying ‘this is your job or mine,’ everyone pitches in. They provide support.”

P17: “Everyone looks out for each other. We have a team that works with heart. We do everything together.”

P12: “When my coworkers organize everything efficiently, it makes me feel like I am included by them, and they don’t ignore me or my work.”

P20: “If we can make joint decisions about the work we do, and even about each other’s personal lives, discussing and exchanging ideas is nice.”

P9: “When I need something, I want to be sure that someone will help me, at least one person.”

Descriptive Analysis of the Group Communication-Socialization Dimension

Participants explain how communication and collaboration affect inclusivity. The importance of joint decision-making and idea exchange is particularly emphasized. These statements reveal that interactions and cooperation among coworkers play a critical role in creating an inclusive work environment. It is understood that misunderstandings arising from a lack of communication can weaken inclusivity. This situation highlights the necessity of open and effective communication in the workplace, while demonstrating that collaboration and idea exchange help coworkers understand and support each other. Below are the participants’ views:

Table 3: Categories and Codes for the Question “What Situations Show That Your Colleagues Are Inclusive?”

Theme: Colleagues Inclusivity	
Categories	Codes
Collaboration and Solidarity	Helping each other, Supporting one another, Coming together on common ground, Providing support, Assisting each other, Being helpful, Offering help, Working in an organized manner, Doing everything together, Discussing things collectively
Intra-group Communication-Socialization	Let’s make coffee and drink it, Being able to catch the communication, Including someone, Asking “Will you come too?”, Inviting someone when going for a meal, Sharing many things, Coming and telling me, Asking “How are you?” for example, Inviting me when going for a meal, They didn’t include me, Sharing information, Polite and sweet communication, At least they could have invited me, If it was offered, We would have come together and talked, We would have discussed how to do it, They didn’t greet me, Not engaging with me

P15: *"I like to be cared for, for example, if they ask me, 'How are you?' If I'm sick, I'd like them to call me. It makes me feel good."*

P21: *"They didn't greet me, didn't say good morning. They were excluding us. But it wasn't personal; it was a general attitude towards all the workers, except for a few people they liked. Things like this happen at the workplace. If it happens, I don't know, it could be a hierarchy issue, like when someone becomes the boss and stops interacting with the subordinates."*

P6: *"Communication, first, it's about being able to catch the communication. It's something related to being able to catch this communication, for example, my coworkers might have gone out together at that moment. Maybe there was something happening at that moment that didn't concern me, something that was just about them. Once they explain this to me... catching the communication."*

The participants statements indicate that being invited to social events and participating in group activities positively affect inclusivity among coworkers. Additionally, the ability to share personal life and go beyond professional relationships by attending social events together is seen as contributing to fostering inclusivity. The participants views are as follows:

P11: *"Also, since they share most things with me, I feel included by my friends. Even when they come and tell me the smallest thing, it makes me feel included. We can even meet and talk outside of work. We sit together, we go out. I feel it."*

P6: *"When they ask, 'Will you come too?' when they're going on break or when they offer me a drink, those things definitely show that my coworkers are inclusive."*

P8: *"But if everyone goes to lunch together and they don't invite me, I would be very upset. If I go alone, it would make everyone sad. This situation forces a kind of friendship, and feeling and making others feel included in such cases is important because it creates a sense of inclusion."*

CONCLUSION

The concept of inclusion that emerges as a result of the translation process of diversity management practices within the European context, adapted to local conditions, has been theorized by Shore et al. (2011) through the dimensions of high uniqueness and high belonging. This study examines the translation process of the concept of inclusion within the context of Turkey, and it is expected that context-specific dimensions will emerge. When analyzing the research findings, it was determined that

in Turkey, inclusion is defined through the dimensions of high similarity, acceptance, and respect. In this context, the translation of inclusion dimensions shows differences according to Turkey-specific dynamics.

When the findings are evaluated, it is observed that in the context of Turkey, the concept of inclusion is approached with a "blind to differences" perspective, where differences are overlooked, and a high level of similarity expectation is emphasized. Participants do not express any statements regarding the presentation or highlighting of differences, the richness brought by differences, or how these differences can be utilized. This indicates that inclusion is more often experienced and expressed with a "blind to differences" approach. This expectation of similarity highlights the dimension of acceptance or being accepted. In the European context, the ability of individuals to exist with their differences is transformed in Turkey into an approach where respect for differences is shown, but these individual differences are ignored. It is observed that the dimension of inclusion, defined as high belonging in the European context, is expressed as acceptance or being accepted in the Turkish context. The findings suggest that in Turkey, inclusion is primarily evaluated in terms of acceptance or non-acceptance, and it is not understood as a process of creating or feeling belonging. In this regard, it is concluded that the dimensions of inclusion built on high uniqueness and high belonging in Europe are defined in Turkey within the framework of respect, ignoring individual differences—high similarity, acceptance/being accepted, and respect.

According to the theory of optimal distinctiveness, inclusion occurs at an optimal level at the intersection point where assimilation and differentiation are in balance. This theory suggests that, at the point where inclusion is at its highest, differentiation reaches its peak, while assimilation remains at its lowest level. In contrast, at the point where inclusion is at its lowest, the level of assimilation is at its highest, and individual differences are minimized. Therefore, when a balance between assimilation and differentiation is achieved, inclusion is said to occur at its optimal level (Brewer, 1991). In this context, an individual experiences both a high sense of belonging and high uniqueness at the optimal point, while in a situation dominated by assimilation, they experience a high sense of belonging and low uniqueness.

The dimensions of inclusion examined in the context of Turkey are characterized by high similarity and high acceptance/belonging. Respect emerges as a

fundamental element of this understanding of inclusion, and the dimensions of high similarity and acceptance are evaluated within this framework of respect. The respect for individuals' differences leads to the disregard of these differences, thus adopting a "blind to differences" approach. This approach causes individuals to show a greater tendency to conform to group norms by ignoring their own differences. This high expectation of similarity, based on the essence of being human, strengthens the assimilation process. As a result, the dimension of acceptance or being accepted defines the assimilation individuals experience during this process. In the context of Turkey, it is concluded that inclusion and assimilation progress in parallel, with inclusion existing where assimilation occurs, and assimilation existing where inclusion is present.

In the case where inclusion is at its highest, assimilation reaches its peak while othering and prejudices, or alienation, are at their lowest level. On the other hand, in the case where inclusion is at its lowest, assimilation is at its lowest level, and alienation is at its highest level. In this context, inclusion can be classified into four types based on the dimensions of high similarity and high acceptance. According to the findings of the study, assimilation occurs with high similarity and high acceptance. Therefore, the optimal point where inclusion is achieved is defined as assimilation, leading to the conclusion that inclusion is an assimilation-based phenomenon. Assimilation refers to the situation where an individual's differences are overlooked in order to be accepted into the group.

Exclusion is defined by low similarity and low acceptance dimensions. According to the findings of this study, exclusion refers to the situation where an individual's differences are ignored, but they are not accepted into the group.

Alienation, on the other hand, is explained by high similarity and low acceptance dimensions. According to the study, alienation is described as the feeling of being marginalized, isolated, or misunderstood.

Integration is characterized by low similarity and high acceptance. In this case, the individual shows low similarity with the group, but is fully accepted within it. Even if the individual does not fully conform to the group norms or behaviors, and holds different values or opinions, they are still accepted by the group members.

Mor Barak and Cherin (1998) define organizational inclusiveness at the business level through dimensions such as access to information and resources, participation

in workgroups, and involvement in decision-making processes. They describe inclusiveness as an individual's perception of being part of organizational processes (Mor Barak & Cherin, 1998:48). Shore et al. argue that studies and definitions of inclusiveness in the European context share a common foundation in the dimensions of high uniqueness and high belongingness. In this context, Mor Barak and Cherin's (1998) definition of business inclusiveness highlights the dimension of high belongingness as one of the key aspects of inclusiveness.

In this study, inclusiveness is defined through the dimensions of high similarity and high acceptance, based on respect, in the process of accepting an individual's differences within the group. The findings show that there is a relationship between business inclusiveness and colleagues' inclusiveness, particularly through the dimensions of high similarity, acceptance, and respect. It is observed that the critical importance of accepting individuals' differences within a framework of respect is essential to enhance the effectiveness of business inclusiveness, which includes dimensions such as diversity, merit, valuing ideas and suggestions, and participation in decisions. It is suggested that businesses adopting this approach can increase diversity by fostering a work-focused strategy that does not overlook differences in employee recruitment and evaluations. Additionally, the necessity of ensuring merit based on performance and competence before focusing on individual differences is emphasized.

In this study, two fundamental dimensions of inclusiveness among colleagues are highlighted: collaboration and solidarity, and intra-group communication and socialization. The findings reveal that these dimensions play a critical role in the formation and strengthening of relationships among colleagues. Collaboration and solidarity are built upon elements such as mutual assistance and support, emphasizing the importance of individuals being accepted as part of the group. In this context, social identity theory suggests that individuals act based on comparisons between in-group and out-group members (Turner, 1982; Tajfel, 1978). On the other hand, optimal distinctiveness theory argues that individuals strive to balance the need for approval and similarity within the group with the desire for individuality and uniqueness. According to this theory, an individual's sense of belonging within the group is achieved by balancing the needs for approval and maintaining individuality (Shore et al., 2011). This balance, as proposed by the theory, is related to the process of being accepted within the group while preserving one's differences.

In this context, the findings obtained in Turkey emphasize that for individuals to be part of the group, their differences must be overlooked and they should be evaluated based on their humanity. It has been concluded that individuals who are respected for their differences can be accepted within the group by establishing high similarity. Therefore, it is believed that the dynamics of inclusiveness among colleagues will effectively emerge based on the dimensions of inclusiveness. Individuals who experience high similarity and acceptance within the group contribute to the development of collaboration, solidarity, intra-group communication, and socialization processes, thus reinforcing inclusiveness among colleagues. In this framework, the importance of being accepted as part of the group and having one's differences disregarded and evaluated is emphasized.

From an organizational perspective, it is argued that a management concept will reshape itself according to the unique characteristics of a different organizational context. Based on this approach, the dimensions of inclusivity specific to the Turkish context have been explored, and the context-specific elements of inclusivity have been identified. The research examines the translation process of the concept of inclusivity, an advanced management practice in the European context, in the Turkish context, and concludes that it is perceived through the dimensions of respect, high similarity, and acceptance in Turkey. These findings are significant in demonstrating how a management concept, when transferred to an organizational context with different characteristics from the one in which it originated, gains new meaning. Moreover, the discovery, understanding, and conceptualization of the dimensions of inclusivity specific to the Turkish context is expected to make a valuable contribution to the literature. The study presents important findings regarding how the concept of inclusivity is understood and interpreted in different cultural and organizational contexts. On the other hand, the perceptions of employees in Turkey, the meanings attributed to inclusivity, and the expectations surrounding this concept are crucial for human resources departments, which are responsible for developing and supporting policies aimed at increasing workforce diversity and ensuring inclusivity. Therefore, the contextual dimensions of concepts are decisive for both theoretical and practical studies. This study, with its exploratory nature, contributes to the theoretical field and provides insights for human resources practices and policies by helping to redefine the concept of inclusivity.

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A Smart - Selection - Based Genetic Algorithm for Delivery and Pickup Problem with Order Time Windows

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ABSTRACT

In a highly competitive environment, businesses strive to optimize their distribution networks to reduce logistics costs. This study focuses on solving vehicle routing problems involving simultaneous delivery and pickup with time windows, addressing both backhaul and divisible delivery and pickup scenarios. A novel hybrid genetic algorithm incorporating smart selection and harem-based crossover methods is proposed to minimize transportation costs while adhering to capacity and time constraints. The smart selection method expedites the solution process by pre-selecting feasible vehicle-route combinations, significantly reducing the computational complexity. Computational experiments on real-world data from the automotive supply industry demonstrate that the proposed algorithm outperforms traditional approaches, achieving substantial cost reductions and high-quality solutions within shorter computation times.

Keywords: Vehicle Routing Problem, Delivery and Pickup Problem, Genetic Algorithm, Smart Selection, Hybrid Optimization.

JEL Classification Codes: C44, C61

Referencing Style: APA 7

INTRODUCTION

One of the fundamental ways to reduce costs in enterprises is by minimizing logistics expenses, which constitute a significant portion of product costs. Distribution costs, accounting for approximately 50% of logistics expenses, are crucial for operational efficiency. The Vehicle Routing Problem (VRP), first introduced by Dantzig and Ramser (1959), plays a significant role in optimizing distribution networks. It focuses on creating a set of minimum-cost routes for a fleet of vehicles to meet customer demands, often subject to constraints like capacity, time windows, and precedence rules (Baker and Ayechev, 2003).

This paper discusses a delivery and pickup problem which is an extension to the VRP. The vehicles should not only deliver goods to the suppliers but also pick up some goods at the supplier locations. In this type of problem, there are two types of suppliers: linehaul and backhaul (Wang and Chen, 2013). A linehaul supplier requests a specific quantity of products to be delivered from the depot, while a backhaul supplier requires a certain

quantity of products to be collected and transported back to the depot (Liu et al., 2013). Our problem considers every supplier as either “as both linehaul and backhaul” or “as either linehaul or backhaul”. Hence, we must deliver to every supplier and pick up from every supplier for delivery to the depot.

