INNOVATIVE APPLICATIONS AND RESEARCH METHODS IN SOCIAL SCIENCES

EDITORS
ASSOC. PROF. DURSUN DEDE, PH.D.
ASSOC. PROF. HACI MUSTAFA PAKSOY, PH.D.

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Innovative Applications and Research Methods in Social Sciences

Editors

Assoc. Prof. Dursun Dede, Ph.D.

Assoc. Prof. Hac Mustafa Paksoy, Ph.D.

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CHAPTER 1

The Effects of Trends in Maximum, Minimum Temperatures, and Precipitation Series on Drought in the Kop Region, Türkiye

Türkan Bayer-Altın[1]

[1] Prof. Dr., Faculty of Humanities and Social Sciences, Department of Geography, Niğde Ömer Halisdemir University, Niğde , Türkiye, 0000-0001-8692-1713

Introduction

The Konya Plain Project (KOP) is a multi-sectoral, sustainable, people-oriented, and integrated regional development initiative that aims to address the region's irrigation and basic infrastructure needs, while accelerating its economic and social development. (KOP BKİ, 2023). The term "KOP Region" refers not to a geographical area, but to a key sub-region for agricultural development, which includes several settlements in the central and northern parts of the Central Anatolia Region. Namely, the KOP region is not one of the country's seven geographic regions. The KOP Region encompasses the provinces of Aksaray, Karaman, Konya, Nevşehir, Niğde, Kırıkkale, Kırşehir, and Yozgat. Geographically, some of these provinces (Konya, Karaman, and Aksaray) are located in the Konya section of the Central Anatolia Region, while others (Nevşehir, Niğde, Kırıkkale, Kırşehir, and Yozgat) are located in the Central Kızılırmak Sub-region. Agriculture, industry, trade, and tourism are the most prominent sectors in the KOP Region, with agriculture and livestock farming constituting the primary sources of income for the region's economy. As such, they also contribute significantly to the Turkish economy. Therefore, a detailed study of drought in the KOP Region is crucial (KOP BKİ, 2024). According to projections obtained by regional climate modelling, the 2021-2029 common dry period, which is expected to last 8 years in the region, especially in the Konya Basin, is predicted to have a much drier climate than today, at least in the near-medium future (MEU, 2015). The most severe drought events expected to occur during this expected common dry period will be observed in the Karaman region, followed by Konya, Karapınar, Kulu, Aksaray, and Niğde (MEU, 2015). The hydrometeorological drought analysis of Aksaray using the integrated drought index was examined for the period 1950-2008, and an increasing trend was observed in the drought indicators calculated for multiple periods between 2000 and 2008 (Hınıs, 2013). This study also found that moderate droughts increased 2.5 times more than in other periods during this time period, indicating a shift from wet to dry periods. Meteorological drought analysis of the Kızılırmak Basin, which is part of the region, was conducted by Arslan et al. (2016) for the period 1973-2013. Comparing this period to past droughts, significant increases were found in recent drought durations for 12- and 60-month periods in the basin. This situation is likely to result in the conversion of a significant portion of existing irrigated agricultural land to dry land in the future. Therefore, to minimize drought problems, some researchers (Pınarkara et al., 2013) have proposed projects to bring water from external basins. Additionally, Research was conducted on the region's soil-water resources, their potential, and sustainability (Şahin et al., 2013). Drought affects not only the agricultural sector but also ecological conditions related to natural environmental conditions (Bayramoğlu and Ağızan, 2022).

For the Konya Closed Basin, the Standardized Precipitation Index (SPI) was applied to the monthly precipitation series projected until 2100 under the optimistic (RCP 4.5) and pessimistic (RCP 8.5) conditions of the "Representative Concentration Pathway (RCP)" in the HadGEM2 global climate model. As a result of the studies, four common agricultural dry periods (2043-2044, 2046-2047, 2086-2087, and 2090-2091) were determined according to the RCP 4.5 scenario. Five common agricultural dry periods (2041-2043, 2060-2062, 2072-2074, 2092-2094, and 2095-2097) were determined according to the RCP 8.5 scenario (Taş and Yıldırım, 2020). Bayer-Altın (2017) analyzed the dry periods in Nevşehir for the period 1960-2016 using the Standard Precipitation Index (SPI) and Precipitation Normal Index (PNI) methods and found that the driest years were 1970, 2001, and 2013. Bayer-Altın (2019) investigated the drought status and vulnerability of cities in the KOP region. This study revealed changes in climate type (from semi-humid to semi-arid) at some stations. Bayer-Altın et al. (2023) determined that the most sensitive sub-region to desertification processes in the Central Anatolia Region is Konya and its immediate surroundings, as evidenced in their study, which employed the SPI and Aridity Index methods for the arid conditions of the Central Anatolia Region. A statistically significant increasing trend in the maximum and minimum temperatures was observed, indicating that this increase will enhance evaporation of the Central Anatolia Region for the period 1960-2021.The number and severity of drought years are increasing in the KOP Region. Therefore, instead of increasing agriculture across large areas, it is necessary to maintain the existing amount of irrigated and dry land areas, improving the quality of both rather than quantity (WWF, 2014). Increased evapotranspiration rates, coupled with expected snow and precipitation deficits, particularly in our extensive plains and inland areas, will increase stress on water resources and, consequently, the agricultural and forestry sectors (Kadıoğlu et al., 2017). This situation is taking place in the KOP Region today (KOP BKİ, 2023).

The primary objectives of this study are to determine whether statistically significant trends (increases and decreases) exist in precipitation, maximum, and minimum temperatures in settlements located in the KOP region. Furthermore, it aims to reveal the relationships between temperature and drought index, as well as the relationship between precipitation and drought index. Thus, it will be determined whether the factor causing drought is the decrease in precipitation or the increase in temperature.

Location and climate

The study area (KOP Region) is located between 40º19'05.68"-36º 20'56.18" North latitude and 31º16'32.71"-36º07'18.10" East longitude and covers an area of 95,580 km^2 (Figure 1a). The region is bordered to the north by the Central

Black Sea sub-region, to the east by the provinces of Kayseri and Sivas, to the south by the Taurus Mountains, and to the west by the provinces of Afyonkarahisar, Eskişehir, and Ankara. It includes the provinces of Aksaray, Karaman, Kırıkkale, Kırşehir, Konya, Nevşehir, Niğde, and Yozgat. The region exhibits a diversity of landforms within these boundaries. Elevation decreases from the north, averaging 1300 m (above sea level, asl.), to the south, averaging 1000 m asl. The lowest elevations (900-910 m asl.) correspond to Salt Lake and its immediate surroundings (Figure 1b). The Taurus Mountains bound the southern and southwestern parts of the Konya Plain. Akşehir, Beyşehir, and Hadım are high settlements located at the foothills of the inner slopes of the Taurus Mountains. This section is bordered by the Mts Sultan in the west and the Anamas, Gidengelmez, and Bolkar Mountains in the east. These mountains range in elevation from 2,700 to 3,500 meters. Volcanic mountains are also found in the central and eastern parts of the region. These high volcanic mountains are Mount Hasan (3,268 m), Küçük Hasandağ (3,040 m), and Mount Melendiz (2,963 m), located between the provinces of Niğde and Aksaray. The second macro morphological unit in the region is the plateaus situated between the mountains. The Bozok plateau is located to the north, and the Cihanbeyli and Obruk plateaus are near the Salt Lake. The plains correspond either to formerly dried lake bottoms (Konya-Ereğli plain and Bor plain) or to narrow alluvial bottoms in mountain foothills and valleys. The most extensive plain is the Konya-Ereğli plain (approximately 5,000 km^2). The Bor and Misli plains, located within Niğde province, and the Aksaray plain, situated within Aksaray province, are other essential plains. Yozgat is the province with the smallest plains. The Yerköy and Boğazlıyan plains cover approximately 35 km^2.

The study area is one of the driest regions in Türkiye, receiving very little precipitation. This is primarily and significantly due to the imposing mountainous terrain that borders the area to the north and south. These mountains act as a barrier, blocking the moisture-laden air coming from the Mediterranean to the south and the Black Sea to the north. Specifically, the stations located in the southern part of the region—such as Karapınar, Karaman, and Ereğli—are particularly affected, as they lie in a rain shadow. This situation has intensified the continental climate conditions, leading to a decrease in precipitation. The temperature amplitudes, which are highly variable and unpredictable, are notably high between seasons and day and night. These amplitude values, which can range between 21 ºC and 25 ºC, are even more pronounced in the east. The annual mean temperatures in the region vary between 9 °C (Yozgat and Boğazlıyan) and 12 °C (Aksaray, Karaman, Konya, Ereğli, Akşehir, and Kırıkkale). Annual mean temperatures decrease from the central region in both northward and southward directions. January is the coldest month, with mean temperatures ranging from -1.9 ºC (Boğazlıyan) to 0.9 ºC (Akşehir) (Bayer-Altın, 2019). July is the warmest

month, with mean temperatures ranging from 19.9 °C (Yozgat) to 24.1 °C (Kırıkkale). Annual total precipitation varies from 292 mm (Karapınar) to 641 mm (Hadım). Topography influences precipitation distribution. Hadım (641 mm), Akşehir (547 mm), and Beyşehir (495 mm) receive more precipitation than other settlements in the region, as they are positioned to meet the humid air masses that bring precipitation to the Taurus Mountains. Precipitation deficits are evident in the southern and central parts of the region, as follows: Aksaray (343 mm), Cihanbeyli (322 mm), Karaman (334 mm), Niğde (337 mm), and Ulukışla (322 mm). For this reason, it is the most vulnerable part of the region to drought risk. Precipitation amounts generally increase from the central parts to the north. In the north, precipitation ranges from 351 mm (Boğazlıyan) to 581 mm (Yozgat).

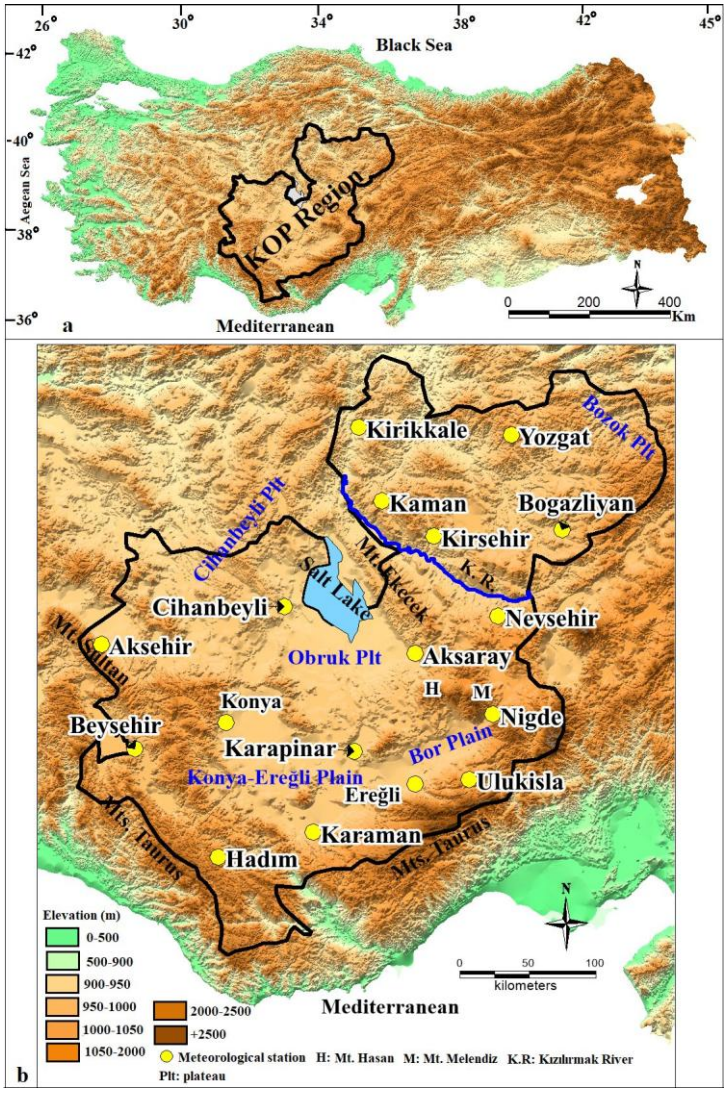

Figure 1. The location of the Kop Region in Türkiye (a) and geographical distribution of the meteorological stations used in the study (b).