Our paper also contains vehicle routing problems with backhauls (VRPB), which necessitates that all deliveries must be made on each route before any pickups can be made (Goetschalckx and Jacobs-Blecha, 1989). This is also named the delivery-first, pickup-second strategy. Allowing pickups before completing all deliveries could lead to vehicle overloading during the trip, which may render the tour infeasible (Wang and Chen, 2013). The above-mentioned strategy eliminates such infeasible vehicle tours. In this strategy, the vehicle can visit the supplier twice, first for delivery and then for pickup service. Therefore, this is called the divisible delivery and pickup problem.

Zhong and Cole (2005) introduced a local search heuristic specifically designed to address the VRPB.

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Customer precedence and time windows increased the problem complexity. They developed a new technique of section planning to solve the problem. Gajpal and Abad (2009) presented a multi-ant colony system algorithm for solving VRPB.

On the other hand, sometimes our problem includes simultaneous pickups and deliveries. The Vehicle Routing Problem with Simultaneous Pickup and Delivery (VRPSPD) is a problem where pickup and delivery services are simultaneously operated. The term simultaneous refers to the distribution of delivery and pickup of goods once the destination is reached. Vehicles visit the supplier only once and depart from the supplier after completing the delivery and pickup operation simultaneously. The problem has garnered significant attention from researchers due to its efficiency in managing both services effectively.

VRPSPD was first introduced by Min (1989) for the library distribution system. Dethloff (2001) developed a heuristic algorithm based model for the VRPSPD in reverse logistics processes. Dell'Amico, Righini, and Salani (2006) proposed a dynamic programming model based on the branch and price algorithm for a solution to the VRPSPD in reverse logistics processes. Ashouri and Yousefikhoshbakht (2017) presented metaheuristic models based on the ant colony optimization (ACO) algorithm to solve the VRPSPD.

In this study, we address a complex VRP scenario involving simultaneous delivery and pickup with order time windows, capacity constraints, and real-world operational requirements. Unlike traditional approaches, we propose a novel hybrid genetic algorithm (GA) that incorporates smart selection and harem-based crossover methods. The smart selection method expedites the solution process by pre-selecting feasible vehicle-route combinations, significantly reducing the computational complexity. The harem-based crossover mechanism enhances genetic diversity and accelerates convergence to high-quality solutions (Çiçekli, 2012).

Key contributions of this study include:

1. Development of a hybrid GA tailored for simultaneous delivery and pickup operations with time windows.
2. Application of the algorithm to real-world data from the automotive supply industry, demonstrating its practical effectiveness in reducing transportation costs.

3. Integration of the harem-based crossover method into the GA framework, inspired by biological processes, to improve solution quality and computational efficiency.

By addressing these theoretical and practical challenges, this paper provides a robust framework for optimizing logistics operations under competitive and real-world constraints.

PROBLEM STATEMENT

The Vehicle Routing Problem with Time Windows (VRPTW) is a well-established NP-Hard problem, as identified by Lenstra and Kan (1981). An NP-Hard problem is characterized by the exponential growth of computational complexity as the problem size increases, making classical solutions impractical for large-scale instances. Anily (1996) further highlights that solving such problems requires heuristic or metaheuristic approaches, as exact methods become computationally infeasible. These heuristic methods aim to find near-optimal solutions within polynomial running times, balancing solution quality and computational efficiency.

This study addresses the VRP of a company operating in the automotive supply industry. Due to competitive concerns, the names of the company and its suppliers are kept confidential. Different processes are carried out with the suppliers, depending on the product structures of the company. As a result, either empty or filled boxes can be delivered to the suppliers, while only filled boxes are picked up from them.

The problem involves three different suppliers, referred to as S1, S2, and S3. Route costs vary based on vehicle type and route length, reflecting the operational complexity of the problem.

The company uses the following two types of vehicles that have different maximum permissible weights: semi-trailer trucks and trucks. The maximum load limit is 25000kg for a semi-trailer truck and 12000kg for a truck.

Since the company outsources vehicles, the study had no vehicle limitation. Therefore, all route types [(S1), (S2), (S3), (S1, S2), (S1, S3), (S2, S3), (S1, S2, S3)] and two vehicle types (semi-trailer trucks and trucks) were available for use each day within the specified time periods. As a result, 15 different vehicle-route combinations were created for each day. If a vehicle visits S1, S2, and S3 in sequence, it returns via the reverse route, S3, S2, and S1. Deliveries are made during the outbound journey, while pickups occur on the return journey. No pickups

Table 1: Example of Delivery and Pickup Orders with Time Windows

Order No	Supplier	Box (pcs)	Weight (kg)	Earliest (day)	Latest (day)	Order No	Supplier	Box (pcs)	Weight (kg)	Earliest (day)	Latest (day)
DO1	S3	36	160	6	8	PO1	S3	15	250	6	8

can take place before the outbound route is completed. Therefore, vehicle capacity is calculated separately for deliveries and pickups. Additionally, empty or filled boxes delivered to or picked up from any supplier had to adhere to specific time intervals. It was known how many empty or filled boxes had to be delivered to which supplier on which dates and how many filled boxes had to be picked up. For convenience, each order was encoded as "DO" for departures and "PO" for returns. Table 1 shows an example of departure and return orders.

In the VRP, costs vary depending on route length and vehicle type. The objective of the VRP was to minimize transportation costs. This study aimed to minimize the cost of selected routes and vehicles within the specified period.

A method called smart selection was developed to make the model run faster. Using smart selection, clusters of vehicles with suitable routes and schedules were generated for each order. If smart selection had not been used, there would have been $6,5332E+127$ different potential solutions to the problem. Since orders can be assigned to appropriate vehicles, the vehicles are only checked for weight capacity. There is no volume restriction on vehicles, since the company's orders involve low volume high weight goods. Given these conditions, there are $1,2349E+72$ different potential solutions to the problem. The problem addressed in this study extends the complexity of VRPTW by incorporating simultaneous delivery and pickup operations with time windows, vehicle capacity constraints, and multiple route scenarios. To handle these challenges effectively, this study proposes a hybrid GA that integrates smart selection and harem-based crossover mechanisms. The smart selection method pre-screens infeasible routes, significantly reducing the solution space and ensuring computational feasibility. Meanwhile, the harem-based crossover mechanism enhances genetic diversity within the population, preventing convergence to suboptimal solutions.

MATHEMATICAL MODEL

This section presents the mathematical model developed to solve the VRPSPD, time windows, and capacity constraints. The model minimizes the total

transportation cost while ensuring that operational and logistical constraints are satisfied.

Sets

S : Set of suppliers, $S = \{s_1, s_2, s_3\}$.

V : Set of vehicles, $V = \{v_1, \dots, v_v\}$.

D : Set of delivery orders, $D = \{d_1, \dots, d_i\}$.

P : Set of pickup orders, $P = \{p_1, \dots, p_i\}$.

Parameters

C_v : Capacity of vehicle $v \in V$.

T_v : Scheduling time of vehicle $v \in V$.

R_m^v : Cost of delivery route m for vehicle $v \in V$.

R_j^v : Cost of pickup route j for vehicle $v \in V$.

W_{d_i} : Weight of delivery order $d_i \in D$.

W_{p_i} : Weight of pickup order $p_i \in P$.

e_{p_i}, l_{p_i} : Earliest and latest pickup times for $p_i \in P$.

e_{d_i}, l_{d_i} : Earliest and latest delivery times for $d_i \in D$.

Decision Variables

$x_v = \begin{cases} 1, & \text{if vehicle } v \in V \text{ travels,} \\ 0, & \text{otherwise.} \end{cases}$

$y_{p_i}^v = \begin{cases} 1, & \text{if vehicle } v \in V \text{ transports pickup order } p_i \in P, \\ 0, & \text{otherwise.} \end{cases}$

$y_{d_i}^v = \begin{cases} 1, & \text{if vehicle } v \in V \text{ transports delivery order } d_i \in D, \\ 0, & \text{otherwise.} \end{cases}$

Objective Function

The objective is to minimize the total cost of delivery and pickup operations:

$$\text{Minimize } Z = \sum_{v \in V} \sum_m R_m^v \cdot x_v + \sum_{v \in V} \sum_j R_j^v \cdot x_v$$

The first term minimizes the cost of delivery routes, while the second term minimizes the cost of pickup routes.

Constraints

Vehicle Capacity Constraints:

$$\sum_{p_i \in P} w_{p_i} y_{p_i}^v \leq C_v \quad \forall v \in V$$

The total weight of all pickup orders assigned to vehicle v must not exceed its capacity C_v .

$$\sum_{d_i \in D} w_{d_i} y_{d_i}^v \leq C_v \quad \forall v \in V$$

The total weight of all delivery orders assigned to vehicle must not exceed its capacity C_v .

The capacity constraints determine whether the problem is simultaneous pickup and delivery. Also, the manager decides whether to transport loads between orders according to the capacity constraints.

Order Assignment Constraints:

Each delivery order must be assigned to exactly one vehicle:

$$\sum_{v \in V} y_{d_i}^v = 1 \quad \forall d_i \in D$$

Each pickup order must be assigned to exactly one vehicle:

$$\sum_{v \in V} y_{p_i}^v = 1 \quad \forall p_i \in P$$

Time Window Constraints:

Also, if vehicle v handles pickup or delivery order, pickup or delivery time T_v must fall within the time window specified for:

$$e_{p_i} y_{p_i}^v \leq T_v y_{p_i}^v \leq l_{p_i} y_{p_i}^v \quad \forall p_i \in P, \forall v \in V$$

$$e_{d_i} y_{d_i}^v \leq T_v y_{d_i}^v \leq l_{d_i} y_{d_i}^v \quad \forall d_i \in D, \forall v \in V$$

Binary Decision Variables:

$$x_v, y_{p_i}^v, y_{d_i}^v \in \{0,1\} \quad \forall v \in V, \forall p_i \in P \forall d_i \in D$$

This mathematical model incorporates simultaneous delivery and pickup operations while adhering to time window and capacity constraints. The smart selection method simplifies the solution process by predefining feasible vehicle-route combinations, allowing for faster computation and high-quality solutions. A total of

360 different vehicle-route-time combinations were generated, considering time, route and capacity. With smart selection, suitable vehicle-route-time alternatives were determined in advance for each order. For example, for the 1st picking order, the number of alternatives decreased from 360 to 27.

METAHEURISTICS and SOLUTION PROCEDURE

Metaheuristic methods are a means of solving difficult and complex problems in various fields. Metaheuristic methods are used to efficiently find optimum or near optimum solutions by combining different concepts to explore the search space (Osman and Laporte, 1996). Many metaheuristic algorithms such as simulated annealing, GA, PSO, ACO, artificial neural networks, and tabu search are used to solve VRP (Çiçekli, 2012). Michalewicz et al. (1991) define a GA as a class of algorithms related to the genetic processes occurring in nature with randomly generated population and towards developing better solutions. GA makes it possible to discover solutions to a much wider range of problems than other algorithms (Hsiao et al., 2010). GA enables exploration of a problem over a much wider range than with other algorithms.

The proposed hybrid GA incorporates smart selection and harem-based crossover mechanisms to optimize VRPSPD with time windows. This section outlines the key steps of the algorithm and highlights its unique components.

Solution procedure

The GA developed in this study follows the steps below to optimize the VRPSPD:

1. Load Parameters:

Load all problem parameters, such as vehicle capacities, order weights, time windows, and other constraints.

2. Smart Selection:

Apply the smart selection method to pre-filter infeasible routes. This reduces the solution space and ensures that the initial population contains only feasible solutions.

3. Generate Initial Population:

Create the initial population of chromosomes (potential solutions) based on the feasible routes identified by the smart selection method.

4. Evaluate Fitness:

Evaluate the fitness of every chromosome in the population to determine their suitability as potential solutions. The fitness function considers factors such as total cost, time window satisfaction, and capacity constraints.

5. Select Best Chromosomes:

Identify the best-performing chromosomes (solutions) based on their fitness values.

6. Harem-Based Crossover (Step 1):

Select the best chromosome as the “leader” (first parent). Choose subsequent chromosomes in the population as “followers” (second parents) to form the harem. This ensures diversity and avoids premature convergence.

7. Generate Offspring (Step 2):

Combine the leader and followers to generate offspring using the crossover operator. The harem-based crossover ensures genetic diversity and high-quality solutions.

8. Apply Mutation:

Introduce mutations into the offspring population with a predefined mutation rate. Mutation helps explore new areas in the solution space and prevents stagnation.

9. Evaluate New Generation:

Calculate the fitness values of the new generation of chromosomes.

10. Replace Population:

Replace the current population with the new generation if the fitness of the new generation is better.

11. Check Termination Criteria:

The algorithm terminates when one of the following conditions is met:

- The maximum number of iterations is reached.
- The improvement between successive generations falls below a predefined threshold.

12. Output Best Solution:

Output the best chromosome (solution) as the optimal route for the problem.

Chromosome Encoding

One of the problems in the GA is the identification of encoding. Çiçekli (2012) notes that there are four categories of coding: binary, real number, permutation, and data structure.