Data and Methods

This study used long-term (1964-2024) annual total precipitation and annual mean maximum and minimum temperature series from meteorological stations. Stations with record periods exceeding 30 years, complete record periods, and unchanged locations were selected for the analyses. The recording times, coordinates, and altitudes of the stations in the region are listed in Table 1. The nonparametric Mann-Kendall test was used to detect potential trends in the climate data over 61 years (1964-2024). The Erinç drought index (1965) was used to determine the climate and drought status of the stations. The Pearson correlation test was used to reveal whether there was a relationship between the index values and precipitation and temperature data. The spatial distribution of the results from the Erinç formula, the Mann-Kendall test, and the Pearson correlation coefficient is mapped.

The Erinç Drought Index (Im) was chosen to determine the climate type of the stations and the arid-humid periods. This index was developed by Erinç (1965) to identify drought problems that may occur in arid/humid areas of Türkiye. It represents the ratio between the amount of precipitation falling on a location and the amount of water lost due to the mean maximum temperature of that location. This ratio, represented by Equation 1, is defined as the "Erinç Drought (Precipitation Efficiency) Index (Im)". The obtained index values are classified and interpreted as given in Table 2. Erinç (1965) determined six main classes by comparing the spatial distribution of vegetation and the index results.

Table 1. Introductory information about the meteorological stations in the KOP Region.

Station	Period	Elevation (m)	Latitude	Longitude
Yozgat	1964-2024	1301	38°40'	34°05'
Boğazlıyan		1071	39°19'	35°24'
Kırıkkale		769	39°87'	33°44'
Kırşehir		1075	39°10'	34°09'
Kaman		1080	39°21'	33°43'
Aksaray		980	38°23'	34°03'
Nevşehir		1150	38°37'	34°42'
Cihanbeyli		951	38°65'	32°92'
Akşehir		1050	38°02'	31°24'
Niğde		1230	37°58'	34°41'
Ulukışla		1427	37°54'	34°48'
Beyşehir		1147	37°67'	31°72'
Konya		1020	37°86'	32°48'
Karapınar		1026	37°71'	33°54'
Ereğli		1050	37°51'	34°04'
Karaman		1033	39°93'	32°85'
Hadim		1511	36°99'	32°46'

Table 2. Erinç (1965) Drought Index values and the climate and vegetation types corresponding to values.

Im	Climate type	Vegetation type
<8	Severe arid	Desert
8-15	Arid	Desert-like steppe
15-23	Semi-arid	Steppe
23-40	Semi-humid	Dry forest
40-55	Humid	Humid forest
>55	Perhumid	Perhumid forest

To more clearly visualize the change in the climate at the stations, the Im values were divided into two separate periods, periods 1 and 2. The first period covers the years 1964-1993, and the second period covers the years 1994-2024.

$$Im = P/Tom \qquad \text{(Equation 1)}$$

Where *Im* is the precipitation efficiency index, *P* is the long-term mean of the annual precipitation total (mm), and *Tom* is the long-term mean of the annual maximum temperature (ºC).

The Mann-Kendall trend (M-K) test is a test recommended by the World Meteorological Organization and is widely used to detect trends in time series. The M-K test is a nonparametric test, and is a special application of Kendall's test known as Tau. In this method, the size of the data is not taken into account, and the order of the data is essential (sorting from smallest to largest). This test is

helpful because it allows for the presence of missing data and does not require the data to fit a particular distribution (Sneyers,1990; Kalaycı and Kahya, 1998). To determine the likely trend of the maximum and minimum temperatures, as well as the precipitation series for the study area, and to assess whether there is a statistically significant increasing or decreasing trend, the M-K trend analysis was applied to the temperature and precipitation data for the study area. This trend analysis was also used to monitor changes in the climate of the stations.

The Pearson correlation (r) formula (Equation 2) was used to determine whether a relationship exists between the maximum temperature values and index values, as well as between precipitation values and index values, at the stations. The Pearson correlation coefficient (r) is defined as a measure of the strength of the relationship between two variables and their relationship with each other (Table 3). It is a value between -1 and 1 that measures the strength and direction of the relationship between two variables. The coefficient describes the strength and direction of the linear relationship between two quantitative variables. A correlation value alone is not sufficient to determine a cause-and-effect relationship. It is also necessary to consider the possibility that a third variable may be influencing the relationship. In other words, the cause-and-effect relationship between two variables should not be evaluated independently of the effects of different variables (Ratner, 2009; Sedgwick, 2012).

Table 3. Descriptions of the strength of the relationship between two variables

Pearson correlation coefficient (r) value	Strength	Direction
Greater than 0.50	Strong	Positive
Between 0.30 and 0.50	Moderate	Positive
Between 0 and 0.30	Weak	Positive
0	None	None
Between 0 and –0.30	Weak	Negative
Between –0.3 and –0.50	Moderate	Negative
Less than –0.50	Strong	Negative

$$r = \Sigma(x_i-\dot{x})(y_i-\dot{y})/\sqrt{\Sigma(x_i-\dot{x})^2\,\Sigma(y_i-\dot{y})^2} \qquad \text{(Equation 2)}$$

Where r is the correlation coefficient, xi is the value of variable x in the sample, ẋ is the mean of the values of variable x, yi is the value of variable y in the sample, and ẏ is the mean of the values of variable y.

Results

Spatial distribution of annul Im value and trend in annula Im values

As shown in Figure 3a, the primary driver of the variability and trend in the Im values is the amount of precipitation received at the station. The higher a station's elevation and the more exposed it is to frontal activity, the greater the precipitation and the lower the mean maximum temperature. Therefore, Beyşehir, located in the southern part of the study area, has the highest Im value (37.2). Beyşehir is followed by Hadim (Im: 29.3) and Yozgat (Im: 26.6), respectively, which have high Im values. The stations located in the middle of the study area (Cihanbeyli, Konya, Karapınar, Ereğli, Karaman, Aksaray) have the smallest Im values, ranging from 11.4 (Karapınar) to 13.3 (Aksaray). The Im value for Ulukışla and Niğde is 14.2 and 13.9, respectively. This value increases to 26 towards the north. The Im values for Boğazlıyan, Kırıkkale, Kırşehir, and Kaman are 14.4, 14.9, 15.7, and 20.2, respectively. When the magnitudes of the Im values are examined, it is noteworthy that precipitation tends to decrease significantly from north to south, especially as one approaches the foothills of the Taurus Mountains (rain shadow). It can be concluded that the temperature increases as one approaches the foothills of the Taurus Mountains, and that the Im value corresponds to the arid and semiarid climate zone, as it triggers evaporation.

The Mann-Kendall trend test applied to the Im values of the stations showed a statistically decreasing trend at the 0.001, 0.01, 0.05, and 0.05 levels in Akşehir, Hadim, Boğazlıyan, and Konya, respectively (Fig. 2b). A statistically insignificant increase was detected in Niğde, Ulukışla, Beyşehir, and Karapınar. An insignificant decrease was detected in other stations.

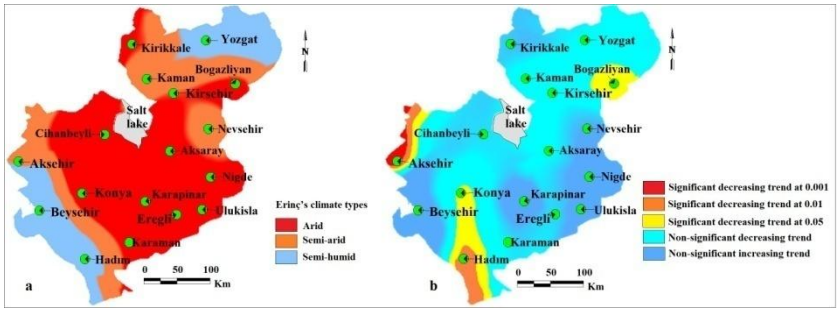

Figure 2. The spatial distribution of the annual Im values (a) and long-term trends obtained by calculating the *u(t)* statistics of the M-K rank correlation coefficients for annual Im values (b).

Spatial distribution of Im values in the first and second periods

In the KOP Region, the Im values ranged from 11.4 (Karapınar) to 37.8 (Beyşehir) in the first period (1964-1993) (Figure 3a). The stations with an arid climate (8<Im<15) in this period are Niğde, Ulukışla, Konya, Cihanbeyli, Ereğli, Karapınar, Karaman, Aksaray, and Kırıkkale. The stations with semi-arid (15<Im<23) climate are Boğazlıyan, Kırşehir, Kaman, and Nevşehir. A semi-humid (23<Im<40) climate prevailed in Akşehir, Beyşehir, Hadim, and Yozgat stations. As shown in Figure 3a, the region experienced a predominantly arid climate during the first period. When comparing the climate types of the first period with those of the second period (1994-2024), changes were observed in Akşehir, Boğazlıyan, and Kırşehir. Akşehir experienced a semi-humid climate in the first period, while a semi-arid climate was observed in the second period (Figure 3b). A similar situation is also observed at Boğazlıyan station. While a semi-arid climate dominated at Boğazlıyan station during the first period, an arid climate prevailed during the second period. The Im value of the Hadim station, which was 32 in the first period, decreased by 4.9 to 27.1 in the second period (Table 4). The climate type in Hadim remains unchanged in the second period; however, if the increase in maximum temperatures and decrease in precipitation values continue, semi-arid climate conditions are expected to dominate in the future. The trend in maximum temperature and precipitation at the Hadim station is statistically significant at the 0.05 and 0.001 levels, respectively. This decreasing trend is also reflected in the long-term (1964-2024) Im values, and a statistically significant decreasing trend (direction towards an arid climate) has emerged in the annual Im values at the 0.01 level. Apart from the stations mentioned above, the Im values of some stations (Konya, Cihanbeyli, Ereğli, Aksaray, Karaman, Yozgat, Kaman, Nevşehir, and Kırıkkale) decreased in the second period. In the future, desert climate conditions will prevail in stations where the first Period arid climate prevails, and arid climate conditions will prevail in stations where the semi-arid climate prevails. In other words, these stations with decreasing Im values in the second period are at risk of desertification. There are also stations where Im values increased in the second period. These stations are Niğde, Ulukışla, Beyşehir, and Karapınar. However, the increase is not significant enough to change the climate type (Table 4).

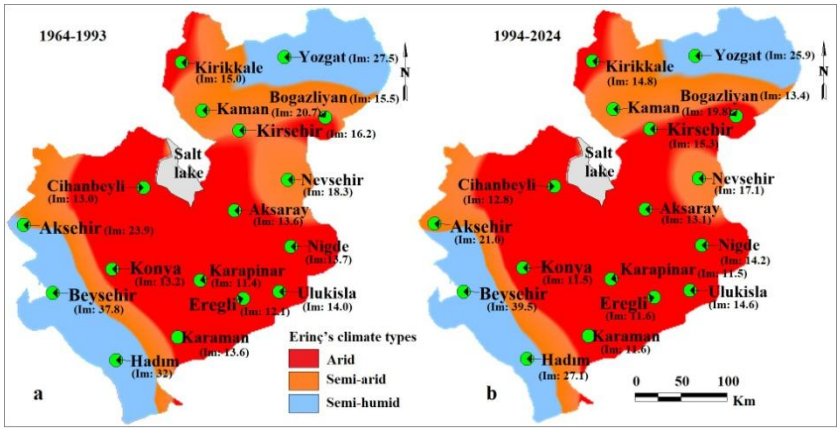

Figure 3. Spatial distribution of Im values in the first (a) and second periods (b), and climate types of the stations

Table 4. Im values in the first and second periods, and the difference between them. Red and blue indicate decreases and increases in Im values, respectively

	Im 1964-1993	1st Period climate type	Im 1994-2024	2nd Period climate type	Difference
Niğde	13.7	Arid	14.2	Arid	0.5
Ulukışla	14.0	Arid	14.6	Arid	0.6
Konya	13.2	Arid	11.5	Arid	-1.7
Akşehir	23.9	Semi-humid	21.0	Semi-arid	-2.9
Beyşehir	37.8	Semi-humid	39.5	Semi-humid	1.7
Cihanbeyli	13.0	Arid	12.8	Arid	-0.2
Ereğli	12.1	Arid	11.6	Arid	-0.5
Hadim	32.0	Semi-humid	27.1	Semi-humid	-4.9
Karapınar	11.4	Arid	11.5	Arid	0.1
Karaman	13.6	Arid	12.7	Arid	-0.9
Aksaray	13.6	Arid	13.1	Arid	-0.5
Yozgat	27.5	Semi-humid	25.9	Semi-humid	-1.6
Boğazlıyan	15.5	Semi-arid	13.4	Arid	-2.1
Kırşehir	16.2	Semi-arid	15.3	Semi-arid	-0.9
Kaman	20.7	Semi-arid	19.8	Semi-arid	-0.9
Nevşehir	18.3	Semi-arid	17.1	Semi-arid	-1.2
Kırıkkale	15.0	Arid	14.8	Arid	-0.2

Trend in annual mean maximum and minimum temperatures and correlation

Results of the M-K test are shown in Table 5. Considering the trend values of annual mean maximum temperatures, a statistically significant increase (at the 0.001 level) was detected at seven stations (Niğde, Cihanbeyli, Aksaray, Yozgat, Kırşehir, and Kaman). While a statistically significant increase at the 0.01 level was detected in Kırıkkale, an increase at the 0.05 level was detected in Karapınar, Beyşehir, and Konya. Statistically insignificant increases were also observed in

the annual mean maximum temperatures at other stations. The lowest increase was observed at Boğazlıyan (*u(t)* value: 1.08).

The relationship between maximum temperatures and the Im values is shown in Figure 4 and Table 5. In the map showing the distribution of the r-value, a negative relationship of weak to medium strength is observed in the northern and central parts of the region. A strong inverse relationship is observed between the maximum temperature values and the Im values at the Nevşehir and Beyşehir stations, as the correlation coefficients are less than -0.50 at both stations. A moderately strong negative relationship was detected in Ulukışla, Cihanbeyli, Ereğli, Hadim, and Karapınar. At other stations, a weak negative correlation is observed, ranging from -0.27 to -0.13. Regardless of the strength of the relationship, the significant negative correlation between the maximum temperatures from all stations and the Im values remains. In other words, as maximum temperatures increase, the drought index decreases at the same rate. Considering the increasing trend in maximum temperatures, the stations with arid, semi-arid, and semi-humid climates today will have desert, arid, and semi-arid climates in the future, respectively.

The Mann-Kendall test results applied to the annual mean minimum temperature series showed a statistically significant increasing trend at the 0.001 level at all stations (except Beyşehir) for the period 1964-2024. The highest increasing trend was detected in Ereğli (*u(t)* value: 7.12) (Table 5).

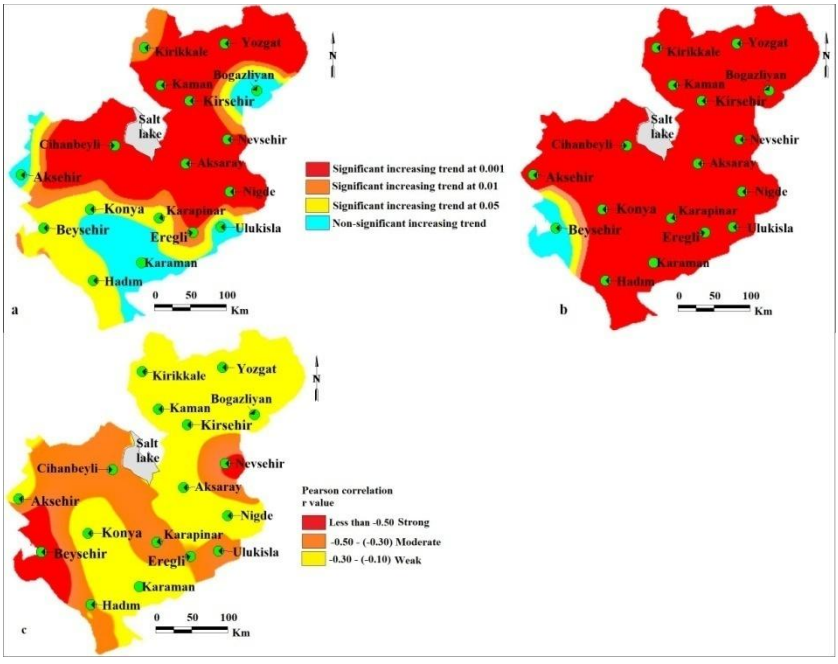

Figure 4. The spatial distribution of long-term trends obtained by calculating the *u(t)* statistics of the M-K rank correlation coefficients for the annual maximum (a) and minimum temperatures (b), and the spatial distribution of the correlation coefficient (*r*) showing the relationship between the maximum temperatures and annual Im values (c) of the stations.

Trend in annual total precipitation and correlation

According to the M-K trend test (Table 5), a statistically insignificant decreasing trend was observed in the annual total precipitation series across the region (Figure 5a). The stations where this trend was observed were Kırıkkale, Nevşehir, Kaman, Kırşehir, Yozgat, Aksaray, Karaman, Ereğli, Cihanbeyli, and Konya. A statistically insignificant increase in the total annual precipitation series was observed at Karapınar, Beyşehir, Ulukışla, and Niğde stations. A significant increase at the 0.001 level was detected at Hadim and Akşehir stations, and a significant increase at the 0.01 level was detected at Boğazlıyan station.

Figure 5b and Table 5 show a strong positive relationship between precipitation and Im values. In other words, as precipitation values increase or decrease, the Im value responds in the same direction and to the same magnitude. The strong positive correlation coefficient ranges from 0.61 to 0.99. A moderately strong correlation was observed in Beyşehir with an r value of 0.51.

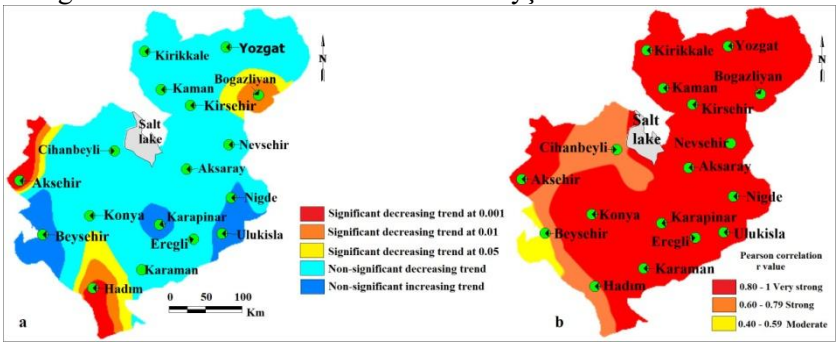

Figure 5. The spatial distribution of long-term trends obtained by calculating the *u(t)* statistics of the M-K rank correlation coefficients for the annual total precipitation (a) and the spatial distribution of the correlation coefficient (*r*) showing the relationship between precipitation and Im values of the stations (b).

Table 5. The annual Im values of stations and results of M-K and Pearson correlation tests. Meaning of abbreviations, max: maximum, min: minimum.

Station	Erinç Aridity index (mm/°C)	Index class	Erinç Index M-K trend *u(t)*	Max tept. M-K trend *u(t)*	Min tept. M-K trend *u(t)*	Precipitation M-K trend *u(t)*	Correlation between index and max. tept. *r*	Correlation between index and precipitation. *r*
Niğde	13.9	Arid	0.57	3.56***	5.74***	0.03	-0.23	0.93
Ulukışla	14.2	Arid	0.79	1.66	5.67***	0.43	-0.39	0.89
Konya	12.3	Arid	-2.01*	2.06*	3.93***	-1.73	-0.20	0.99
Akşehir	22.3	Semiarid	-3.39***	1.47	4.72***	-3.94***	-0.27	0.93
Beyşehir	37.2	Semihumid	1.23	2.54*	1.54	0.74	-0.68	0.51
Cihanbeyli	12.8	Arid	-0.60	4.15***	5.51***	-0.65	-0.36	0.59
Ereğli	11.8	Arid	-0.52	3.02**	7.12***	-0.95	-0.30	0.92
Hadim	29.3	Semihumid	-2.73**	2.16*	4.97***	-3.19***	-0.32	0.61
Karapınar	11.4	Arid	0.87	2.24*	5.95***	0.42	-0.38	0.90
Karaman	13.1	Arid	-0.71	1.62	5.65***	-1.41	-0.22	0.94
Aksaray	13.3	Arid	-0.98	3.28***	5.92***	-0.95	-0.22	0.95
Yozgat	26.6	Semihumid	-1.0	4.11***	5.93***	-0.88	-0.24	0.88
Boğazlıyan	14.4	Arid	-2.35*	1.08	4.49***	-2.97**	-0.17	0.94
Kırşehir	15.7	Semiarid	-1.19	3.76***	4.59***	-1.30	-0.16	0.93
Kaman	20.2	Semiarid	-1.28	3.44***	3.41***	-1.37	-0.18	0.92
Nevşehir	17.5	Semiarid	-0.00	3.22***	5.26***	-0.57	-0.50	0.85
Kırıkkale	14.9	Arid	-0.30	2.84**	5.09***	-0.41	-0.13	0.96

Discussion

Drought is a condition where precipitation is lower than expected in a region. Therefore, dry periods can occur not only in regions with consistently low precipitation but also in rainy regions. For a period to be classified as a drought, precipitation must be below normal levels for at least one season or one year (Şahin and Kurnaz, 2014). In other words, drought occurs when a region receives less precipitation than usual over a specific period (Wilhite and Glantz, 1985; Smakhtin and Huhes, 2004). Several factors contribute to the emergence of drought, including not only decreased precipitation but also increased temperatures, lower relative humidity, strong winds, and irregular precipitation regimes. These patterns may include insufficient precipitation during the crop planting period, as well as the intensity and duration of precipitation events (Wilhite and Glantz, 1987; Gimeno-Sotelo et., 2024).