In real-number encoding, chromosomes are made up of the real value of parameters (Herrera et al., 1998). Goldberg (1991) and Eshelman and Schaffer (1993) used real-coded GA for function optimization that represents the real number vector of chromosomes. These real-coded GA performed better than traditional bit-based (binary coding) GA. Wright (1991) listed the strengths of real-coded GA as increased efficiency, increased precision, and greater freedom in using different mutations and crossover techniques.

This study employed real-number encoding to achieve more efficient outcomes. For the representation of chromosomes as per the GA, genes were allocated to all routes and vehicle types within each day in the program. Considering many factors such as the variety of routes and schedules, and the maximum weight limit of vehicles, real-number encoding was used to achieve a more efficient outcome. Table 2 displays the codes of semi-trailer trucks and trucks for 24 days in line with the route schemes and their costs.

As shown in Table 2, two different types of vehicles were encoded based on days for all potential routes. “ST1_1” represents a semi-trailer truck with the route “S1”, while

Table 2: Vehicle Types, Costs, and Routes Encoded by Dates

Day	ST1_1	ST2_1	ST3_1	ST12_1	ST13_1	ST23_1	ST123_1	T1_1	T2_1	T3_1	T12_1	T13_1	T23_1	T123_1	T123_2
5	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
6	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30
Cost	675	675	850	795	1525	1525	1645	550	550	700	650	1250	1250	1350	1350

Table 3: Real-Coded Chromosome

24	7	11	156	225	75	128	140	139	33	57	148	203	21	88	154	3	193	136	10	62	192	31	164	63
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"T123_1" represents a truck with the routes S1, S2, and S3. The vehicle encoded 20 represents a semi-trailer truck at the cost of 1525 with the routes S1 and S3 running on day 6. What is important here is the encoding shaped by the dates.

By making use of the coding of semi-trailer trucks and trucks, real-coded values make up the sample chromosome sequence as shown in Table 3.

As seen in the real-coded chromosome example in Table III, code 24 in the first gene means that the first order in the order list will be carried by the truck with the route S2 on day 6. Similarly, code 7 in the second gene indicates that the second order in the order list will be carried by the semi-trailer truck with the route S1-S2-S3 on day 5. Following the real-number encoding, the initial population is generated.

Initial Population

An initial population (generation) of random individuals which shows solutions of the related problem is created (Baker and Ayechev, 2003). One of the parameters of GA is population size, showing how many individuals are in the population (Çiçekli and Kaymaz, 2015). The size of the population is important for an efficient GA. If the number of individuals is small, only a certain part of the solution space can be reached, and there is not much choice for crossover (Grefenstette, 1992).

Individuals in the population are obtained by randomly generated real-coded chromosome sequences. However, these randomly generated chromosome sequences often do not provide the constraints of route and time intervals. In order to prevent this and with the aim of reaching the best solution more quickly, the smart selection method is used to create the population. Therefore, in the mathematical model, route and time interval constraints are not used.

Evaluation: Fitness Function

The process to be performed after the initial population is created is to calculate the fitness values of the generated chromosomes. VRP aims to reveal the most cost-effective chromosome sequence in such a way as to provide constraints. GA operators are included in the process, and after the new chromosomes are obtained this fitness value is calculated again.

In the study, the fitness function tried to reach the minimum cost. The calculation of the fitness function took place by collecting the current costs of the selected vehicles, regardless of departure and return. Even if a vehicle was used in departure and not used on return, both the departure and the return costs were generated. Therefore, the model aimed to use vehicles in both directions. Also, if the capacities of the vehicles were not suitable for the necessary transport (if the total of the departure or return weights was more than the weight of the vehicle), they were exposed to the penalty cost, and they were left out of the solution.

Selection Harem

After the initial population and identified fitness function selection are made in the GA, replication of the chromosomes in the current population and the possibility of placement in the new generation are proportional to their fitness (Whitley, 1994). Parent selection is the undertaking of allotting regenerative opportunity to every individual in the population. Elitism is one of the selection methods which arrange the chromosomes in increasing order according to their fitness value (Yadav and Sohal, 2017). We used elitism method for our algorithm. For solving the problem using the elitism method, the best 21 chromosomes in the population are selected. The 1st place chromosome takes the name "leader chromosome". The subsequent 20 chromosomes constitute the "harem". This method prepares the ground for the crossover operator.

Crossover

The crossover operator is designed to merge key attributes from two high-quality "parent" solutions, aiming to produce superior "offspring" solutions. Its primary objective is to create valid solutions that inherit the strengths of both parents. The specific coding of the problem directly influences the structure and implementation of the crossover operator (Poon and Carter, 1995).

It has been seen that crossover processes are employed for parent selection using the harem structure, which is used in many aspects of natural life. The harem represents the chromosome pool where the best chromosomes are collected as a result of the processes. The harem contains

Table 4: Crossover Example

Parent 1	29	86	103	92	116	94	123	107	149	206	205	201	247	251	251
Parent 2	48	86	87	107	98	114	119	109	130	169	209	232	200	238	239
Bit	0	1	0	0	1	0	1	1	0	1	0	0	1	0	1
Offspring	48	86	87	107	116	114	123	107	130	206	209	232	247	238	251

the best chromosomes in the population, behind the best chromosome called the leader chromosome. It has been seen that the harem method brings diversity by making loops efficient in GA (Çiçekli, 2012).

In our test studies, it was decided to determine the harem size as 20. Therefore, 20 chromosomes after the leader chromosome were included in the harem. The critical point here is that the leader remains constant in every crossover and that the chromosomes in the harem in turn enter the crossover with the leader. At this stage, the crossover operation is performed by the dominance code. Dominance code is randomly generated as bits. If the value is 1, the leader is the dominant, if the value is 0, the second parent will be dominant. Dominance code determines which parent will affect the genes of the new generation. As a result of each crossover, a new generation occurs.

Mutation

The crossover operator used to investigate gene potential may sometimes not produce the desired solution. In such a case, a mutation operator with the ability to produce new chromosomes from the existing chromosomes is required. Mutation aims to reveal new genetic material from an existing individual (Engelbrecht, 2007).

The new generation is added to the population after the fitness values are calculated. However, the crossover operator alone may not be enough to achieve the best solution. In such an eventuality, implementation of the mutation operator is necessary. The most accurate mutation process can take place with the most appropriate mutation rate (Kocamaz and Çiçekli, 2010).

After crossover and mutation operators, sometimes duplicate chromosomes can occur. Lim and Chew (1997) and Brown et al. (1994) performed operations ensuring that no duplicate chromosomes were permitted within the population. As duplicate chromosomes contain the same information, all duplicated chromosomes

were removed from the population in this study.

The best chromosome is obtained after the crossover operator is mutated. The application of the mutation operator depends on the mutation rate, randomly assigned to each gene of the best-selected chromosome. If the gene is not covered by the specified mutation rate, the gene remains the same on the new chromosome. If the gene is covered by the determined mutation rate, the gene is added to the chromosome by taking advantage of the previously mentioned smart selection structure. This is done for all genes in the chromosome. Thus, the new chromosome generated is expected to give better results.

COMPUTATIONAL RESULT

In this paper, the GA was developed in Visual Basic for Applications (VBA) for Excel. The advantage of Excel as a development environment is that it provides capabilities that permit analysis and control of the output and results. By creating the "Userform", the algorithm is processed according to the values determined by the decision maker. The GA we developed was run on 40 equivalent computers in the computer lab.

Impact of population size

It is an important issue to determine the size of the initial population. Determining the optimal population size will create a more favorable environment for the solution. Figure 1 shows the tests to find the optimal population size. We tested population size from 100 to 1500 in multiples of 100. We ran each population size 50 times. The tests identified the optimal initial population size as 700.

Smart selection helped eliminate those genes that made it impossible to speed up the solution to the GA, while creating the population. As a result, it was observed that improvements in the solution to the problem were achieved within a short time.

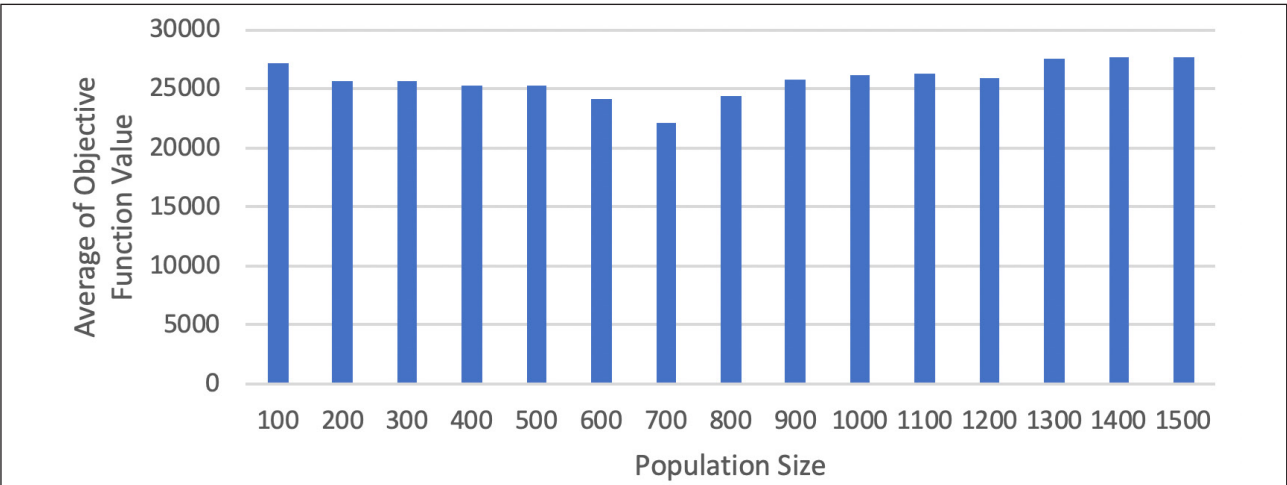


Figure 1: Impact of Population Size on the Objective Function Value

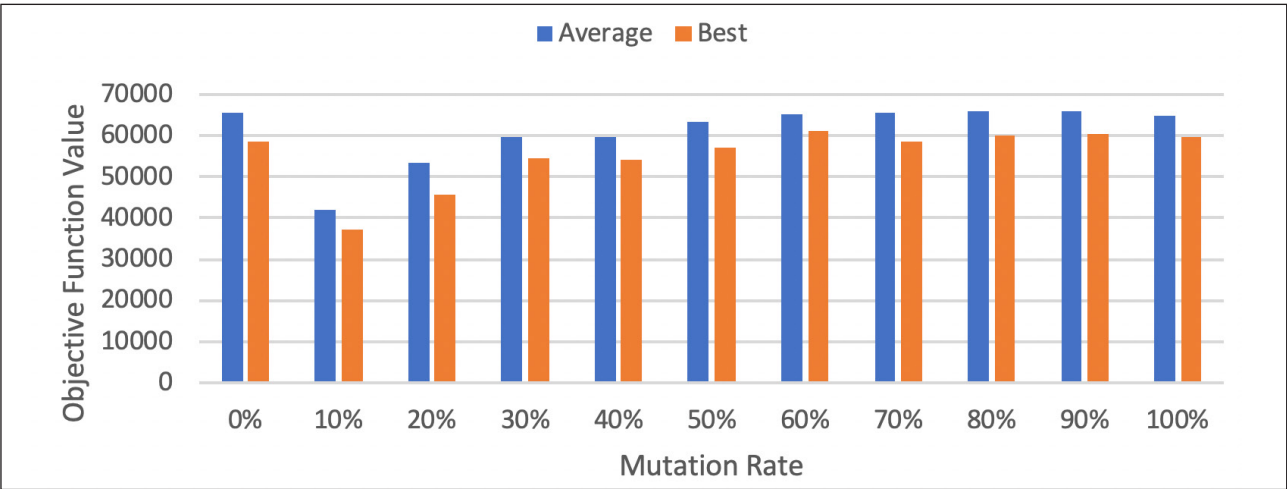


Figure 2: Impact of Mutation Rate on the Objective Function Value (0-100)

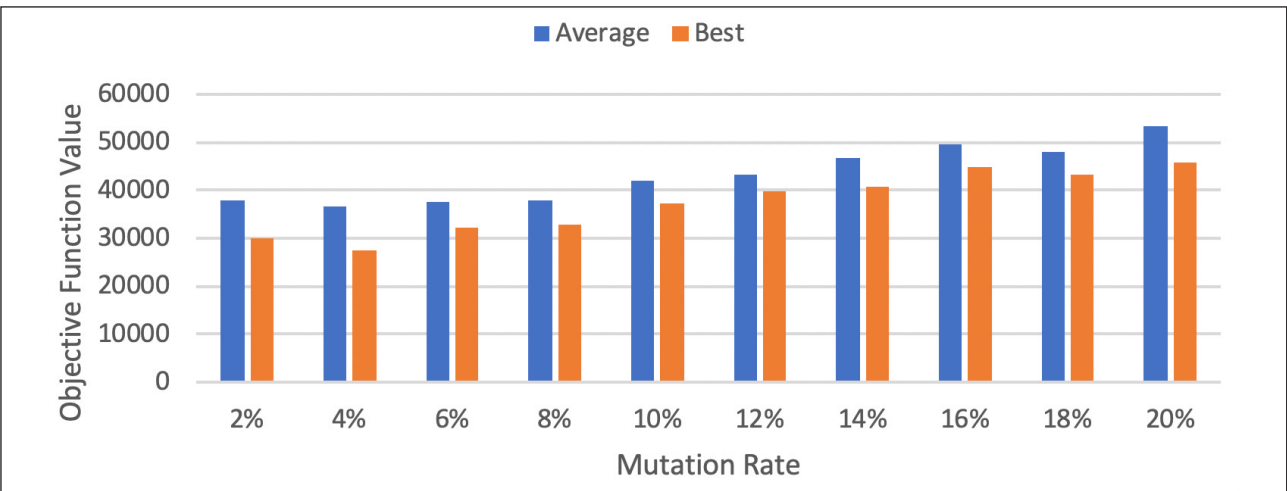


Figure 3: Impact of Mutation Rate on the Objective Function Value (2-20)

Impact of mutation rate

We have carried out various tests to find the most appropriate mutation rate for the problem structure. We tried to find the segment range where the appropriate mutation rate would take place. From 0% up to 100%,

mutation rates were tested to increase by 10%. In the tests, each mutation rate was run 50 times. Fifty trials were performed with 1000 iterations for each mutation rate. As shown in Figure 2 the lowest average and the best value were found in 10% mutation rate. Therefore, we performed more detailed analyses for 2-20% segment (Figure 3).

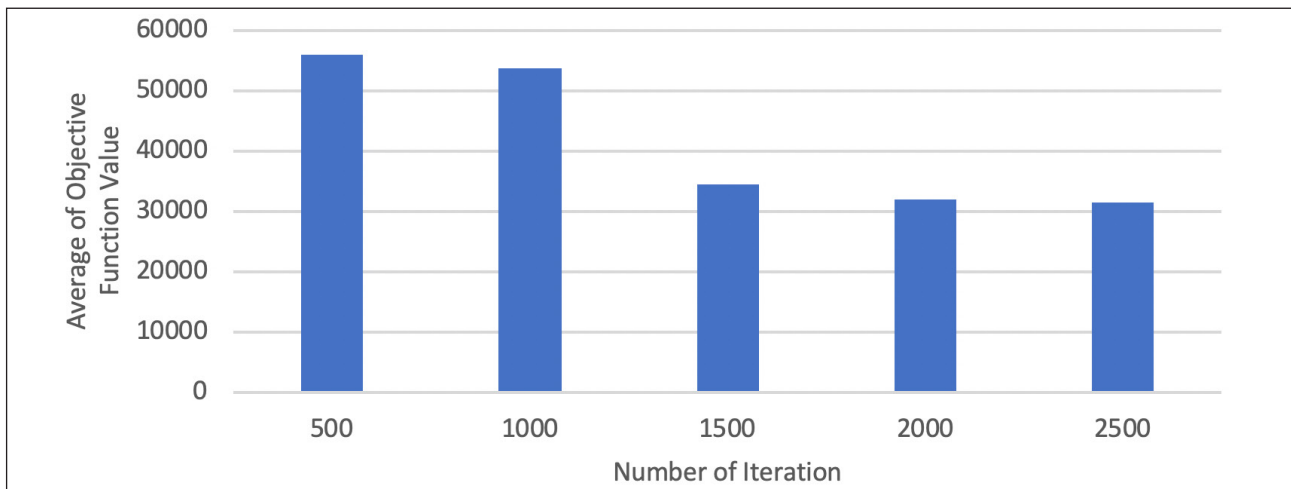


Figure 4: Impact of the Number of Iterations on the Objective Function Value

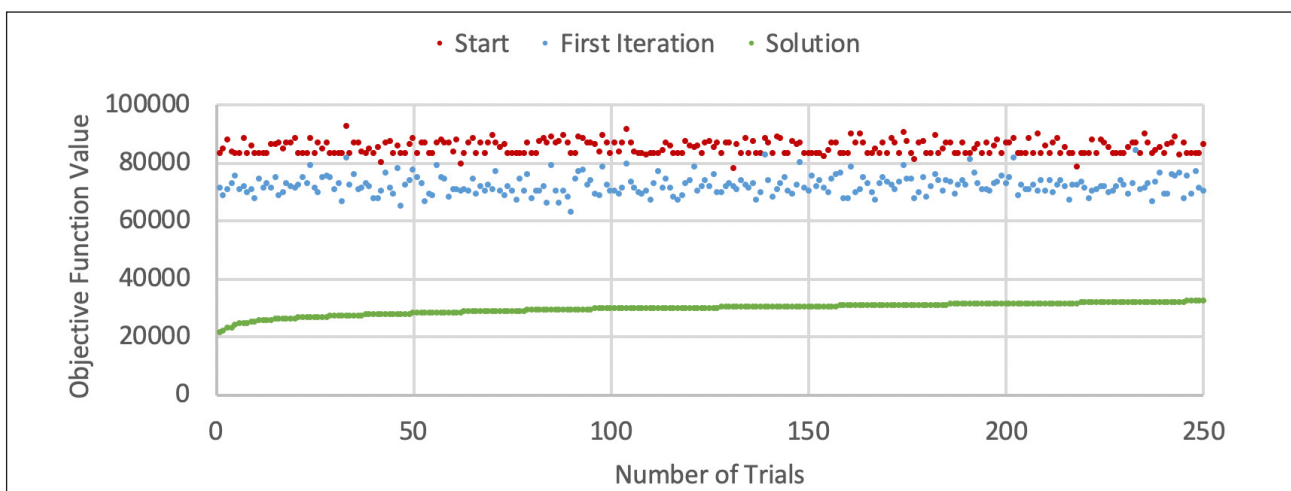


Figure 5: Objective Function Value of Initial, First Iteration, and Solution for Each Iteration

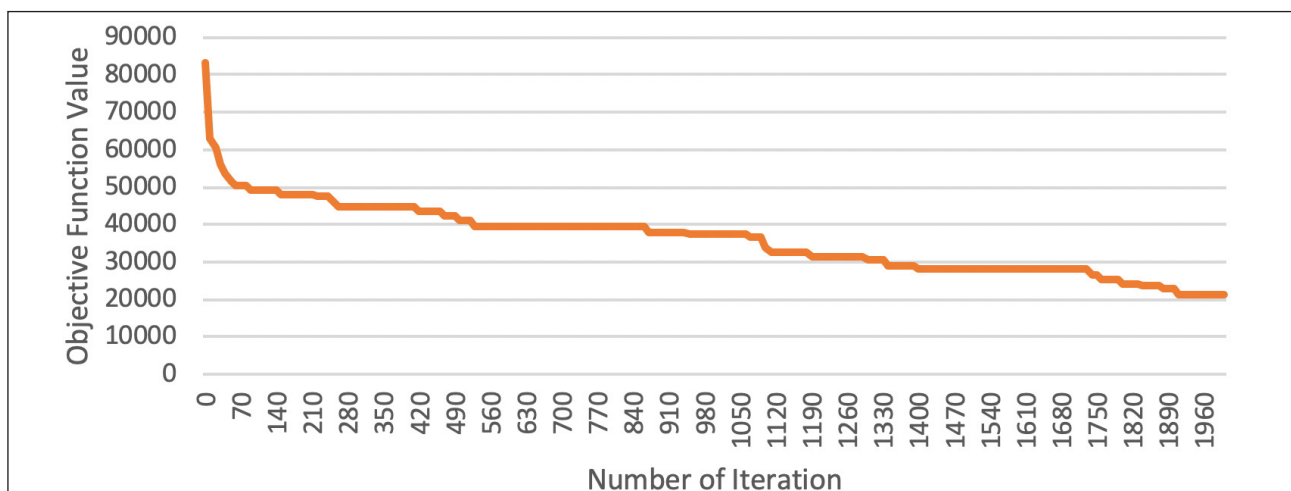


Figure 6: Evolution of the Best Solution

Figure 3 shows the detailed analysis of mutation rates between 2-20%. In the tests, each mutation rate was run 50 times. As a result of our tests, we determined the best mutation rate for this problem at 4%.

Impact of the number of iterations

We tested the developed model for 500, 1000, 1500, 2000, and 2500 iterations. Figure 4 shows the impact of the number of iterations on the objective function value. As a result of our tests, we determined that the best number of iterations for this problem was 2000.

Table 5: The Chromosome of the Best Solution

D	25	86	103	86	86	114	103	103	130	189	190	219	218	219	234	218	234	237	324	310	324	286	341	341	341
P	25	86	103	86	86	114	103	114	130	190	189	190	218	219	234	237	234	237	324	310	324	286	341	341	341

Best Solution

The developed model was run over 250 trials as 2000 iterations. Figure 5 presents the values of each repetition. These values include the initial value, the first iteration value, and the solution value. Solutions are sorted in ascending order. The average value of 250 trials is 29453, and the standard deviation is 1925. The computation time for 2000 iterations was 268 seconds.

Figure 6 shows the iteration values of the best result. At the end of the tests, our algorithm achieved the best result 21150 TL at 4% mutation as the best solution.

Table 5 gives the chromosome of the best solution obtained from 250 trials.

Table 6 presents the orders delivered and picked up by the vehicles daily. Table 6 shows the capacity and route of the vehicle, as well as which suppliers are visited during departure and return. For example, a truck with route S2 is preferred on day 12.

The decision maker can interpret the solution shown in Table 6 in different ways. The decision maker will decide whether the delivery and pickup for the supplier orders will be carried out simultaneously. On Day 27, V341 truck will deliver to S1 and S2 suppliers and pick up from them. Due to the load weight-fuel consumption relationship, the decision maker may not want to transport the PO23 order from the supplier S1 to the supplier S2. The decision maker may decide to collect the PO23 order either when the truck comes to supplier S1 for the first time, or when the truck comes back to supplier S1.

RESULTS and DISCUSSION

The proposed hybrid GA was evaluated using real-world data from an automotive supply chain, focusing on simultaneous delivery and pickup operations with time window constraints. The results demonstrate that the algorithm outperforms existing methods in terms of both cost efficiency and computational performance.

The algorithm achieved a 20% reduction in transportation costs compared to the company's current practices, highlighting its effectiveness in optimizing vehicle routes.

Compared to traditional GA, the hybrid approach reduced computation time, enabling faster decision-making for logistics planning.

The harem-based crossover mechanism contributed to generating high-quality solutions by maintaining genetic diversity and avoiding premature convergence.

The algorithm's scalability was tested with varying problem sizes, ranging from 10 to 500 orders. Results indicate that the model maintains its efficiency across different scales, demonstrating robustness for larger logistics networks.

The application of the proposed algorithm in a real-world automotive supply chain demonstrated its capability to handle complex logistical challenges. By adhering to time window constraints and optimizing vehicle capacities, the algorithm ensured timely delivery and pickup while minimizing operational costs. This makes it a valuable tool for decision-makers aiming to enhance efficiency in competitive industries.

CONCLUSIONS

This study presented a novel hybrid GA to address the VRPSPD, incorporating time window and capacity constraints. The proposed method integrates a smart selection structure and a harem-based crossover mechanism to optimize vehicle routes, reduce transportation costs, and enhance computational efficiency. Computational results demonstrated that the algorithm not only meets real-world logistical requirements but also outperforms traditional methods in terms of cost savings and solution quality.

In this problem, each supplier's order is subject to specific earliest and latest deadlines, creating a time window constraint for both delivery and pickup operations. The proposed model ensures that all orders are fulfilled within their respective date ranges, adhering to operational requirements. This feature makes the model particularly suitable for real-world applications where precise scheduling is critical.

The decision-maker can utilize the model as a flexible decision support system. Depending on the

Table 6: Summary of Results for Real-World Test Cases

Day	Vehicle	Delivery			Pickup		
6	V25 (12000)	DO1 (S3)			PO1 (S3)		
	(3)	5760			3750		
10	V86 (12000)	DO5 (S1)	DO2 (S2)	DO4 (S2)	PO5 (S1)	PO2 (S2)	PO4 (S2)
	(1-2)	200	5950	350	1800	1400	350
11	V103 (12000)	DO3 (S3)	DO7 (S3)	DO8 (S2)	PO3 (S3)	PO7 (S3)	
	(2-3)	4160	2720	3150	6750	750	
12	V114 (12000)	DO6 (S2)			PO6 (S2)	PO8 (S2)	
	(2)	6650			5950	3850	
13	V130 (12000)	DO9 (S3)			PO9 (S3)		
	(3)	9920			8250		
17	V189 (12000)	DO11 (S3)			PO11 (S3)		
	(2)	4000			7750		
	V190 (12000)	DO10 (S2)			PO10 (S2)	PO12 (S2)	
	(3)	7700			1400	5950	
19	V218 (12000)	DO13 (S1)	DO16 (S1)		PO13 (S1)		
	(1)	150	200		1500		
	V219 (12000)	DO12 (S2)	DO14 (S2)		PO14 (S2)		
	(2)	4200	4900		7000		
20	V234 (12000)	DO15 (S2)	DO17 (S2)		PO15 (S2)	PO17 (S2)	
	(2)	350	350		1050	2100	
	V237 (12000)	DO18 (S3)			PO16 (S1)	PO18 (S3)	
	(1-3)	8480			5400	6250	
24	V286 (25000)	DO22 (S1)			PO22 (S1)		
	(1)	150			24000		
25	V310 (12000)	DO20 (S3)			PO20 (S3)		
	(3)	4640			8000		
26	V324 (12000)	DO19 (S2)	DO21 (S2)		PO19 (S2)	PO21 (S2)	
	(2)	7700	4200		3500	2100	
27	V341 (12000)	DO23 (S1)	DO24 (S2)	DO25 (S2)	PO23 (S1)	PO24 (S2)	PO25 (S2)
	(1-2)	100	5250	700	1200	2100	350

operational context, they can decide whether delivery and pickup operations for a supplier should be carried out simultaneously or separately. This flexibility allows the problem's structure to dynamically adjust between the VRPSDP or the Divisible Delivery and Pickup Problem (VRPDDP). Such adaptability makes the model applicable to various logistical scenarios, enhancing its practical value.