Previous studies (Türkeş, 2005; Türkeş et al., 2009; Bayer-Altın et al., 2012; Kızılelma et al., 2015; Bayer-Altın, 2019, 2023; Türkeş and Yurtseven, 2025) on drought in the KOP and Central Anatolia regions identified a trend of increasing temperatures and decreasing precipitation. In this study, it was determined that there was a statistically significant increasing trend in maximum and minimum temperatures at all stations, and that precipitation decreased statistically at some stations (Akşehir, Hadim, and Boğazlıyan). According to the Thornthwaite humidity and the Erinç drought indices reported by Türkeş (2005), the Cappadocia Region, covering the central and eastern parts of the KOP region, is vulnerable to desertification. In the study in which drought analysis was carried out using the Palmer Drought Index (Türkeş et al. 2009), Karaman was identified as the station with the strongest long-term drought trend. In a study by Sarış and Gedik (2021), the meteorological drought in the Konya Closed Basin was analyzed for the period from 1930 to 2019. This analysis used the Standardized Precipitation Index (SPI) method to create 20 separate precipitation series at various temporal scales. The study highlighted significant trends in long-term drought, showing that meteorological droughts in the Konya Closed Basin lead to agricultural and hydrological droughts, ultimately increasing the basin's vulnerability to water deficits. Another study (Bayer-Altın, 2019) found that semi-humid conditions prevailed in Akşehir from 1959 to 1988, while a semi-arid climate prevailed in the second period, from 1989 to 2018. This situation has been attributed to increased temperatures and decreased precipitation in Akşehir, and the results of the M-K analysis confirm this. Temperature trends were analyzed using M-K, Sens's slope for the period 1970-2010, and linear regression tests by Kızılelma et al. (2015). The results show that there are statistically significant increases in maximum and minimum temperatures across the study area, within the 95% confidence interval. Thus, the present study is compatible

with previous studies. The stations with the most significant decreases in Im values in the second period were Akşehir, Hadim, Boğazlıyan, and Konya. These stations had the largest decreases in total precipitation and the most significant increases in minimum temperatures among all stations. The correlation between Im values and the increasing trend in maximum temperatures is negative. This indicates that increasing temperatures in the region may lead to arid conditions. The positive correlation between increasing precipitation and Im values indicates a weak probability of drought. A positive correlation between increasing precipitation and Im values indicates a weaker probability of drought. Increasing Im values indicate increased precipitation, leading to a wetter climate. Conversely, decreasing Im values indicate decreased precipitation, suggesting a trend toward an arid climate. The statistically significant decreasing trends in Im and precipitation values at the Konya, Akşehir, Hadim, and Boğazlıyan stations confirm this (see Table 5). A medium-strength correlation occurs at the stations (Cihanbeyli and Ereğli), where there are insignificant increases and decreases in precipitation and Im values. The results of the M-K test indicate an insignificant increasing trend in precipitation at the Niğde, Ulukışla, and Karapınar stations, which is also reflected in an insignificant increasing trend in the Im value. For these stations, the climate classification for the second period is expected to be semiarid; however, the second-period Im value suggests an arid classification. A similar condition is observed at Beyşehir. Despite a slight increase in precipitation, Beyşehir's Im value for the second period remains in the semi-humid class. However, a humid climate class would have been expected for the Beyşehir station. As a matter of fact, Bayer-Altın et al. (2023) found a statistically significant increase in annual precipitation at the Ulukışla and Beyşehir stations in the 1970-2020 period at the 0.05 level. In other stations, an insignificant decreasing trend in the Im values is observed, parallel to the insignificant decreasing trend in precipitation. This confirms the positive correlation. There was no change in the climate type at these stations during the second period. However, a strong increasing trend was observed in both maximum and minimum temperatures (see Tables 4 and 5). This indicates that drought at the stations results not from a decrease in precipitation, but from a significant increasing trend in both maximum and minimum temperatures. Bayer-Altın et al. (2012) and Bayer-Altın (2023) identified a statistically significant increasing trend in annual and seasonal mean temperatures at Aksaray, Niğde, Ulukışla, Cihanbeyli, and Hadim from the late 1970s to the mid-2000s. The current study confirms that the increases in both maximum and minimum temperatures have likely contributed to the rise in annual mean temperatures. According to the M-K test results, the strong upward trend in temperatures in September and October caused summer conditions to occur in autumn. This indicates that summer extended for an additional two months (Bayer-Altın, 2023).

Çoşkun (2020) detected a strong increase in the annual mean temperature trends in the Salt Lake-Konya closed basins for the period 1970-2018. In this study, Çoşkun (2020) reported that decreases in precipitation and temperature increases negatively affected streamflow. A study reported by Uçar (2024) presents findings that contradict previous research. It indicated that there is no evidence of a drought trend associated with precipitation in the Konya closed basin. The study notes that the rate of very severe drought conditions in the stream is significantly higher than that of the precipitation class. Additionally, the rates of moderate and severe drought conditions in the stream differ across monitoring stations compared with precipitation levels (Uçar et al., 2024). Orhan and Ekercin (2015) suggested that drought intensified in the Konya Closed Basin between 1984 and 2011 due to increased temperatures and decreased soil moisture. In this study, the severe and arid years observed over long periods are concentrated in similar periods, particularly in Konya, Ereğli, Aksaray, and Karaman. Bayer-Altın (2023) detected a strong increasing trend in annual minimum temperatures for the period 1960-2021 at KOP region stations, and reported that this increase raised temperatures in Central Anatolia by a mean of 1.44 °C over the last 31 years. A study by Türkeş and Yurtseven (2025) examined the Köppen-Geiger climate classification for Turkey. It found that under a very high-emission scenario for the period 2071-2099, the BWk (cold desert) climate is expected to prevail in the part of the Central Anatolia Region corresponding to the KOP provinces.

Conclusion

This study examined the changes and trends in annual mean maximum and minimum temperatures, as well as annual total precipitation in the KOP region for the period 1964-2024. The aim is to determine whether the factor contributing to drought is an increase in temperatures or a decrease in precipitation.

The results indicate a weak, statistically insignificant decreasing trend in precipitation across the region. In contrast, statistically significant increases are observed in both maximum and minimum temperatures, with a stronger increasing trend noted in minimum temperatures. This suggests that minimum temperatures should also be factored into drought calculations.

The low Im values observed in the second period (1994-2024) indicate that the dry conditions are primarily attributable to increasing temperatures rather than decreasing precipitation. Higher minimum temperatures increase surface evaporation, which continues to occur throughout the night. Considering all these conditions, stations that have experienced statistically significant increases in both maximum and minimum temperatures are at risk of drought. This situation is observed at all stations in the region.

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CHAPTER 2

The Economic Impacts of Climate Change in Central Asia: Risks and Resilience

Zamira Oskonbaeva[1]

[1] Assoc. Prof. Dr., Kyrgyz-Turkish Manas University, ORCID: 0000-0002-3711-6918

Introduction

Climate change is one of the most significant causes of both economic and ecological change in Central Asia and is changing the climate landscape of the area of the world. The vast steppes, deserts, and mountains that house more than 75 million people depend on agriculture, nomadic lifestyles, and the exploitation of natural resources for their livelihoods. The increase in temperature, altered rain, and extreme weather lead to transformations of water supply and crop production, and the infrastructure in Kazakhstan, Kyrgyzstan, Tajikistan, Turkmenistan, and Uzbekistan. Average temperatures in the region have risen about 2° C since the first of the twentieth century, and they increase problems such as drought, desertification, and shortage of water supply, thereby putting a great strain on the natural resources and license of growth and economic development (Fallah et al., 2024). Climate change increases the severity of these environmental changes and brings very serious economic losses for the region, mainly in agriculture, hydropower, or food security (which are in the basic sectors for the Central Asian economies) (Goryachkin, 2024; Mukhitdinova, 2023). The socio-economic conditions of the region, being semi-arid, make it extremely vulnerable to climate stresses as well. It further exacerbates poverty, inequality, and socio-political tensions and stalls and impedes sustainable economic growth (Mukhitdinova, 2023). It is estimated that without sufficient adaptation and resilience measures, the economic impacts of climate change are set to intensify (Farajzadeh et al., 2023; OECD, 2023), placing long-term development prospects in Central Asia at high risk. These changes in the environment are causing huge economic losses in the region as climate change accelerates, most notably by compromising agriculture, hydropower and food security — the crucial sectors underpinning Central Asian economies (Goryachkin, 2024; Mukhitdinova, 2023). This suggests that knowledge about the pathways through which climate change affects economic growth, such as losses in productivity, devaluation of capital, and loss of resources, is crucial in order for policymakers to guide their interventions to increase resilience and protect the economic future of the region. It is necessary to highlight that climate adaptation must be part of economic planning for addressing these complex vulnerabilities resulting from persistent environmental transformations (Fallah et al., 2024; Mukhitdinova, 2023).

Climate Trajectory in Central Asia: Threats to Sustainability and Growth

Among Central Asian countries, Kazakhstan, Kyrgyzstan, and Tajikistan experience the highest warming rates, with Kyrgyzstan and Tajikistan particularly vulnerable given the countries' large glacier reserves, melting at approximately 1 percent annually since the 1960s and reducing crucial runoff from surface waters downstream (Climate Centre, 2021). Particularly in northern

and central Kazakhstan, due to rapid warming events and extreme heat events (Climate Centre, 2021), while both Turkmenistan and Uzbekistan are rapidly increasing their temperatures, with Turkmenistan amongst the region's highest (Green Central Asia Initiative, 2024). These countries have experienced 1.5 to 2.5°C rises in average temperature between 1950 and 2010 beyond mid-20th-century values, with mountainous regions experiencing enhanced heating related to altitude effects (CABAR.asia, 2019). Since 1991, the continent has warmed around 0.45°C per decade across Asia — more than double a century ago between 1961–1990 — and Central Asia is home to the fastest-warming subregions by landmass geography (Statista, 2025). This continued hyper-warmth has fueled heatwaves, glacier shrinkage, droughts, and extreme weather variability, disrupting water resources and energy systems as well, with negative effects on agriculture and energy systems, worsening socio-economic vulnerabilities. According to projections by the World Meteorological Organization (WMO), the temperature in Central Asia is projected to increase 1.2 to 1.9°C above pre-industrial temperatures. The 2025-2029 period is expected to be the warmest on record globally. The long-term trend toward warming is also contributing to increasingly frequent and extreme droughts, rapid melting of glaciers in mountainous regions such as the Pamirs, and greater variability in rainfall and precipitation patterns, including sudden heavy rains and longer dry spells (WMO, 2025). These climate dynamics are relevant for water bodies, agricultural systems, and energy systems throughout Central Asia. Melting glaciers, for instance, are threatening the sustained freshwater supply for irrigation and hydropower, especially in Tajikistan, where hydroelectricity is used over 90%. The region is also being afflicted with “spring floods followed by summer droughts” due to earlier snowmelt and shorter runoff seasons, putting pressure on water management frameworks that are often not equipped to manage these shifting flows.

These climate dynamics are important for water resources in water bodies, agricultural systems, and energy systems throughout Central Asia. Glacial melt threatens, for instance, the sustained availability of freshwater for irrigation and hydropower, particularly in Tajikistan, where hydroelectricity is used over 90%. The area is also experiencing 'spring floods followed by summer droughts' due to earlier snowmelt and shorter runoff seasons, placing strain on water management structures that often lack the capacity to handle these changing flows.

The area is also facing “spring floods followed by summer droughts” due to earlier snowmelt and shorter runoff seasons that are putting a strain on water management structures that frequently do not have enough capacity to cope with these new flows. In response to these increasing risks, Central Asian nations are participating in regional partnerships and global climate discussions to bolster

adaptation. It was significant that the 2025 Central Asia Climate Change Conference emphasized action in the funding of climate finance, creation of new climate risk resilience tools, and convergence between national policies and global climate requirements. The event highlighted the significant need for united transboundary water management and investments in sustainable infrastructures to address socioeconomic vulnerabilities in the region (CACCC, 2025). So there we have it, Central Asia's climate change path is becoming more unstable with increasing warming and more erratic precipitation; the increase in the number of glaciers falling and increasingly severe droughts that are endangering a continent's ecological and economic health. Combating these issues will necessitate cohesive regional adaptation strategies that involve scientific monitoring, policy coordination, and funding to ensure that the region's future remains secure in the context of climate uncertainty (WMO, 2025; CACCC, 2025).

Regional drivers behind highest national warming

Human activity, and in particular the generation of greenhouse gases (GHGs) from burning fossil fuels by humans (such as coal, oil, hydrocarbons) and burning wood and other resources, has resulted in significant increases in the level of heat in much of the world, such as Central Asia. All these emissions lead to increasing the energy imbalance of Earth, resulting in increased surface temperatures and an acceleration of warming trends (Infante-Amate, 2025; Forster et al., 2025).

Specifically, region-specific drivers include:

Landlocked geography and continental climate: Central Asia is a large landmass with a low maritime influence, resulting in more pronounced temperature increases than coastal regions. This leads to more intense warming, particularly in Kazakhstan, as well as Kyrgyzstan and Tajikistan's mountainous areas.

Amplification of warming through altitude and ice/snow feedback: In Central Asia's mountainous regions, where glacier retreat from a region and the loss of snow cover reduce albedo, warming gains momentum as the result of positive feedback loops. The Pamir and Tien Shan mountains are especially at risk of these activities.

Decreased cloud cover and atmospheric circulation changes: The present studies showed that low cloud cover and irregular circulation patterns have enhanced surface shortwave radiation, contributing to overall increases in regional temperature (Minobe et al., 2025).