Since this is a new problem formulation and no established benchmarks exist, the results of the proposed metaheuristic model were compared with the firm's current practices. The computational experiments demonstrated that the algorithm achieves superior performance, yielding better cost savings and operational efficiency than existing methods used by the firm.

Key findings include:

- The algorithm successfully handled complex constraints, including time windows, capacity limits, and simultaneous delivery and pickup.
- The use of the smart selection method significantly narrowed the solution space, enabling faster and more efficient optimization.
- The harem-based crossover method provided a unique genetic diversity mechanism, leading to high-quality solutions.
- The model's flexibility allows it to be tailored to varying operational conditions, providing decision-makers with actionable insights.

Implications for Future Work:

- While the proposed algorithm demonstrated strong performance, there are several avenues for future research:
- Dynamic Adjustments: Integrating real-time data, such as traffic updates and dynamic customer demands, into the algorithm could enable adaptive and responsive logistics solutions.
- Fuel Efficiency and Sustainability: Incorporating environmental factors, such as fuel consumption and carbon emissions, into the optimization process could align the model with green logistics objectives.
- Parameter Optimization: Exploring advanced techniques for tuning GA parameters, such as mutation rates and population sizes, could further enhance solution quality.

- Scalability: Investigating the algorithm's scalability for larger problem instances, including more suppliers, vehicles, and orders, could broaden its practical applicability.
- Multi-Objective Optimization: Extending the model to address multiple objectives, such as minimizing costs and maximizing customer satisfaction, could increase its versatility in complex logistics environments.

The findings from this study contribute to the growing body of literature on advanced optimization techniques for VRP. The proposed algorithm provides a robust framework for businesses aiming to optimize their distribution networks in competitive and resource-constrained environments. Future work should investigate how innovative technologies like AI and IoT can be utilized to optimize the algorithm's performance and broaden its use in diverse logistical contexts.

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Time-Varying Betas and Effects of Data Frequency and Estimation Window Preferences: Case of Istanbul Stock Exchange

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ABSTRACT

In this study, we analyzed the changes in Beta over time for the leading indexes of Borsa Istanbul (XU100, XUHZ, XUMAL, XUSIN, XUTEK) across 5-10 year and 15-year intervals from 2008 to 2023. We utilized Rolling regression and Recursive regression methods to estimate the fluctuations in Beta over time and compared the performance of these estimation techniques. To evaluate the effect of the estimation window length on Beta, we incorporated daily and weekly estimation windows of various lengths: 252 days, 126 days, 52 weeks, and 26 weeks. Additionally, we examined how data frequency affects Beta estimation using daily and weekly datasets. Our analysis showed that the Rolling regression method consistently outperformed the recursive method. Moreover, we found that employing daily datasets, instead of monthly datasets, significantly enhanced Beta forecast performance. We also found that a 126-day window is the most effective length for the estimation window.

Keywords: Time-Varying Beta, Beta Forecast, Forecast Performance, Financial Markets, Istanbul Stock Exchange.

JEL Classification Codes: G12, G17

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INTRODUCTION

The transformation in modern finance initiated by Markowitz's (1952) pioneering approach has paved the way for the development of the Capital Asset Pricing Model (CAPM), with significant contributions from studies by (Sharpe, 1964), (Lintner, 1965) and (Mossin, 1966). In CAPM, the return of an asset is understood as a function of its relevant risk. Beta, which quantifies the asset's responsiveness to market risk factors within the model, finds application across various domains of modern finance, including asset pricing, portfolio performance evaluation, risk management, investment preferences, and capital allocation decisions.

Practically, CAPM operates under the assumption that Beta remains constant over time, leading to the presumption of a linear relationship between the asset's return and the market portfolio. This linearity simplifies the model's application and enhances analytical clarity. However, sometimes such assumptions may not consistently hold true in financial markets. When deviations occur, it can result in substantial challenges, including a reduction in

the model's validity and reliability, complications in risk assessment, and potential impacts on investment strategies.

Beta, one of the most important parameters guiding practitioners in the field of finance, needs to be estimated as it is not directly observable. Therefore, the accuracy and reliability of Beta estimation are of paramount importance (Brenner & Smidt, 1977). The most frequently used method for Beta estimation is to estimate covariances and variances from historical return data. However, the main problem encountered in calculating the Beta coefficient is the variation it shows over time. At this point, it would not be wrong to express Beta as a type of stochastic parameter based on the feature it shows (Collins, Ledolter, & Rayburn, 1987). The variation seen in Beta over time also leads to the elimination of the linear relationship between the market portfolio and asset return in CAPM. The reason for the mentioned variation is due to the non-stationarity in returns and risks. Ignoring these variations can lead practitioners to make substantial errors in their estimates of systematic risk (Estrada, 2000).

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This study is derived from the doctoral thesis titled "Essays on Risk-Free Interest Rate and Beta", which is being written by Musa OVALI, Accounting-Finance Doctoral Program in Manisa Celal Bayar University.

Researchers have been discussing the variation in Beta and its implications for nearly half a century (Meyers, 1973; Blume, 1975; Fabozzi & Francis, 1978; Sunder, 1980; Theobald, 1981; Bos & Newbold, 1984; Bollerslev, Engle, & Wooldridge, 1988; Brooks, Faff, & Lee, 1992; Gong, Firth, & Cullinane, 2006; Abdymomunov & Morley, 2011; Ciner, 2015; Rizvi & Arshad, 2018; Kalnina, 2022). A common finding in these studies is the significance of accounting for the variation in Beta when selecting the estimation methods used. Because variability in Beta not only complicates its interpretation but also presents challenges in estimation for both practical applications and the use of the CAPM (Faff, Lee & Fry, 1992; Groenewold & Fraser, 1999).

The challenges encountered in forecasting Beta necessitate a careful approach. We argue that this approach should take into account not only the selection of Beta estimation methods but also factors such as the characteristics of the dataset (e.g., frequency selection) and the estimation windows employed in the application of these methods. Because Damodaran (1999)¹ and Daves et al. (2000)² demonstrated that the return interval used for forecasting Beta significantly impacts the results, as evidenced by examination of returns at varying frequencies. However, it cannot be said that a significant amount of research has been conducted on the effects of both data frequency and estimation window selection on Beta forecast. At this point, our study aims to expand the existing literature. Our research addresses 2 more research problems while evaluating the performance of Beta estimation methods: The first is to investigate whether the length of the estimation window affects Beta estimation, and the second is to investigate whether the frequency of the data selected for Beta estimation influences its performance. Beta forecast will be implemented using Rolling and Recursive regression methods across the leading indexes of Borsa Istanbul (BIST), utilizing four estimation windows based on weekly and daily frequencies: 252 days, 126

days, 52 weeks, and 26 weeks. In order to make a more comprehensive performance evaluation rather than using a specific interval like many studies in the literature when evaluating the forecast performance of the methods, the data were examined in three sub-periods as 31.12.2008 - 29.12.2023, 31.12.2013 - 29.12.2023 and 31.12.2018 - 29.12.2023 at daily and weekly frequencies for 15, 10 and 5 years, respectively. The subsequent sections of the study are organized as follows: the second section reviews existing literature on Beta forecast, while the third section presents information regarding the dataset and methodology employed. The fourth section contains the findings derived from the analyses conducted. Finally, the study concludes with a section that offers final evaluations and reflections.

LITERATURE REVIEW

The risk and return of an investment, capital structure decision, investment decision and many other financial decision-making have always been of interest to financial manager and academics. The main factor here is the widespread use of CAPM Betas as a risk indicator. Moonis & Shah (2003) stated that the Betas of most stocks fluctuates over time. In this context, it is seen that studies on Beta reveal the multiple approaches in its estimation due to its inherent characteristics. So studies examining the forecasting performance of different methods are quite common in the Beta literature. Groenewold & Fraser (1999) conducted a study estimating Beta values for 23 industries in Australia over a monthly frequency from 1979 to 1994. They analyzed the fluctuations in Beta over time utilizing Rolling regression, Recursive regression, and Kalman filter methodologies. Their findings revealed significant instability in the Beta values across the examined industries. Furthermore, the study indicated that the variations in Beta over time were influenced by the estimation method employed. They discovered that nearly half of the industry Betas determined using the Kalman Filter were non-stationary, while almost all Betas estimated via the Rolling and Recursive regression methods displayed variability. Marti (2006) investigated the performance of various methods for estimating time-varying Beta in the US stock market from 1980 to 2005. The methods analyzed included Rolling regression, GARCH (Generalized Autoregressive Conditional Heteroskedasticity), the Kalman filter, and the Schwert and Seguin model. The evaluation, based on Mean Square Error (MSE), revealed that the Kalman filter exhibited a lower error rate compared to the other methods throughout the examined period. Mergner & Bulla (2008) investigated the time-varying behavior of

¹ The author stated that the return interval in Beta estimation can be calculated at different frequencies, such as annual or quarterly. However, he cautioned that shorter intervals may present challenges due to the asset's non-continuous trading, which impacts its correlation with the market index and, consequently, the accuracy of Beta estimation. To address the non-trading issue, he recommended using lower frequency intervals or high-frequency data with necessary corrections. For more details, see Damodaran (1999).

² The authors noted that there is a dilemma that financial managers face in Beta estimation: the choice of forecast period and the choice of return interval. As the number of observations in the forecast period increases, the standard error of beta decreases, but this increases the calendar period of the forecast period. The longer the calendar period, the more likely it is that the firm will encounter decisions and practices that will change its financial structure and cause changes in Beta.

systematic risk across 18 European sector portfolios by employing various methodologies, including GARCH, Kalman filter, Monte Carlo simulations, and Markov Switching techniques. Their analysis, conducted at a weekly frequency from 1987 to 2005, revealed that the Kalman Filter outperformed the other methods in accurately estimating the Beta of the sector portfolios. Domenech, Orbe Mandaluniz & Zarraga (2011) employed Rolling regression, Nonparametric Estimation, and GARCH methods to estimate time-varying Beta in their research. They analyzed data from six portfolios consisting of companies listed on the Mexican stock market between 2003 and 2009. In their evaluation of forecast performance using the Mean-Variance approach, the authors found that the GARCH-based models yielded superior results. Zhou (2013) analyzed the estimation performance of four different methods for Beta forecast of the Real Estate Investment Trust index traded on the London Stock Exchange from 1999 to 2011. The methods employed included Rolling regression, Dynamic Conditional Correlation, the Schwert and Seguin model, and the State Space model. The results of the study were assessed using Mean Absolute Error (MAE) and Mean Squared Error (MSE) as performance metrics. The findings indicated that the State Space model exhibited better performance throughout the examined period. Wijethunga & Dayaratne (2015) investigated the time-varying Beta forecasts of 26 stocks listed in the Finance, Banking, and Insurance indices of the Sri Lankan Stock Market. They employed Rolling regression and Recursive regression methods across three sub-periods from 2005 to 2013. Their analysis revealed that Beta fluctuated over time within the examined sectors of the Sri Lankan stock market, indicating that the choice of method influenced the changing Beta forecasts. However, they did not compare the performance of these methods. Messis & Zapanis (2016) analyzed the time-varying Beta values of 135 stocks listed in the S&P 500 index from 1993 to 2011. They compared the performance of various Beta estimation methods, including UGARCH, BGARCH, the Kalman Filter, and the Schwert and Seguin Model, by proposing a new approach that treats the Beta coefficient as a function of market return. The findings revealed significant differences in Beta forecast results among the methods. Specifically, the Kalman Filter demonstrated superior forecast performance in the short sample period, while UGARCH and BGARCH excelled over a five-year span, and the Schwert and Seguin Model performed best in the long sample period. Notably, the newly proposed method also exhibited enhanced forecast performance. Mantsios & Xanthopoulos (2016) examined the existence

of time-varying Beta forecast and range effect in the Athens stock market between 2007 and 2012 during the Greek debt crisis. In their study, where they estimated Beta with daily, weekly and monthly data using the OLS method, they found that there was an increase in the standard deviation as the estimation window increased. Chakrabarti & Das (2021) examined the temporal changes in sector Betas using the multivariate Diagonal VEC GARCH method. They selected six industries from both the Indian and US markets, analyzing daily frequency data from 1999 to 2017. Their findings revealed that Betas did fluctuate over time, with variations in magnitude across different sectors and periods. They also noted that the proliferation of methodologies capable of capturing these changes in Beta over time could have beneficial implications for market risk assessment and hedging strategies. Lopez Herrera et al. (2022) forecasted Beta values for 23 stocks listed on the Mexican Stock Market, examining both pre-pandemic and pandemic periods from 2019 to 2020 using the Rolling regression method. The study's findings highlight the potential implications of assuming a constant Beta in return estimation and provide recommendations for practitioners to employ methods that account for fluctuations in Beta. Drobetz et al (2023) conducted an examination of all companies listed on US stock markets (NYSE, AMEX, and NASDAQ) utilizing Machine Learning-based methods for Beta forecast. Their findings revealed that the Machine Learning approach outperformed other methods, including Linear Regression, Tree-Based Models, and Neural Networks, in terms of Beta forecast results. Blasques, Francq & Laurent (2024) conducted an examination of the time-varying Betas for 16 companies listed on the US Stock Market between 1999 and 2017, employing the Autoregressive Conditional Beta and Least squares methods. Their findings, derived from the Mean Squared Error (MSE) approach, indicated that their model, when applied to high-frequency data, outperformed both the Conditional Beta and Least Squares methods.