Aerosol changes: Reduction of optical thickness and sulfur release in aerosols limits cooling effects in the atmosphere, which will be increased in a small area.

In conclusion, the strongest warming rates for Central Asia are attributable to a combination of global greenhouse gases plus regional phenomena such as a continental climate, elevated land (high altitudes), glacier feedbacks, and atmospheric anomalies that, in combination, drive up the rising temperature (Minobe et al., 2025; Forster, 2025).

Economic Vulnerabilities and Sectoral Impacts of Climate Change in Central Asia

Climate change has a strong and multifaceted impact on Central Asian GDP, affecting essential sectors and global economic balance. Natural resources such as water supply, land, and energy are critical to the region's economy and are under more and more stress from events brought on by climate, which include thermal stress, extreme weather patterns (e.g., droughts and glacial retreats) (CAREC, 2024; ERI, 2011). Agriculture, a key part of GDP and thus life-saving to food security and the economy, is most vulnerable. The impact of climate change is that, through heat stress, water scarcity, and changing precipitation patterns, crop yields are affected. During severe droughts, agricultural productivity has decreased by up to 40% in some remote areas, directly diminishing rural socio-economic production and raising concerns regarding food insecurity (Banik & Gafarovich, 2025; International Climate Initiative, 2025). Such sector vulnerability only amplifies poverty and socioeconomic inequalities, which in turn impede sustainable development (UNDP, 2025). Hydropower, a critical energy source for Kyrgyzstan and Tajikistan, is threatened with uncertainties from altered river flows and declining glaciers that would make water sources less reliable. Decreased hydropower is also an area of the economy that can curb industrial activity and electricity supply (CAREC, 2024). Moreover, climate change-induced infrastructure destruction through floods and other extreme events represents a significant maintenance and adaptation cost, which adds costs to government budgets and economic growth (CAREC, 2024). Land degradation, desertification, and water scarcity impact migration pressures, social tensions, and economic livelihoods—mainly in rural areas, where people depend on agriculture and natural resource availability (Green Central Asia, 2025). Without proper adaptation measures, the total impact of these impacts can cause GDP growth rates in most severely impacted countries to decrease by 4-6% per annum (IASPoint, 2025). To resist these pressures, governments and regional entities in Central Asia are prioritizing climate adaptation and mitigation measures. The economy is considered resilient to climate change, and economic resiliency would depend on investments in climate-resilient infrastructure, sustainable land and water management, diversification, and renewable energy transition. Regional cooperation frameworks, including the CAREC Climate Change Action Plan, which enables coordination of investment and dissemination

of technology, support coordination of policies and practices with global climate objectives (CAREC, 2024; UNDP, 2025; Swiss Re, 2025). The climate change implications of Central Asia's vulnerability to risks that include the disruption of agriculture, energy, and infrastructure, as well as the development of social and economic vulnerabilities, are important to note in this context. Addressing these risks is vital at the regional level through climate adaptation and mitigation measures, and in doing so can further consolidate regional economic stability and sustainable growth trajectory in the face of persistent climate pressures.

Climate-induced economic losses within Central Asia

The economic losses in Central Asia driven by climate-related issues are increasing very quickly and are seriously jeopardizing the region's development profile and socio-economic sustainability. Central Asia, according to the UN Environment Programme (UNEP, 2025), is among the fastest-warming areas in the world, where rising temperatures exceed the global average by a large margin. This warming aggravates glacial melt, soil erosion, and water scarcity—key environmental stressors that undermine local livelihoods in the region. Agriculture, which provides jobs for over 70 percent of the workforce in countries like Tajikistan and Kyrgyzstan, faces severe climate-related risks.

Minimising glacier volumes results in less irrigation water, causing crop failure and livestock to die out, notably during prolonged droughts, which have been exacerbated by increasing temperatures and increasingly unpredictable precipitation (UNEP, 2025; Rudenshiold, 2025). As evidence, Kazakhstan recorded a 26% decrease in wheat production in 2024 in response to extreme heat and drought, which shows the serious impact on food security and rural incomes, a considerable part of the country's GDP (Rudenshiold, 2025). Changing river flow and glacial melt make electricity generation and stability in energy markets difficult to ensure, and significant supply challenges to hydropower sectors critical for energy supply for the countries of Kyrgyzstan and Tajikistan are also threatening water resource challenges. These impacts ripple through industrial and residential sectors, declining productivity and enhancing energy costs (CAREC, 2024). These economic impacts go beyond just direct sector losses. Damages in infrastructure are induced by climate phenomena and cause high repair costs in infrastructure, including roads, flood defenses, and urban facilities, resulting in the diversion of public funds from development priorities (CAREC, 2024). In terms of social factors, climate stress increases disparities, drives migration, and drains government resources for social safety nets and disaster response (UNDP, 2025). Some regional evaluations estimate annual economic losses at 4–6% of GDP in the absence of adequate adaptation action (IASPoint, 2025; Swiss Re, 2025). The cost of inaction continues to rise; for example, UNEP has estimated that adaptation investments of tens of billions of dollars a year are

needed by 2035 merely to prevent losses from growing exponentially (UNEP, 2025). To mitigate those costs, such steps involve the development of climate-resilient infrastructure, sustainable water and land management, regional cooperation on transboundary resources, and transition to renewable energy. The CAREC Climate Change Action Plan (2025–2027) is a paradigm of regional promises to harmonize responses and channel finance, technical, and policy assistance for climate adaptation and mitigation (CAREC, 2024). On the whole, climate-induced economic losses in Central Asia constitute a primary threat to development as temperatures rise, water insecurity, and severe weather events occur. With these two regions exposed to widespread climate change, mitigating this vulnerability will be critical to protecting livelihoods, preserving economic growth, and advancing resiliency in a future of climate change and more.

Projected GDP Losses in Central Asia under Different Warming Scenarios

2025 Asian Development Bank Annual Global GDP (GDP annual loss) estimates for Central Asia (under a 2°C warming scenario) were estimated to be between 1.7% and 2% (Campagnolo et al., 2025; 24.kg, 2024), whereas a more severe 4°C warming scenario predicted an annual GDP loss with the predicted global GDP losses rising to about 3.8% and 6% in a mid-century to post-decarbonization world (Campagnolo et al., 2025). According to the Asian Development Bank's modelling, if substantial greenhouse gas emissions contribute to elevated global warming, Central Asia may incur similar regional GDP losses, of ≈ 0.7% of GDP by 2035, reaching 1.7% by 2050 under moderate global warming (about 2°C) and about 3.8% by 2070, with losses of roughly 6% and possibly greater by 2100 under a 4°C scenario (24.kg, 2024). Losses have highlighted the increasing pressure on key economic sectors — agriculture, hydropower, and infrastructure — fueling increased heat stress, a diminished water supply due to glacier retreat, and greater volatility in the climate. A heightened energy demand for cooling, supply chain disruptions, and damage repair costs have all acted against productivity and multiplied these effects (IASPoint, 2025). Overall: Warming Scenario (2°C (2050) - ~ 1.7% - ~ 2% 4°C (2070-2100) - ~ 3.8% - 6%). The projections highlight the significance of adapting and mitigating policies for the global climate to reduce greenhouse gas emissions, strengthen resilience, and limit the long-run impacts on economic growth in Central Asia.

Achieving Policy Goals Through Enhanced Climate Resilience

There are clear policy implications for Central Asia, especially with regard to the necessity for more robust regional collaboration, investment in environmental resilience across industries for their sustainable long-term future, and harmonization, especially regarding adaptation to globalization, in the region.

The Climate Change Action Plan (2025–2027) under the Central Asia Regional Economic Cooperation (CAREC), jointly developed with the support of the Asian Development Bank, sets out an integrated agenda to address these challenges through better coordination between countries and sectors, increased mobilization of climate financing, and enhanced regional adaptation capacity (CAREC, 2024).

Key policy priorities include:

- Enhancing regional coordination: Central Asian countries should build the instruments to promote joint climate action, share knowledge, and harmonize adaptation and mitigation. That would also involve establishing a regional Climate Adaptation Secretariat and participating in the global climate dialogue (Green Central Asia, 2025).
- Enhancing climate finance access: The capacity to capture and leverage climate finance is key, notably to receive and channel climate finance from, for example, the Green Climate Fund. Such regional collaboration will allow for holistic climate project planning and optimize resource mobilization efficiency (CAREC, 2024).
- Investing in climate-resilient infrastructure: policies are the focus here, with a focus on the improvement of urban, agricultural, and energy infrastructures to support resilience to the stress from climate change and to reduce the risk of extreme weather events (CAREC, 2024).
- Fostering sustainable management of natural resources: It means integrated management of the water resources, avoiding the degradation of the land, preserving the glaciers, and making the transition towards green energy to decrease emissions and reduce the reliance on climate-sensitive sectors (Green Central Asia, 2025).
- Enhancing social resilience—Programme promotes the capacity-building, social safety-nets, and disaster risk reduction of vulnerable populations to reduce climate-related socioeconomic destabilization (CAREC, 2025).
- Building on global climate commitments: The regional model underpins the pursuit of the Paris Agreement and Sustainable Development Goals by harnessing global cooperation toward low-carbon, climate-resilient growth (Green Central Asia, 2025).

- Climate Risk Management and Preparedness: We encourage higher capacity for climate risk evaluations, multi-hazard early warning systems, disaster preparedness, and health service adaptation in climate shocks and climate-related losses and vulnerable populations.
- Water-Energy-Food Security Nexus: Advanced integrated management of shared water, promotion of water-use efficiency, rehabilitation of irrigation infrastructure, production of sustainable energy, and sustainability, particularly in the case of hydropower. Upstream and downstream countries must cooperate on water sharing to manage competing concerns.
- Low Carbon Growth and Sustainable Development: Decarbonizing critical sectors such as transportation and urban areas by adopting renewable energy sources and replacing obsolete grids, to both mitigate emissions as well as create green jobs.
- Regional Cooperation and Knowledge Transfer: Enabling platforms for institutional action on the climate, joint funding schemes for climate programmes, sharing of public information, and convergence of multilateral climate policies.
- Sustainable natural resource use: Protecting glaciers, avoiding land degradation, and desertification. Promoting sustainable farming processes and conserving biodiversity to provide ecosystem services on which its economy relies.
- Social inclusion and equity: Climate action should be designed to include those with few resources and people under conditions of resilience: by integrating gender and vulnerable groups in climate planning; building up local safety nets for their protection; enhancing adaptive capacity and ability at the state level to manage climate change so that all areas are kept better off by such measures.
- Climate finance and investment: access to international climate finance and investment; the mobilization of domestic resources for climate adaptation and mitigation, effective allocation of money; not only ensuring the right kind of investment for adaptation as well as mitigation projects; in addition, by concentrating their whole-hearted efforts on these policy areas—by combining regional and national approaches— Central Asia will be able to strengthen economic sustainability in the face of changing environmental pressures and ensure that everyone benefits the most. It is through this means that Central Asia can come into line with international frameworks such

as the Paris Agreement and Sustainable Development Goals on climate matters.

Conclusion

Climate change is drastically restructuring the environmental and economic dynamics of Central Asia at record speed, leading to significant strains on water resources, agriculture, energy supplies, and regional stability. It demonstrates that high temperatures, increased glacier melt, and more erratic precipitation patterns are driving stronger vulnerability among all five Central Asian states. Such changes are not only a threat to ecological integrity but also to the long-run economic growth, social cohesion, and regional development. Without rapid and coordinated adaptation, the region is expected to experience a steep fall in GDP, growing inequality, and a deepening divide in human security. All of these risks—which have been exposed throughout this analysis—indicate that climate change is not a menace to be feared at a distance but rather a significant structural threat to Central Asia's most important economic sectors from agriculture and hydropower, right up to infrastructure. Building climate resilience should therefore be seen as a core economic imperative, not an additional environmental issue. Regional responses articulated via initiatives such as CAREC indicate that nations are coming to terms with the fact that no one state alone can resolve these challenges. Enhancing resilience capability and access to climate finance, increasing investment in resilient infrastructure, and the inclusion of water–energy–food security responses are all important ways we can protect the region's future. Moreover, equally crucial is the incorporation of social equity, disaster preparedness, and sustainable resource management into domestic policies — at national and regional levels — into national and regional policy agendas. By taking collective action, sharing knowledge, and harmonizing with worldwide pledges to be sustainable in the face of climate change, Central Asia can avert economic losses from the climate crisis and shape a sustainable, resilient path to low-carbon development in the region. In the end, the region's capacity to protect its economy, ecosystems, and society depends on long-term collaboration and strategic adjustment — and the persistence of action — for the region. The way forward will entail not only policy actions at the moment but a long-term outlook that situates climate resilience at the heart of development planning, throughout Central Asia.

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CHAPTER 3

Topic Modelling of Master's Theses in The Field of Management Information Systems in Turkey With Lda Algorithm

Göktuğ İlısu[1] & Nursal Arıcı[2]

[1] Gazi University, Informatics Institute, Dept. of Management Information Systems, Ankara, Türkiye , ORCID: 0000-0001-8566-3433
[2] Prof. Dr., Gazi University, Applied Sciences Faculty, Dept. of Management Information Systems, Ankara, Türkiye, ORCID: 0000-0002-4505-1341

1. INTRODUCTION

Management Information Systems (MIS) is an academic discipline that aims to meet the information needs of governments, communities, organizations, teams, and individuals across strategic, tactical, and operational levels through the use of information systems and digital technologies. It adopts an interdisciplinary perspective, integrating knowledge from computer science, management, statistics, organizational studies, and operations research to develop applied methodologies for solving real-world problems. Furthermore, MIS addresses socio-economic and psychological dimensions by examining how information technologies are adopted, used, and how they impact individuals and institutions [1].

MIS also focuses on the practical and strategic utilization of technological systems to strengthen organizational performance and competitiveness. Positioned at the intersection of technology and business, the field supports the flow of information within organizations, enhancing functions such as decision-making, coordination, monitoring, data analysis, and the visual representation of information [2].

Moreover, text mining plays a vital role in expanding the analytical capacity of MIS by enabling the extraction of meaningful patterns and insights from unstructured textual data. MIS infrastructures provide platforms for the large-scale collection, storage, and management of text-based data from diverse sources. When text mining techniques are integrated into MIS environments, organizations can transform raw textual information into valuable knowledge. Additionally, combining these tools with real-time data processing capabilities enables decision-makers to access timely and relevant insights, facilitating more effective and proactive strategic actions [3].

1.1. Text Mining (Metin Madenciliği)

In academic research, as well as in marketing and economics, large volumes of textual data are frequently collected in various forms. Besides fully unstructured content, substantial amounts of data are also generated in semi-structured formats, such as server logs and network records. In such cases, text mining methods become highly valuable, as they can analyze both unstructured and semi-structured textual information. While text mining shares similarities with data mining, its primary focus lies in processing and interpreting text-based data rather than structured numerical datasets [4].

Text mining, also referred to as knowledge extraction from text, is the process of identifying and deriving meaningful patterns and information from large textual corpora. Commonly associated with fields such as text analytics and natural language processing, it combines approaches from computer science,

linguistics, statistics, and machine learning to interpret and analyze unstructured text. Unstructured textual data refers to content that does not follow a predefined format, including but not limited to emails, social media posts, news articles, and customer reviews [5].

1.1.1. Text preprocessing

Before conducting any analysis, textual data typically undergoes a set of preprocessing steps to improve data quality and ensure consistency across different sources. Text preprocessing is a critical component of many text mining techniques. A typical text classification pipeline is composed of four main phases: preprocessing, feature extraction, feature selection, and classification. Academic studies have demonstrated that the overall performance of text classification systems is significantly influenced by the feature extraction and selection methods, as well as the classification algorithm itself. However, the preprocessing stage also plays a significant role in determining classification success. In this context, Uysal et al. examined various preprocessing operations and emphasized their influence on text classification tasks. Standard preprocessing procedures include tokenization, filtering, lemmatization, and stemming [6].

Tokenization refers to the process of breaking down a sequence of characters into smaller units known as tokens, such as words or sentences. During this process, punctuation symbols may also be removed. The resulting token list serves as the foundation for further text processing. The primary objective of tokenization is to identify meaningful word units within a text. Accurate and effective tokenization relies on the use of a reliable parsing mechanism that can accurately handle language structures.

Filtering involves eliminating specific terms or expressions from the text that are considered uninformative. A widely used filtering approach is the removal of "stop words," which are frequently occurring words that carry little semantic value, such as articles, conjunctions, and prepositions. In addition, extremely common words are often excluded because they do not contribute to distinguishing one document from another. Similarly, very rarely used words can also be removed, as they generally carry limited relevance for text analysis and classification tasks [7].

Text data may contain inconsistent usage of uppercase and lowercase letters, which can complicate large-scale text processing and classification tasks. To address this issue, all characters are commonly converted into lowercase, ensuring uniformity across the document set. Moreover, punctuation marks and special characters are typically removed since they may introduce noise and adversely affect the performance of classification algorithms.

Lemmatization focuses on reducing words to their base or dictionary forms by considering their morphological structures. This process enables different inflected versions of a word to be treated as a single standardized form during analysis. Similarly, stemming aims to normalize words by reducing them to their root or stem, particularly for verbs and nouns, to achieve consistency in textual representation [5].

The purpose of stemming is to identify the core part of a word by removing prefixes and suffixes through predefined linguistic rules. The choice of stemming algorithm varies according to the language being analyzed. For English, rule-based stemmer algorithms such as the Porter Stemmer are commonly employed. Through such operations, words are transformed into simplified base forms, thereby reducing dimensionality and improving the effectiveness of text mining and classification processes [7].

1.1.2. Feature selection

Following the preprocessing stage, textual data must be converted into numerical representations to be processed by machine learning algorithms. Research suggests that text representations that combine both syntactic and semantic characteristics tend to produce more successful results, especially in sentence selection tasks involving complex and technical content, such as genomic literature. Additionally, syntactic structures in text can be effectively captured through feature extraction techniques, such as the *n-gram* model [8].

The n-gram approach works by identifying consecutive sequences of *n* characters or words occurring within a given corpus, rather than serving solely as a raw representation of text, n-grams function as informative features used in text modeling. The Bag-of-Words (BoW) model, on the other hand, represents text as a collection of individual words, disregarding word order. It transforms documents into fixed-length numerical vectors, making it computationally efficient and easy to implement. Within this framework, n-grams are used as extended BoW features, where sequences of two or three words (bigrams and trigrams) are commonly applied. This helps capture contextual patterns more effectively than relying on single-word features alone [9].

In the field of natural language processing, term frequency (TF) is a widely used statistical measure that indicates the frequency at which a particular term appears within a document or corpus. In its basic form, TF assigns weights to words based on their frequency of occurrence. More advanced weighting methods extend this concept by applying techniques such as binary weighting or logarithmic normalization to reduce the dominance of very frequent words. In these approaches, documents are transformed into word-frequency vectors. Although TF-based representations are intuitive and straightforward, they may

suffer from the problem of overemphasizing highly frequent terms that carry limited discriminatory power [10].

The Bag-of-Words model offers a basic yet effective method for representing textual data by focusing on word occurrence frequencies. It has been extensively used across various applications, including information retrieval, text classification, natural language processing, machine learning, computer vision, and spam detection. In the BoW model, a document or sentence is represented as an unordered collection of its words. During this process, words are listed in a vector space while ignoring grammatical structure, syntax, and word order. Despite neglecting semantic relationships and syntax, the model is still capable of capturing the main thematic content of documents [11].

K. Sparck Jones introduced the concept of *Inverse Document Frequency (IDF)* to reduce the impact of terms that occur excessively across many documents. The IDF measure assigns greater importance to words that are relatively rare in the document collection, while reducing the influence of prevalent terms. When IDF is combined with *Term Frequency (TF)*, it forms the well-known weighting method called *Term Frequency–Inverse Document Frequency (TF–IDF)*. This method determines the importance of a term within a specific document in relation to the entire corpus. The mathematical expression used to calculate the TF–IDF weight of a term in a document is presented in Equation (1).

$$W(d, t) = TF(d, t) * \log\left(\frac{N}{df(t)}\right) \quad (1)$$

Within this formulation, N represents the total number of documents in the corpus, whereas $df(t)$ refers to the number of documents in which the term t appears. The first part of the formula primarily contributes to increasing recall, while the second part strengthens the precision of term weighting. Although the TF–IDF approach is effective in lowering the influence of overly standard terms, it also has certain limitations. One major shortcoming is that it ignores the semantic relationships among words by processing each term independently. Nevertheless, more recent developments in language modeling, such as word embedding techniques, provide alternative solutions by capturing semantic similarities between words and incorporating additional linguistic features, including part-of-speech information [12].

1.2. Topic Modelling

A large portion of academic and professional content is now converted into digital form and stored within electronic databases, including digital libraries and social media platforms. As a result, there is a growing need for advanced automated tools that can efficiently process this vast amount of information and

uncover latent thematic structures. One of the primary objectives of data analysis is to identify commonalities among data instances. In the context of text analytics, this often involves determining the main topics or conceptual themes that a document addresses. While human readers can naturally interpret such patterns, computer systems process text only at a syntactic level, which makes this task more complex. To overcome this limitation, researchers employ topic modeling techniques. Topic modeling is a widely used approach in text mining for uncovering hidden thematic structures within extensive text collections. Although it is predominantly applied in textual analysis, it is also utilized in disciplines such as bioinformatics, social sciences, and environmental research. This method facilitates the organization and structuring of large-scale datasets, thereby making them easier to analyze and interpret [13].

The extraction of meaningful patterns and statistical features from data is highly dependent on the selection of appropriate analytical methods. Although modern topic modeling techniques have advanced significantly beyond earlier methods, they still require careful parameter tuning and optimization to achieve reliable outputs. Different topic modeling models are designed to address various data characteristics, such as short versus long texts, correlated topics, and complex structural dependencies. Therefore, selecting a practical topic modeling framework for a given study requires a clear understanding of the differences among existing models and the fundamental algorithms upon which they are built [14].

1.2.1. Classification of Topic Modelling

Topic modeling is a statistical approach that aims to identify hidden thematic structures within a collection of textual documents. As a branch of unsupervised machine learning and natural language processing (NLP), it enables the organization and categorization of large-scale text data by detecting recurrent patterns, themes, and semantic structures. When applied to preprocessed text, topic modeling algorithms reveal the latent topics that are embedded within the data. Among the most commonly used topic modeling techniques are Latent Dirichlet Allocation (LDA) and Non-negative Matrix Factorization (NMF).

Latent Dirichlet Allocation (LDA) is one of the most widely recognized methods for topic modeling. It is based on the assumption that each document consists of multiple topics, and a distribution of words characterizes each topic. LDA assigns words to topics through an iterative process that analyzes word co-occurrence patterns across documents, gradually refining the topic–word and document–topic relationships [15].

Non-negative Matrix Factorization (NMF) provides an alternative framework for discovering topics in text corpora. This method factorizes the document–term

matrix into two non-negative, lower-dimensional matrices: one representing the latent topics through word distributions and the other capturing the strength of association between each document and these topics [16].

1.2.2. Topic modelling with LDA algorithm

Within the fields of natural language processing (NLP) and machine learning, topic modeling has become a crucial technique for uncovering hidden thematic patterns in large-scale text collections. Among the wide range of topic modeling algorithms, Latent Dirichlet Allocation (LDA) is recognized as one of the most widely applied and influential approaches.

LDA is a probabilistic generative model that assumes documents are composed of multiple latent topics, and a specific distribution over words defines each topic. The core principle of LDA lies in inferring the hidden generative mechanism from observed data to identify the underlying topic structure of the document set [17].

A central element of the LDA framework is the Dirichlet distribution, which acts as a prior for both document–topic distributions and topic–word distributions. A set of positive parameters defines it and ensures that the resulting vectors form valid probability distributions. The hyperparameter α controls the topic distribution across documents, while β regulates the distribution of words within topics. Lower values of these parameters typically lead to sparser topic representations.