As can be seen from the studies given above, many methods have been used in the Beta literature to examine forecast performance. However, we think that not only the estimation method but also the frequency of the data set and the estimation window should be taken into consideration by the practitioners when forecasting Beta. As a matter of fact, studies emphasizing the importance of the mentioned parameters can be found in the literature. Baesel (1974) showed that Beta stationarity depends on the length of the period over which is estimated. When the studies examining the effects of choosing the estimation window length in

Beta forecast are examined, Groenewold & Fraser (2000) examined 18 industrial sectors operating in Australia at a monthly frequency between 1973 and 1998. In their research, where they examined the forecast performance with the Rolling regression technique in a 5-year period, it was determined that Betas that changed over time showed significant instability. In addition, in the analysis they conducted to determine the optimal length of the estimation window, they determined that it was more appropriate to apply a 3-year period in the sample period. Hollstein, Prokopczuk, and Simen (2019) analyzed optimal forecast windows using daily data from NYSE, AMEX, and NASDAQ stocks between 1963 to 2015. They examined 1, 3, 6, 12, 24, 36, and 60-month windows for daily frequency data and 12, 36, and 60-month windows for monthly frequency data. They used Historical Beta, EWMA Beta, Shrinkage Beta, Dimson Beta, Scholes–Williams Beta, Correlation Separated Beta and Macro Beta methods in Beta forecast. The results show that a Historical Estimator based on daily return data with exponential weighting scheme and simple shrinkage adjustments in 12-month estimation window with daily frequency data gives the best estimates for Beta. Akyatan & Çetin (2020) forecasted Beta for 30 randomly generated portfolios comprised of 154 stocks from the XUTUM index, utilizing daily frequency data from 2003 to 2013. The authors employed the Rolling regression method combined with MGARCH DVECH, MGARCH DBEKK, MGARCH CCC, and MGARCH DCC techniques, focusing on 30-60-120-240 and 360-day windows for estimation. To evaluate forecast performance, they utilized RMSE, MAE, and MAPE methods. Their analyses revealed that the Beta estimation using dynamic methods outperformed traditional approaches. Notably, they found that the MGARCH CCC method yielded the most successful results. Additionally, the research indicated that a 120-day window length provided superior outcomes among the various rolling window estimations utilized. Agrawal, Gilbert, & Harkins (2022) examined the optimal length and return range in Beta forecast in the US stock market between 2000-2021 with the OLS method at daily, weekly and monthly frequencies. They found that the tracking error in Beta forecast decreased as the data frequency increased. In addition, in their study where they examined sub-periods from 1 to 5 years as the estimation period, they could not reach an optimal combination, but they mentioned the existence of a trend in choosing a long estimation period with daily and weekly data.

DATA AND METHODOLOGY

Data

Economic arguments suggest that Beta can change over time, leading to its modeling as a time-varying parameter (Moonis & Shah, 2003, p.6). As stated by Hawawini (1983), the Beta of a security can vary significantly depending on whether it is estimated using daily, weekly, or monthly returns. Since the Beta parameter forecast results are directly affected by the number of observations, the following question comes to mind when making a decision: should the number of observations be high or low?

While extending the length of the estimation period may reduce the observed change in Beta, it may also lead to a result that increases the probability of financial decisions and practices that have the potential to cause changes in Beta factors. At this point, the estimation period length that strikes the optimal balance becomes crucial (Theobald, 1981, p.747). Alexander & Chervany (1980) stated that the optimal estimation interval is 4-6 years in their study. Daves et al. (2000) proposed that an estimation period of 2-3 years yields more accurate results for daily frequency in Beta forecast. Choudhry & Wu (2008) determined the estimation window length as 1 and 2 years at daily frequency. In another study conducted by Choudhry & Wu (2009), the estimation window length determined as 1 and 2 years at weekly frequency. Akyatan & Çetin (2020) determined the estimation window length as 30-60-120-240 and 360 days with daily frequency data. It can be seen that recent studies in the literature tend to narrow the estimation window length. Because extending the time interval may introduce variability issues. A change in Beta during the estimation period inevitably introduces bias into the forecasted Beta values (Bartholdy & Peare, 2001, p.4). Consequently, selecting a longer estimation period raises concerns regarding the accuracy of the estimated Beta values. In this context, opting for a shorter estimation period can facilitate a more reliable estimation (Frankfurter, Leung, & Brockman, 1994). In various studies on Beta forecast across different estimation window length, such as those by Fama and Macbeth (1973), Corhay & Rad (1993), Frankfurter et al. (1994), Levy, Guttman, & Tkatch (2001) and Brzeszczynski et al. (2011) etc., it was found that Beta varies depending on the time interval used for estimation. Therefore the estimation windows are set at 126 days and 252 days for daily frequency data, and 26 weeks and 52 weeks for weekly frequency data. To reveal the change in Beta and determine whether the methods have an impact on the forecast performance, we examined three sub-periods:

Table 1. The indexes examined in the study

Indexes	Period	Frequency	Data Resource
Borsa İstanbul 100 (XU100)	31.12.2008-29.12.2023	Daily and Weekly	https://datastore.borsaistanbul.com
Hizmet (XUHIZ)	31.12.2013-29.12.2023		
Mali (XUMAL)	31.12.2013-29.12.2023		
Sinai (XUSIN)	31.01.2018-31.01.2023		
Teknoloji (XUTEK)	31.01.2018-31.01.2023		

31.12.2008 - 29.12.2023, 31.12.2013 - 29.12.2023 and 31.12.2018 - 29.12.2023 for 15, 10, 5 years, respectively. The purpose of choosing 3 sub-periods for Beta forecast is to evaluate whether the estimation success of the methods differs in different time periods. The objective is to assess the performance of the methods across specific time intervals and to investigate whether prediction performance varies across different windows and frequencies. Hence we have the motivation that this approach provides a more comprehensive perspective when revealing the effects of method success and data set frequency choice.

In our research, we utilized the total return data for the indices under examination, as recommended by Çayırılı et al. (2022)³. This comprehensive dataset was sourced from the Borsa İstanbul Data Center, ensuring accuracy and reliability. For a detailed overview of the indices used in the study, please see Table 1, which presents essential information about each index.

Methodology

The findings from practitioners who calculate Beta using historical data indicate that Beta is a somewhat constrained method for estimating market risk due to the variations observed over time (Rossi, 2016). Consequently, exploring different approaches to Beta forecast has made it essential to consider methods that could enhance forecast performance. As stated by Chakrabarti & Das (2021), employing various methods to capture changes in Beta over time is crucial for managing and calculating risk effectively.

Although there are numerous approaches to Beta forecast in the literature, we focused on only two methods. Our aim was not only to evaluate the performance of

Beta forecast methods but also to examine the effects of data frequency and estimation window length on the performance of forecast, which makes our study different from most other studies. Accordingly, Beta was forecasted using both Rolling regression and Recursive regression methods. The analysis was conducted using Stata, E-views, and MS Excel software. Detailed information on the methods used in the research is provided below.

Market Model

The formulation of the market model used in the research is given in Equation 1.

$$E(r_i) = r_f + \beta_i [E(r_m) - r_f] \quad (1)$$

$E(r_i)$: Expected return for index i

r_f : Risk-free interest rate

β_i : Systematic risk (Beta) for index i

r_m : Market return

The return calculation was carried out with the formula in Equation 2.

$$R_{it} = \ln\left(\frac{E_t}{E_{t-1}}\right) \quad (2)$$

R_{it} in Equation 2 represents the logarithmic return of index i on day t , E_t represents the index closing value on day t , and E_{t-1} represents the index closing value of the previous day. The return data for the XUTUM index has been used as the market return (r_m). The risk-free interest rate was calculated by considering Turkey's 2-year bond yield⁴. The steps followed in the daily and weekly risk-free interest rate conversion are given in Equation 3 and Equation 4.

$$r_{fd} = \left((1 + F_{t-1})^{\frac{1}{360}} - 1 \right) \quad (3)$$

$$r_{fw} = \left((1 + F_{t-1})^{\frac{1}{52}} - 1 \right) \quad (4)$$

³ In their studies, the authors investigated the impact of using price returns instead of total returns on the resulting outputs while exploring topics such as asset pricing models and portfolio selection. They demonstrated that tests assessing the validity of models constructed using price returns could lead to inaccurate results. And also they revealed that using price return causes a bias in portfolio selection in favor of assets with low dividend yields and against those with high dividend yields and showed that the share of price return in total return also has an effect on the estimated betas.

⁴ Similar to the approaches of Kaya and Soybilgen (2019), Buberoku (2021) and Tanyıldızı & Yüksel Yigiter (2024), the 2-year bond yield was utilized, as it is the most frequently observed rate, exhibits the highest trading volume, and functions as a benchmark for borrowing costs in the Turkish market.

r_{fd} : Daily risk-free interest rate

r_{fw} : Weekly risk-free interest rate

F_t : Risk-free interest rate for day/week (t)

F_{t-1} : Risk-free interest rate for day/week (t-1)

Rolling Regression

Rolling regression is a method used in empirical studies to characterize parameters that change over time (Cai & Juhl, 2023, p.1447). The Rolling regression method employs a variable regression model on time series data by dividing the dataset into specific estimation windows, training a regression model for each window. By shifting these windows, the method enables the model to adapt over time and facilitates the observation of trends within the dataset and the Beta value is updated with each new observation, allowing for real-time estimation of Beta. The calculation of Beta follows the same methodology as the Least Squares (LSS) method, as outlined in Equation 5 (Yeo, 2001);

$$R_{it} = \alpha + \beta_i R_{mt} + \varepsilon_i \quad (5)$$

T: t-30,...,t

t:30,...,x

R_{it} : Return of index i on day t

R_{mt} : Return of market portfolio (XUTUM) on day t

To provide a more detailed understanding of the methodology, let's consider a scenario where Beta forecast is performed using a 30-day estimation window. Initially, the first 30 days of data undergo regression analysis, yielding the Beta forecast result for the 30th day. For calculating the forecast for the subsequent day, data from the 2nd to the 31st day is utilized. In summary, for each new day to be estimated within the specified window, the observation sample is advanced by one observation (t+1). In this research, four different estimation windows were employed for the Beta forecast using the relevant method, consisting of 252 and 126 days for daily frequency, and 52 and 26 weeks for weekly frequency.

Recursive Regression

The Recursive regression method operates on a foundational logic that enables the estimation of future values by utilizing both current and past data. This method features a continuous adaptation and update mechanism, allowing for the incorporation of new data

into previous estimates. It is important to establish the estimation period at the outset of the analysis. In this method, the model is trained by excluding the first 30 days of observation for the selected period (e.g., 30 days), after which the Beta forecast begins. Each Beta forecast is retained within the system, and the estimated values generated throughout the estimation period are preserved in the observation set. While this method shares similarities with the EKK method, akin to the Rolling regression method in its application, it differs in terms of sample size. In contrast to the Rolling regression method, the sample size continues to grow throughout the estimation period. The methodology underlying this method is given in Equation 6 (Yeo, 2001);

$$R_{it} = \alpha + \beta_i R_{mt} + \varepsilon_i \quad (6)$$

R_{it} : Return of index i on day t

R_{mt} : Return of market portfolio (XUTUM) on day t

T= 1.....t,

t=T₀....T

In this research, we applied a method using various estimation windows for Beta calculations, which commence at 252 and 126 days, as well as 52 and 26 weeks prior to the observation value. This approach depends on the length of the estimation period relative to the starting date of the examined timeframe.