LDA models the probabilistic process by which documents are generated from a mixture of topics and words. Through Bayesian inference techniques, the algorithm seeks to invert this process and estimate the latent topic structure hidden within the observed text. The overall generative process of LDA is illustrated in Figure 1 [18].

Before applying LDA, textual data undergoes a preprocessing phase that typically involves tokenization, removal of stop words, and lemmatization. Once cleaned, the text is then represented in numerical form using a document–term matrix, where each row represents a document, and each column corresponds to a unique word from the corpus.

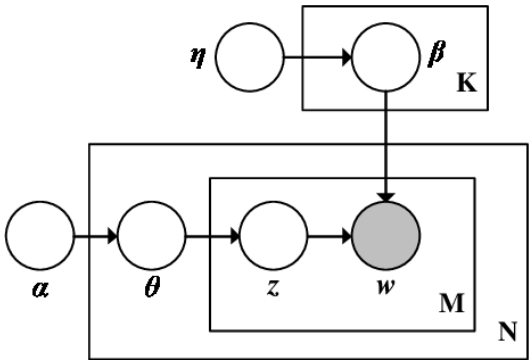

Figure 1. LDA creation process [18] (LDA üretim süreci)

After determining the appropriate number of topics, the LDA model is implemented on the preprocessed dataset using the Gensim library in Python, which provides a convenient and computationally efficient interface for topic modeling tasks. The performance of the model is assessed using evaluation measures such as *perplexity*, which reflects the model's predictive capability on unseen data, and the *coherence score*, which measures the semantic consistency of the most significant words within each topic. Based on these evaluation outputs, both the model's hyperparameters and the number of topics are fine-tuned to optimize overall performance.

Once the LDA model reaches convergence, the resulting topics are analyzed by examining the highest-probability words associated with each topic. Additionally, the topic distribution for individual documents is interpreted to understand how different themes are represented across the corpus. To support interpretation and insight generation, visualization tools such as word clouds, topic proportion plots, and interactive applications like LDAvis are used to present the results in an interpretable and visually intuitive manner [19].

Overall, Latent Dirichlet Allocation (LDA) stands out as a powerful and reliable technique for identifying latent thematic structures in large-scale text datasets. By incorporating Bayesian inference and Dirichlet priors, it provides a robust probabilistic framework for topic modeling across diverse domains, including content analysis, recommender systems, and information retrieval. When applied with proper preprocessing, parameter tuning, evaluation, and interpretation, LDA enables the transformation of unstructured textual data into structured, meaningful, and actionable information [20].

2. LITERATURE REVIEW

A review of the existing literature indicates that numerous studies have applied topic modeling using the LDA algorithm. However, there is a notable lack of research specifically focused on performing both quantitative and qualitative evaluations of master's theses based on their subject matter. The following section summarizes the key studies in this area.

Çallı et al. [21] analyzed 574 graduate thesis abstracts completed between 2002 and 2020 within the Management Information Systems (MIS) departments of Turkish universities. The abstracts were examined using the Latent Dirichlet Allocation algorithm, resulting in the identification of 11 thematic clusters: E-commerce and Marketing, System Development and Effects, Effects of Information Systems on Organizations, Data Mining, Human Resources Management, Organizational Change, Field-Specific Studies I, Field-Specific Studies II, Security, Education and Training, and Prediction and Decision Support. The study also compared these results with findings reported in national and international literature, providing insights and guidance for researchers in the MIS field.

Parlina and Kusumarani [22] employed bibliometric analysis to investigate the intellectual structure and thematic evolution of the MIS discipline. Their study analyzed publications from three leading MIS journals indexed in SCOPUS—IJIM, JSIS, and MIS Quarterly—spanning the period from 1980 to 2021. By integrating the LDA approach, the study extended traditional bibliometric analysis, allowing a more comprehensive and updated examination of trends, thematic developments, and key research topics within the top journals.

Özköse and Gencer [23] conducted a detailed bibliometric mapping study of the MIS field. They selected 222 journals indexed in the Science Citation Index Expanded (SCI-E) and Social Science Citation Index (SSCI) from Web of Science and Scopus, narrowing the corpus to 24 journals with expert input to ensure nuanced coverage of the field. From these journals, 20,497 English-language articles published between 1980 and 2015 were collected from the WoS Core Collection. Text mining analyses identified the most influential authors, organizations, and countries, with results visualized through graphs generated using BibExcel. Additionally, annual publication trends and the most cited articles were presented. Using VOSviewer, co-occurrence analysis of abstracts and keywords extracted the most relevant terms and their clusters, which were subsequently visualized through graphs and density maps, with detailed interpretations provided.

The present study aims to analyze master's and doctoral theses in the field of MIS from universities in Turkey and the TRNC using text mining. Topic

modeling with the LDA algorithm serves as the primary analytical method, complemented by a range of data visualization techniques to enhance interpretation and insight generation.

3. METHODOLOGY

The primary objective of this study is to conduct topic modeling on master's theses in the field of Management Information Systems from universities in Turkey using text mining techniques. For this purpose, the Latent Dirichlet Allocation (LDA) algorithm is employed to uncover the underlying thematic structures within the documents.

3.1. Dataset Creation Process

The dataset used in this study comprises 951 master's theses in the field of Management Information Systems, completed between 2002 and 2023, which are accessible via the YÖK National Thesis Centre [24].

The data collection process involved accessing the YÖK National Thesis Centre website through the link https://tez.yok.gov.tr/UlusalTezMerkezi/ and selecting the detailed search option. The term "Management Information Systems" was entered into the primary discipline, branch of science, and subject fields, with the search repeated for each relevant category. The resulting dataset was compiled into an Excel spreadsheet. To facilitate its use in Python for text mining purposes, the Excel file was structured so that Turkish and English thesis titles, Turkish and English keywords, and thesis abstracts were organized into separate columns.

3.2. Text Preprocessing

For the master's theses in the field of MIS, abstracts are available in both Turkish and English on the YÖK National Thesis Centre website. In this study, text preprocessing was conducted using the English abstracts, as well as the "Subject (English)" column of the organized dataset. Preprocessing was performed in Python prior to generating topic models, which were based solely on the thesis abstracts.

Using the Python *re* library, all punctuation marks and numerical characters were removed from the English abstracts, and the remaining text was converted to lowercase to ensure uniformity. Stopwords in English were accessed through Python's NLTK library. In addition to standard stopwords, the NLTK library provides a list of words that are deemed semantically insignificant within the context of English thesis abstracts. These contain:

['In', 'using', 'used', 'also', 'however', 'since', 'via', 'within', 'although', 'among', 'besides','whereas', 'dont', 'u', 'can', 'non', 'thus', 'may', 'towards', 'according',

'study', 'thesis', 'one', 'result', 'obtained', 'different', 'many', 'first', 'second', 'third', 'important', 'use', 'along', 'therefore', 'around', 'moreover', 'furthermore', 'nevertheless', 'whether', 'with', 'without', 'could', 'would', 'should', 'often', 'fourth', 'fifth', 'sixth', 'always', 'generally', 'sometimes', 'never', 'whenever', 'hence', 'across', 'thereby', 'thesis', 'before', 'after', 'meanwhile']

The Python Gensim library provides a convenient simple_preprocess function for breaking text into individual words. In this study, this function was employed to tokenize the thesis abstracts. Using the same function, stopwords were removed from the English abstracts, and a nested list structure was created for the remaining words. Each sub-list in this nested list represents the words from a single abstract, excluding all identified stopwords.

Next, the English natural language processing model from the Spacy library was loaded with the command nlp = spacy.load('en_core_web_sm'). Each word within the nested list was then subjected to lemmatization. During this process, only inflectional suffixes were removed from the words, preserving their original meaning, which made the resulting lemmas suitable for inclusion in the nested list. Words containing derivational or constructional suffixes were left unchanged, as these modify the semantic meaning of the root word.

Finally, duplicate words within each sub-list were eliminated, ensuring that every word appeared only once per abstract. This process produced a cleaned, tokenized, and lemmatized dataset suitable for topic modeling.

3.3. Evaluation of TF, IDF and TF-IDF Values

In this process, the nested list containing the unique words from each thesis abstract (with repeated words removed) was converted into concatenated text strings using Python. A Term Frequency–Inverse Document Frequency (TF–IDF) matrix was then created for these concatenated texts by applying the TF–IDF vectorizer function from the scikit-learn library. The resulting matrix was further transformed into a sequence of words, and the term frequencies of these words were calculated using Python scripts. Finally, visualizations were produced to display the frequencies of Term Frequency (TF), Inverse Document Frequency (IDF), and TF–IDF for the most commonly used terms, providing an overview of word significance across the dataset.

3.4. Conversion of Text Data Into Numerical Format

This step represents the final preparation phase prior to performing topic modeling with LDA. Using the corpora module of the Python Gensim library, a word dictionary is created from the nested list, ensuring that duplicate words are removed. Each unique word in the dictionary is assigned a distinct identification number (ID). The id2word.doc2bow function is then applied to generate a list

containing the ID of each word along with the frequency of that word in the document, where doc2bow stands for "document to bag-of-words."

This procedure is repeated for every document in the dataset, and the resulting data is compiled into a list called the "corpus." The corpus provides a numerical representation of word frequencies, which serves as the input for LDA topic modeling. An illustrative example of the corpus structure is provided in Figure 2.

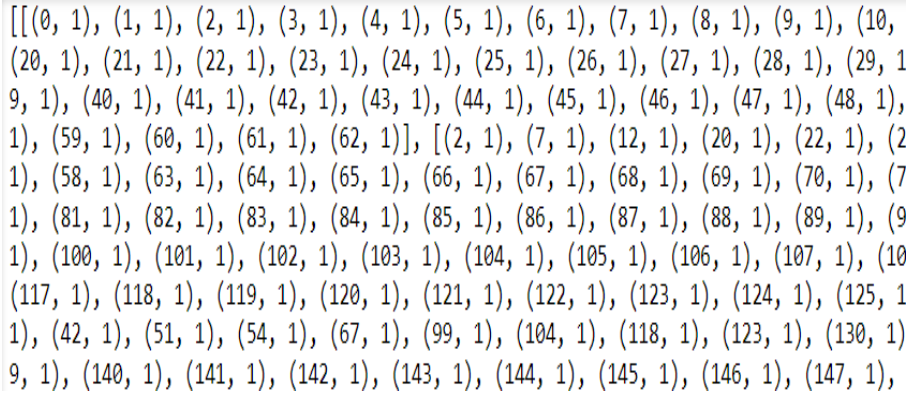

Figure 2. Creation of the corpus (Külliyatın oluşturulması)

3.5. Determination of LDA Topic Modelling Performance Metrics

The performance of LDA topic modeling can be evaluated using metrics such as perplexity, coherence, exclusivity, and corpus distance.

Perplexity measures the uncertainty of a probabilistic language model and is commonly used to assess how well the model represents the observed text data. Lower perplexity values indicate better model performance and a closer fit to the textual dataset. Perplexity is calculated as the negative exponent of the logarithmic likelihood of the model, as expressed in Equation (2).

$$\text{Perplexity} = \exp\left[-\frac{\sum_{d=1}^{M} \log P(w_d)}{\sum_{d=1}^{M} N_d}\right] \quad (2)$$

In this context, $P(w_d)$ denotes the probability of each word in a document. In contrast, N_d represents the total number of words within that document. These values are used in calculating metrics such as Kullback-Leibler (KL) divergence to quantify the difference between probability distributions of topics in different LDA models.

Coherence is a metric used to evaluate the interpretability and meaningfulness of topics in a topic model. Topics are typically represented as collections of words, and coherence measures the degree to which these words are semantically related. Higher coherence scores indicate that the topics are more interpretable and semantically consistent. Coherence is often calculated based on the frequency of word co-occurrences and the similarity between word embeddings.

Exclusivity measures the distinctiveness of each topic within a topic model. Higher exclusivity values signify that topics are more unique and easily separable from one another, which is especially important in models with a large number of topics. Exclusivity is typically assessed by analyzing the overlap among the top-ranked words of each topic; minimal overlap corresponds to higher exclusivity.