Forecast Performance Measurement

To evaluate the forecast performance of two Beta estimation methods, we used Mean Absolute Error (MAE) and Root Mean Squared Error (RMSE). The MAE measures the average absolute differences between estimations and actual values, indicating error magnitude. RMSE, on the other hand, quantifies deviation by taking the square root of the average squared differences, giving more weight to larger errors. Using both metrics allows for a comprehensive assessment of model performance. Lower MAE and RMSE values indicate better accuracy, while higher values suggest larger deviations from true values. Methodologies for these metrics are detailed in Equations 7 and 8.

$$MAE = \sum_{i=1}^n \frac{|y_{i,t} - \hat{y}_{i,t}|}{n} = \sum_{i=1}^n \frac{|e_i|}{n} \quad (7)$$

$y_{i,t}$: Observed return value of index i on trading day/ week t

$\hat{y}_{it}$: Estimated return value of index i on trading day/ week t

e_i : Error series

n: Number of observations

$$RMSE = \sqrt{\sum_{i=1}^n \left(\frac{y_{it} - \hat{y}_{it}}{n} \right)^2} = \sum_{i=1}^n \left(\frac{e_i}{n} \right)^2 \quad (8)$$

$y_{i,t}$: Observed return value of index i on trading day/ week t

$\hat{y}_{it}$: Estimated return value of index i on trading day/ week t

e_i : Error series

n: Number of observations

The calculation of the observed return values in Equations 7 and 8 is crucial for evaluating the forecast performance of the methods used. We adopted a return-based approach to estimate these values. The primary rationale for choosing return over Beta as the observed and estimated value is to minimize potential issues that may arise. Two notable challenges include:

1. The difficulties associated with calculating covariance and variance at daily or weekly frequencies when determining observed Beta values,
2. The return data utilized in the Market model can fluctuate at very small rates, leading to the potential for extreme values resulting from proportional differences in the forecasted Beta values.

To illustrate the second point above, consider a scenario where a return of 0.01 is calculated for a sub-index on day t, while the market return is only 0.001. When the daily

Risk-free rate (which is expected to be quite small) is included in the equation, it results in an extremely high Beta value of around 10. Such conditions inflate Beta estimates and lead to biased outcomes both daily and weekly observations, particularly when return differences between market and index are minimal. The following steps were taken to eliminate the aforementioned problem; The observed return calculation was made with the logarithmic return in Equation 2, and then the CAPM method in Equation 1 was used in the estimated return calculation. The forecasted Beta values obtained from the Rolling and Recursive regression results were substituted into the model and the expected return obtained was compared with the observed return results. We share the idea that this approach is eliminate our potential concerns expressed above.

FINDINGS

The results obtained from the analyses are given below.

When the summary statistics values in Table 2 are examined, it can be said that the data do not show a normal distribution, as can be understood from the skewness and kurtosis values, and therefore these values are preliminary information for the variation seen in Beta. The findings of the average R^2 and average Beta values obtained from the analyses are given in Table 3 and Figure 1.

The analysis of the average R^2 and Beta values presented above reveals that there are differences among the sub-indices in different periods. Notably, the Rolling regression and Recursive regression methods yield distinct average R^2 and Beta values, highlighting variability in findings based on estimation window selection. Moreover, the fluctuations in average Beta values indicate that changes in the alignment of index returns with market returns affect average R^2 values and the model's explanatory

Table 2. Summary Statistical Values

Daily Frequency						
2008-2023						
	XUTUM	XU100	XUHIZ	XUMAL	XUSIN	XUTEK
Mean	0.001	0.000	0.001	0.001	0.001	0.001
Maximum	0.091	0.094	0.090	0.090	0.092	0.091
Minimum	-0.110	-0.111	-0.101	-0.113	-0.114	-0.111
S.Dev.	0.015	0.016	0.014	0.018	0.014	0.015
Skewness	-0.703	-0.591	-0.697	-0.386	-0.908	-0.703
Kurtosis	7.742	7.362	8.139	6.027	9.528	7.742
Observation	3751	3751	3751	3751	3751	3751

2013-2023						
	XUTUM	XU100	XUHIZ	XUMAL	XUSIN	XUTEK
Mean	0.001	0.001	0.001	0.001	0.001	0.002
Maximum	0.091	0.094	0.090	0.090	0.092	0.094
Minimum	-0.102	-0.103	-0.101	-0.103	-0.102	-0.152
S.Dev.	0.015	0.016	0.015	0.018	0.015	0.020
Skewness	-0.764	-0.635	-0.753	-0.428	-0.793	-0.647
Kurtosis	8.198	7.862	8.404	6.443	8.649	8.444
Observation	2505	2505	2505	2505	2505	2505
2018-2023						
	XUTUM	XU100	XUHIZ	XUMAL	XUSIN	XUTEK
Mean	0.002	0.002	0.002	0.002	0.002	0.002
Maximum	0.091	0.094	0.090	0.090	0.092	0.094
Minimum	-0.102	-0.103	-0.101	-0.103	-0.102	-0.105
S.Dev.	0.017	0.018	0.017	0.020	0.018	0.022
Skewness	-0.932	-0.777	-0.846	-0.558	-0.867	-0.532
Kurtosis	8.296	7.891	8.232	6.664	7.795	6.404
Observation	1251	1251	1251	1251	1251	1251
Weekly Frequency						
2008-2023						
	XUTUM	XU100	XUHIZ	XUMAL	XUSIN	XUTEK
Mean	0.004	0.004	0.004	0.003	0.005	0.006
Maximum	0.148	0.158	0.157	0.204	0.134	0.143
Minimum	-0.194	-0.193	-0.152	-0.217	-0.201	-0.217
S.Dev.	0.036	0.038	0.032	0.044	0.034	0.042
Skewness	-0.533	-0.388	-0.373	-0.262	-0.815	-0.531
Kurtosis	5.390	5.134	5.165	5.085	6.493	5.296
Observation	835	835	835	835	835	835
2013-2023						
	XUTUM	XU100	XUHIZ	XUMAL	XUSIN	XUTEK
Mean	0.005	0.004	0.005	0.004	0.006	0.006
Maximum	0.108	0.115	0.105	0.135	0.134	0.143
Minimum	-0.153	-0.144	-0.152	-0.172	-0.169	-0.217
S.Dev.	0.034	0.036	0.033	0.041	0.033	0.042
Skewness	-0.535	-0.381	-0.441	-0.330	-0.512	-0.487
Kurtosis	4.592	4.318	4.681	4.429	5.352	5.572
Observation	574	574	574	574	574	574
2018-2023						
	XUTUM	XU100	XUHIZ	XUMAL	XUSIN	XUTEK
Mean	0.007	0.007	0.007	0.006	0.008	0.006
Maximum	0.108	0.115	0.105	0.135	0.134	0.143
Minimum	-0.153	-0.136	-0.152	-0.136	-0.169	-0.217
S.Dev.	0.037	0.038	0.036	0.0448	0.037	0.047
Skewness	-0.510	-0.300	-0.456	-0.259	-0.539	-0.402
Kurtosis	4.303	3.938	4.474	4.030	5.086	4.696
Observation	313	313	313	313	313	313

Table 3. Average R^2 Values

2008-2023											
Rolling Regression						Recursive Regression					
Av. R^2	XU100	XUHIZ	XUMAL	XUSIN	XUTEK	Av. R^2	XU100	XUHIZ	XUMAL	XUSIN	XUTEK
52wk	0.994	0.767	0.929	0.834	0.502	52wk	0.997	0.715	0.952	0.837	0.521
26wk	0.994	0.762	0.927	0.823	0.491	26wk	0.997	0.726	0.953	0.844	0.501
252d	0.995	0.756	0.931	0.834	0.510	252d	0.997	0.742	0.957	0.840	0.529
126d	0.995	0.748	0.929	0.828	0.501	126d	0.997	0.747	0.958	0.838	0.512
2013-2023											
Rolling Regression						Recursive Regression					
Av. R^2	XU100	XUHIZ	XUMAL	XUSIN	XUTEK	Av. R^2	XU100	XUHIZ	XUMAL	XUSIN	XUTEK
52wk	0.993	0.801	0.914	0.846	0.534	52wk	0.996	0.796	0.945	0.849	0.475
26wk	0.993	0.795	0.911	0.844	0.529	26wk	0.996	0.799	0.940	0.845	0.514
252d	0.994	0.783	0.915	0.847	0.531	252d	0.997	0.779	0.942	0.841	0.502
126d	0.994	0.776	0.913	0.844	0.523	126d	0.997	0.775	0.939	0.834	0.488
2018-2023											
Rolling Regression						Recursive Regression					
Av. R^2	XU100	XUHIZ	XUMAL	XUSIN	XUTEK	Av. R^2	XU100	XUHIZ	XUMAL	XUSIN	XUTEK
52wk	0.988	0.821	0.885	0.866	0.645	52wk	0.990	0.798	0.894	0.831	0.592
26wk	0.987	0.816	0.886	0.870	0.649	26wk	0.989	0.798	0.897	0.843	0.602
252d	0.991	0.814	0.885	0.872	0.650	252d	0.993	0.779	0.888	0.826	0.565
126d	0.990	0.811	0.884	0.878	0.657	126d	0.992	0.774	0.887	0.823	0.607

power. When the average R^2 values for all periods covered in the study are examined, the highest R^2 value in the results obtained from both methods was found in the XU100 index in all windows. This is followed by the XUMAL, XUSIN, XUHIZ and XUTEK indices. Given the dual influence of systematic and idiosyncratic risks on asset pricing, an increase in idiosyncratic risk is likely to reduce the variance's explanatory capacity. Regarding standard deviation values, there is no specific order like R^2 . The rankings of the standard deviations of the indices differ across the examined windows and time periods.

One of the aims of this study is to explore the effect of estimation window frequency on Beta forecast outcomes. Analysis of the preliminary standard deviation values in Figure 1 indicates that daily frequency Beta forecasts yield lower standard errors across most periods and sub-indices. Additionally, average Beta values from daily frequency vary by estimation window. The Rolling regression method shows a decrease in standard deviation values as the estimation window increases, while the Recursive regression method yields similar results, with some exceptions. Notably, differences in forecasted Beta means between the two methods suggest that the choice of estimation technique significantly influences

the results, as corroborated by the descriptive statistics. To assess the predictive accuracy of the methodologies employed in this research for forecasting time-varying Beta, the results derived from the MAE and RMSE metrics are presented in Table 4.

When the MAE and RMSE forecast performance results in Table 4 are examined, the following points stand out in terms of comparing performance between the methods:

When the MAE and RMSE values for the period 2008-2023 and 2013-2023 are examined, the index ranking from lowest to highest is as follows: XU100, XUTEK, XUMAL, XUSIN and XUHIZ. But this situation has changed for the 2018-2023 period. The index ranking is; XUTEK, XU100, XUSIN, XUHIZ and XUMAL.

For the period 2008-2023, the Rolling regression method consistently exhibits lower MAE and RMSE values relative to the Recursive regression method across nearly all indices. When analyzing the RMSE values obtained within the 126-day window, it is observed that this finding cannot be attributed solely to the XUTEK index results. The RMSE value associated with the XUTEK index was recorded as 0.00315 using the Rolling regression method, whereas it was measured at 0.00305 for the



Figure 1. Average Beta Values and Standart Deviation(second axis)

Table 4. MAE and RMSE Forecast Performance Results

	Rolling Regression							Recursive Regression						
			XU100	XUHIZ	XUMAL	XUSIN	XUTEK			XU100	XUHIZ	XUMAL	XUSIN	XUTEK
2008-2023	252d	MAE	.00073	.00491	.00357	.00407	.00175	252d	MAE	.00073	.00506	.00365	.00423	.00208
		RMSE	.00119	.00644	.00503	.00541	.00284		RMSE	.00123	.00662	.00520	.00564	.00290
	126d	MAE	.00072	.00489	.00353	.00404	.00194	126d	MAE	.00074	.00506	.00365	.00423	.00217
		RMSE	.00118	.00640	.00497	.00535	.00315		RMSE	.00123	.00663	.00520	.00564	.00305
	52wk	MAE	.00184	.01044	.00814	.00961	.02045	52wk	MAE	.00190	.01099	.00830	.00986	.02082
		RMSE	.00308	.01365	.01147	.01236	.02795		RMSE	.00318	.01436	.01169	.01266	.02845
	26wk	MAE	.00180	.01035	.00795	.00947	.02006	26wk	MAE	.00190	.01098	.00829	.00986	.02084
		RMSE	.00303	.01344	.01117	.01209	.02748		RMSE	.00318	.01434	.01167	.01266	.02851
2013-2023	Rolling Regression							Recursive Regression						
			XU100	XUHIZ	XUMAL	XUSIN	XUTEK			XU100	XUHIZ	XUMAL	XUSIN	XUTEK
	252d	MAE	.00083	.00470	.00396	.00394	.00140	252d	MAE	.00086	.00478	.00404	.00410	.00146
		RMSE	.00137	.00615	.00558	.00520	.00240		RMSE	.00141	.00625	.00571	.00542	.00210
	126d	MAE	.00082	.00467	.00391	.00390	.00164	126d	MAE	.00085	.00477	.00404	.00409	.00148
		RMSE	.00136	.00611	.00551	.00514	.00274		RMSE	.00141	.00624	.00571	.00541	.00217
	52wk	MAE	.00215	.01006	.00895	.00912	.02011	52wk	MAE	.00225	.01017	.00908	.00943	.02037
		RMSE	.00358	.01321	.01274	.01181	.02722		RMSE	.00371	.01336	.01289	.01222	.02781
2018-2023	Rolling Regression							Recursive Regression						
			XU100	XUHIZ	XUMAL	XUSIN	XUTEK			XU100	XUHIZ	XUMAL	XUSIN	XUTEK
	252d	MAE	.00135	.00488	.00495	.00411	.00085	252d	MAE	.00139	.00493	.00504	.00422	.00092
		RMSE	.00188	.00637	.00681	.00542	.00164		RMSE	.00194	.00646	.00693	.00558	.00140
	126d	MAE	.00134	.00487	.00488	.00405	.00105	126d	MAE	.00139	.00494	.00505	.00421	.00140
		RMSE	.00187	.00635	.00671	.00536	.00185		RMSE	.00194	.00646	.00694	.00556	.00206
	52wk	MAE	.00349	.01070	.01152	.00973	.02022	52wk	MAE	.00368	.01086	.01161	.00991	.02030
		RMSE	.00494	.01397	.01586	.01261	.02734		RMSE	.00510	.01408	.01594	.01281	.02766
	26wk	MAE	.00344	.01077	.01123	.00966	.01999	26wk	MAE	.00368	.01083	.01162	.00986	.02026
		RMSE	.00489	.01398	.01535	.01242	.02707		RMSE	.00509	.01405	.01593	.01274	.02761

Recursive regression method. These results suggest that the Rolling regression method generally demonstrates superior performance in Beta forecast during the 2008-2023 period, with the exception of specific case noted.

For the period 2013-2023, it is seen that the forecast results performed with the Rolling regression method in almost all indices have lower MAE and RMSE values compared to Recursive regression. When the MAE and RMSE values obtained in the 252 and 126-day windows are examined, it is observed that this finding cannot be attributed solely to the XUTEK index results. The RMSE value obtained in the 252-day window was determined as 0.00240 in the Rolling regression method and 0.00210 in the Recursive regression method. In the 126-day window, the MAE value obtained was measured as 0.00164 in the Rolling regression method, 0.00148 in the Recursive regression method, and RMSE was measured as 0.00274

in the Rolling regression method and 0.00217 in the Recursive regression method. Except for the mentioned exception, it can be stated that the Rolling regression method performed better in Beta forecast for the period 2013-2023.

For the period 2018-2023, the findings remain similar; the Rolling regression method demonstrates lower error values across all examined indices, with the exception of the XUTEK index. Moreover, an assessment of the RMSE values within the 252-day window reveals that the Rolling regression method yields an RMSE value of 0.00164, while the Recursive regression method is associated with an RMSE value of 0.00140. Excluding the aforementioned exception, the data demonstrates that the Rolling regression method generally outperforms the Recursive regression method in Beta forecast for the 2018-2023 period.

Table5. Paired T-Test Results

Variable	Obs	Mean	Std. Err.	Std. Dev.	95% Conf. Interval (Lower)	95% Conf. Interval (Upper)
Rolling-RMSE	60	.00913	.00096	.00745	.00721	.01106
Recursive-RMSE	60	.009364	.00099	.00764	.00739	.01134
diff	60	-.00023	.00003	.00027	-.00030	-.00016
t = -6.6917 Ha: mean(diff) < 0 Ha: mean(diff) != 0 Ha: mean(diff) > 0 p value (T < t) = 0.0000 p value (T > t) = 0.0000 p value (T > t) = 1.0000						
Variable	Obs	Mean	Std. Err.	Std. Dev.	95% Conf. Interval (Lower)	95% Conf. Interval (Upper)
Rolling-MAE	60	.00672	.00072	.00558	.00528	.00816
Recursive-MAE	60	.00691	.00073	.00569	.00544	.00838
diff	60	-.00019	.00002	.00017	-.00023	-.00014
t = -8.4918 Ha: mean(diff) < 0 Ha: mean(diff) != 0 Ha: mean(diff) > 0 p value (T < t) = 0.0000 p value (T > t) = 0.0000 p value (T > t) = 1.0000						

To enhance the robustness of the evaluation of prediction performance success for the Rolling and Recursive regression methods in Beta estimation, a paired t-test was used to determine the statistical difference and method success. The findings are presented in Table 5.

Table 5 compares the predictive performance of different methods using RMSE and MAE metrics. The analysis shows t-values of -6.6917 for RMSE and -8.4918 for MAE, with corresponding p-values of 0.000 for both metrics. These results indicate a significant negative difference between the first group (Rolling) and the second group (Recursive), suggesting that the mean error of the Rolling method is lower than that of the Recursive method. Therefore, this evidence supports the conclusion that the rolling regression method is more accurate than the recursive method in terms of predictive performance.

In line with our motivation to determine whether the data set frequency affects the Beta forecast success of the methods, when the results in Table 4 are examined, it is seen that the Beta values estimated using daily frequency data have lower error values compared to those estimated using weekly frequency data in both methods and in all periods examined. Findings indicate that daily frequency data significantly improves the accuracy of Beta forecast, leading to reduced error compared to weekly frequency data for the specific periods and indices under investigation. It is recommended to prioritize daily data over weekly data when selecting the frequency for Beta forecast, as this will enhance the precision of the results.

In the findings obtained in Table 4 regarding whether the length of the estimation window determined in Beta

forecast, which is another motivation of the study, has an effect on forecast success;

For the period 2008-2023, in all weekly frequency Beta forecast performances obtained with the Rolling regression method, it is observed that there is a decrease in forecast errors as the estimation window narrows. In daily frequency estimations, it is determined that there is a decrease in forecast errors as the estimation window narrows in all indices except the XUTEK index. While the 252-day MAE value was measured as 0.00175 in the XUTEK index, the MAE value was determined as 0.00194 in the 126-day window. It can be stated that from the forecast errors obtained with the Recursive regression method in this period, the extension or shortening of the estimation window length does not lead to a difference that will establish superiority in frequency selection.

For the period 2013-2023, in all weekly frequency Beta forecast performances obtained with the Rolling regression method, it is observed that there is a decrease in forecast errors as the estimation window narrows. In the daily frequency forecast performance results, it was determined that this situation was also valid for other indices except for the XUTEK index. While the 252-day MAE value was measured as 0.00140 in the XUTEK index, the MAE value was measured as 0.00164 in the 126-day window, and the RMSE value was measured as 0.00240 in the 252-day window, while the RMSE value was determined as 0.00274 in the 126-day window. When the forecast performances obtained with the Recursive regression method were examined at daily frequency, it was determined that there was a decrease in forecast errors in all other indices except for the XUTEK index as

the estimation window narrowed. In the XUTEK index, the MAE value was measured as 0.00146 in the 252-day window, while the MAE value was measured as 0.00148 in the 126-day window, and the RMSE value was measured as 0.00210 in the 252-day window, while the RMSE value was determined as 0.00217 in the 126-day window. In the weekly frequency, it is not possible to mention the existence of a definite superiority between the estimation window lengths.

For the 2018-2023 period, similar to other periods, it was determined that there was a decrease in forecast errors as the estimation window narrowed in the daily frequency forecasts obtained with the Rolling regression method, except for the XUTEK index. In XUTEK index, MAE value was measured as 0.00085 in 252-day window, MAE value was measured as 0.00105 in 126-day window, RMSE value was measured as 0.00164 in 252-day window, while RMSE value was determined as 0.00185 in 126-day window. In weekly frequency, it was found that as the estimation window narrowed for other indices except for XUHIZ index, forecast errors decreased. In XUHIZ index, MAE value was measured as 0.01070 in 52-week window, MAE value was measured as 0.01077 in 26-week window, RMSE value was measured as 0.01397 in 52-week window, while RMSE value was determined as 0.01398 in 26-week window. In the Recursive regression method, it cannot be said that the estimation window length has a definite superiority over each other for the prediction results obtained from neither weekly nor daily frequency data.

Another finding from the study indicates that the estimation window demonstrating the highest success in prediction across all periods is the 126-day estimation window, noted for its lowest MAE and RMSE values for nearly all indices.

Based on the results obtained from our research, the key outcomes can be summarized as follows:

- Practitioners who utilize traditional methods for estimating Beta values, while assuming that Beta remains constant over time in financial decision-making, risk making incorrect calculations and, consequently, flawed decisions. Therefore, it can be said that the Rolling regression method is more effective than the Recursive regression method for Beta forecast within the specified period and data set examined in this study.
- The length of the estimation window is another crucial factor influencing the results of Beta

forecast. It appears that the most effective estimation window interval for the Rolling regression method is the 126-day window.

- Additionally, the impact of data frequency selection on Beta forecast and its forecast performance is a significant consideration. Opting for daily frequency data rather than weekly data when forecasting Beta is likely to enhance forecast accuracy.

CONCLUSION

The forecast of Beta, a critical parameter for practitioners, poses a challenge due to its non-observable nature. The conventional methodology for forecasting Beta involves computing covariances and variances derived from historical return data. However, in many studies existing literature such as Fama & French (1997), Groenewold & Fraser (1999), Moonis & Shah (2003), Zhou (2013) and Lopez Herrera et al. (2022) highlights significant concerns regarding the inherent instability of Beta, revealing variability over time that undermines the linear relationship posited by the CAPM between market portfolio returns and asset returns. This fluctuation signifies that a fundamental assumption of the CAPM is often violated in practice, which can adversely impact practitioners. The findings from the studies by Faff, Lee & Fry (1992), Groenewold & Fraser (1999), and Estrada (2000) also support the existence of these negative effects, particularly leading to issues in Beta forecasting. Therefore, it is crucial to adopt methodologies that effectively capture these temporal variations to improve estimation accuracy.

Along with the selection of Beta estimation methods, determining the data frequency and estimation window length is another crucial issue. This is because there are significant studies in the literature that provide important findings regarding the impact of data frequency and the selection of estimation windows on Beta forecast results, such as those by Damodaran (1999), Daves et al. (2000), Choudhry & Wu (2008), and Patton & Verardo (2012). At this point our aim was not only to evaluate the performance of Beta estimation methods but also to examine the effects of data frequency and estimation window length on the performance of Beta forecast.

We utilized Rolling and Recursive regression methods to estimate fluctuations in Beta of BIST leading sector indices and compared their forecasting performance using MAE and RMSE metrics. We analyzed three sub-periods: 31.12.2008 - 29.12.2023, 31.12.2013 - 29.12.2023,

and 31.12.2018 - 29.12.2023 to determine the impact of these methods over different time frames. We also assessed the effect of estimation window lengths with daily and weekly data, using 252 days, 126 days, 52 weeks, and 26 weeks, and examined how data frequency impacts Beta estimation.

The findings obtained from this study stand out in terms of providing ideas to financial managers and academics in the following aspects;

Using Rolling regression and Recursive regression techniques over various trading day (126, 252) and trading week (26, 52) windows, our findings confirm previous studies by Groenewold & Fraser (1999), Moonis & Shah (2003) and Wijethunga & Dayaratne (2015), Çenesizoğlu et al. (2017), indicating that Beta is indeed sensitive to temporal fluctuations and occurs variably across the methodologies used.

The analysis of method performances with respect to error forecast metrics indicates that estimates obtained from the Rolling regression approach demonstrate significantly lower error values. This finding suggests a superior estimation performance in comparison to the Recursive regression method. The average R^2 and Beta values derived from the analysis, consistent with Dasgupta et al. (2010), indicate that changes in the alignment of index returns with market returns affect average R^2 values and the model's explanatory power. Contrary to Tunçel (2009) we find both the frequency of the data and the specified estimation window influence the estimation of Beta. The results obtained are consistent with the studies of Damodaran (1999), Patton & Verardo (2012) and Mestre (2023), which highlight that data frequency has an impact on forecasting outcomes. Additionally, they are consistent with the research conducted by Frankfurter, Leung, & Brockman (1994), Odabaşı (2003) and Brzezczynski, Gajdka, & Schabek (2011), which suggest that the selection of the estimation window influences the forecast results. Another finding from the study is that examination of error forecast results across different estimation windows indicates that performance is contingent upon the window selection. This result is consistent with the conclusions drawn by Çenesizoğlu et al. (2016) and Messis & Zapraniş (2016). Notably, in the context of Rolling regression, the most favorable forecast error outcomes are predominantly associated with the 126-day estimation window, while the Recursive regression method fails to demonstrate a clear optimal window. This result is similar to the findings of Akyatan and Cetin (2020), who found the optimal estimation window length as 120 days.

Our results highlight the significance of data frequency in Beta forecast outcomes and shows that utilizing daily frequency data yields lower forecast errors compared to weekly data across the examined time frames and indices. This finding aligns with the assertions made by Daves et al. (2000) Iqbal & Brooks (2007) and Patton & Verardo (2012), who advocate that high-frequency data facilitates more effective detection of Beta variability.

The findings obtained from the 5, 10, and 15-year estimation periods reveal that Beta estimates exhibit variation over the course of the selected estimation period. Also as the length of the estimation window increases, there is a decrease in the standard deviation values for the majority of Beta forecasts. In accordance with the findings presented by Theobald (1981) and Daves et al. (2000), we believe that decision-makers' preference for longer estimation periods based on standard deviation values may carry certain risks. We argue that selecting a longer estimation window may increase the likelihood of financial and operational decisions that could lead to biased Beta forecasts during the chosen extended period.

In conclusion, our findings suggest that practitioners who operate under the presumption that Beta remains constant may inadvertently produce biased analyses, resulting in improper financial decisions. Similar to Chakrabarti & Das (2021) and Lopez Herrera et al. (2022), we share the idea that the adoption of dynamic methodologies capable of capturing Beta over time may have positive effects on market risk and hedging behaviors.

As suggested by Doan et al. (2022) Phin et al. (2022) and Zhou (2025), we believe that Beta estimation using high-frequency data could yield more reliable results. In future studies, using different methods in Beta forecast and comparing their performance with intraday data will make valuable contributions to reduce forecast error in the Beta literature.

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