Corpus distance evaluates the similarities and differences between topics generated by different LDA models, providing insight into how analogous or divergent the topics are across models. Common methods for calculating corpus distance include Kullback-Leibler (KL) divergence and Jensen-Shannon divergence, which quantify the difference between two probability distributions. For example, the KL divergence between the topic distributions of two LDA models indicates the extent to which the topics diverge. The formula for KL divergence, where P and Q represent the probability distributions of topics from two distinct LDA models, is provided in Equation (3).

$$D_{KL}(P \parallel Q) = \sum_i \log \frac{P(i)}{Q(i)} \quad (3)$$

The combined use of perplexity, compatibility, exclusivity, and corpus distance measures helps to select the best model in subject modeling processes and to evaluate the model's performance [17] comprehensively.

4. TOPIC MODELLING WITH LDA ALGORITHM

In this stage, the values of perplexity, corpus distance, coherence, and exclusivity were calculated using Python, and corresponding visualizations were generated for each metric. To perform these computations, the CoherenceModel, LdaModel, similarities, and TfidfModel functions from the Python Gensim library were employed. The corpus was first transformed using TF–IDF values. The minimum number of topics was set to 2, while the maximum was limited to 20. The LDA model was then trained iteratively for different numbers of topics using the LdaModel function. Finally, graphs illustrating the perplexity, corpus distance, coherence, and exclusivity values were produced, with an example visualization provided in Figure 3.

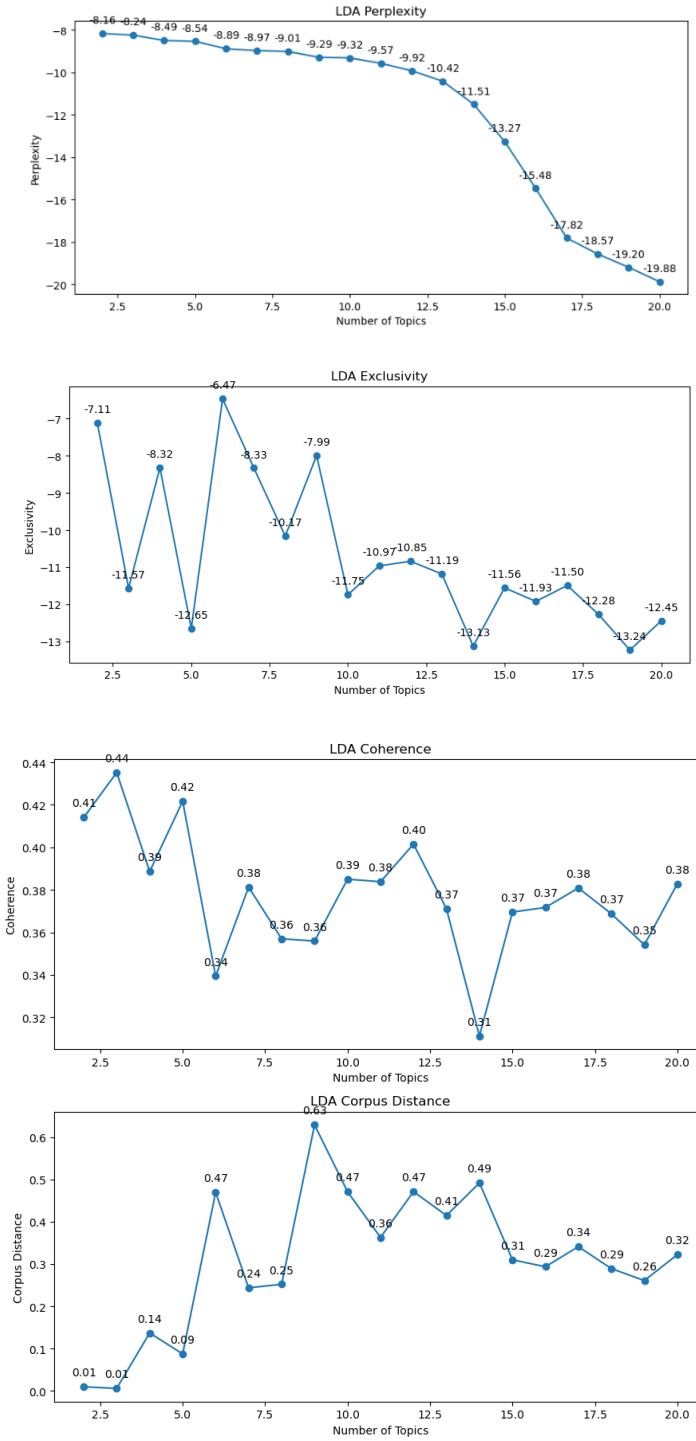

Figure 3. LDA topic modelling measures (LDA konu modelleme ölçüleri)

After calculating the metrics of perplexity, corpus distance, coherence, and exclusivity, the coherence scores of the LDA models were analyzed to identify the number of topics that yield the lowest perplexity and highest semantic consistency. This procedure is used to determine the optimal number of topics that best represent the textual dataset. Coherence serves as an indicator of the interpretability and meaningfulness of the identified topics, making the selection of the optimal number of topics a critical step in text analysis and model evaluation. In this study, the optimal number of topics was automatically determined using Python based on the coherence values. As a result, Python assigned the number of topics as fourteen, indicating that fourteen distinct topics can be represented in the dataset of English-language master's thesis abstracts.

4.1. Creating LDA Topic Model

In the LDA topic model, which was applied to the dataset of English-language master's thesis abstracts, the optimal number of topics was automatically determined to be fourteen. Using the corpus, the number of topics, and the word identification numbers, the LDA model was generated with the help of Python's pprint library and the LdaMulticore function from the Gensim library. A visual representation of the resulting topic model is presented in Figure 4.

```
[(0,
  '0.012*"method" + 0.011*"datum" + 0.011*"information" + 0.010*"system" + '
  '0.009*"process" + 0.009*"technology" + 0.009*"model" + 0.009*"time" + '
  '0.009*"order" + 0.008*"analysis"'),
 (1,
  '0.014*"technology" + 0.014*"research" + 0.014*"datum" + 0.012*"method" + '
  '0.012*"information" + 0.011*"analysis" + 0.010*"system" + 0.008*"process" + '
  '0.008*"effect" + 0.008*"model"'),
 (2,
  '0.014*"technology" + 0.013*"information" + 0.012*"development" + '
  '0.012*"datum" + 0.011*"method" + 0.011*"application" + 0.010*"system" + '
  '0.009*"business" + 0.009*"process" + 0.008*"research"'),
 (3,
  '0.014*"datum" + 0.011*"technology" + 0.010*"analysis" + 0.009*"research" + '
  '0.008*"purpose" + 0.007*"system" + 0.007*"finding" + 0.007*"factor" + '
  '0.006*"development" + 0.006*"education"'),
 (4,
  '0.017*"datum" + 0.012*"research" + 0.010*"process" + 0.010*"technology" + '
  '0.009*"analysis" + 0.009*"system" + 0.009*"business" + 0.009*"effect" + '
  '0.009*"method" + 0.008*"model"'),
```

```
      (5,
       '0.012*"model" + 0.011*"datum" + 0.011*"analysis" + 0.011*"information" + '
       '0.009*"system" + 0.008*"technology" + 0.008*"research" + 0.008*"method" + '
       '0.008*"development" + 0.007*"management"'),
      (6,
       '0.013*"information" + 0.012*"research" + 0.011*"process" + '
       '0.010*"development" + 0.010*"datum" + 0.010*"management" + 0.010*"system" + '
       '0.009*"technology" + 0.009*"sector" + 0.008*"analysis"'),
      (7,
       '0.014*"datum" + 0.012*"research" + 0.011*"model" + 0.010*"technology" + '
       '0.010*"information" + 0.009*"system" + 0.009*"order" + 0.008*"management" + '
       '0.008*"level" + 0.008*"process"'),
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       '0.009*"model" + 0.008*"research" + 0.008*"performance" + '
       '0.008*"information" + 0.008*"time" + 0.007*"finding"'),
      (9,
       '0.013*"system" + 0.010*"method" + 0.010*"term" + 0.009*"datum" + '
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       '+ 0.007*"time" + 0.007*"order"'),
      (10,
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       '0.008*"test" + 0.007*"service" + 0.007*"method"'),

(11,
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 '0.008*"company" + 0.008*"method"'),
(12,
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 '+ 0.009*"system" + 0.009*"survey" + 0.008*"research" + 0.008*"literature" + '
 '0.007*"people" + 0.007*"order"'),
(13,
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 '0.009*"management" + 0.008*"purpose" + 0.008*"research" + '
 '0.007*"technology" + 0.007*"method" + 0.007*"country"')]
```

Figure 4. LDA Topic Model (LDA Konu Modeli)

As illustrated in Figure 4, the LDA topic model identifies fourteen primary topics stated below:

- Topic 0: Methodologies, Data, and Systems Analysis
- Topic 1: General Methodologies and Data Systems
- Topic 2: Technological Research and Analysis
- Topic 3: Technological Development and Applications
- Topic 4: Data Analysis and Research Purposes
- Topic 5: Data-Driven Business Processes and Technology
- Topic 6: Research, Development, and Management Models
- Topic 7: Research, Information Systems, and Management
- Topic 8: Effects, Processes, and Performance Studies
- Topic 9: Systems, Methods, and Data Analysis
- Topic 10: Information, Analysis, and Development
- Topic 11: Technology, Effects, and System Analysis
- Topic 12: Surveys, Information, and Research Literature
- Topic 13: Data Management, Effects, and Research Purposes

4.2. Visualization of LDA Topic Model

Following the generation of the topic model, a visual representation of the LDA topic model was produced using the gensimvis function of the Python pyLDAvis library. This is presented in Figure 5.

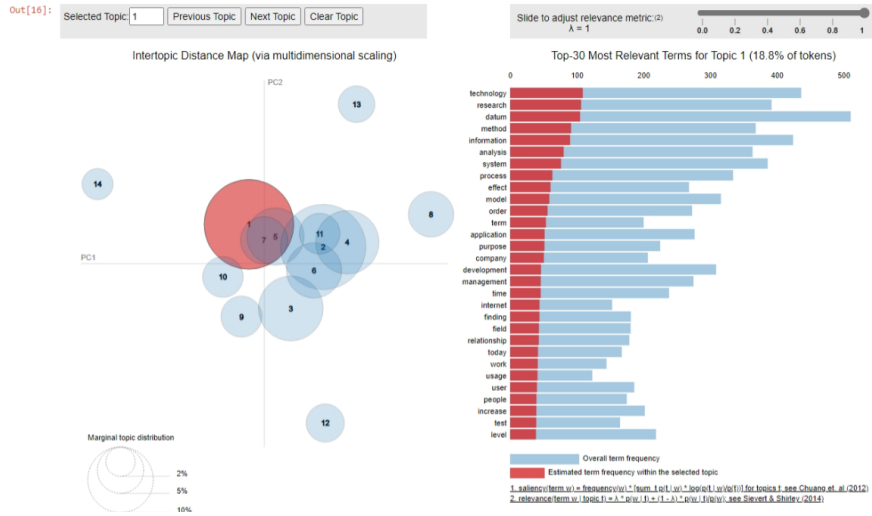


Figure 5. LDA topic model visualization when λ = 1 (λ = 1 iken LDA konu modeli görselleştirilmesi)

When the scroll bar is entirely to the right (λ = 1), the words in Topic 0 (Methodologies, Data, and Systems Analysis) are shown in Figure 5 as an example.

The lambda (λ) used in the PyLDAvis visualization is a tool for effectively exploring the results of the LDA topic model. In the PyLDAvis interface, the variable λ, which determines the relevance of a particular topic to a specific word, can be set between 0 and 1. The properties of the variable λ are as follows [25]:

- λ = 1 means that the general frequency of words is more prominent.
- If λ = 0, the specific relevance of words to a particular topic is more prominent.

A shift to the left of the scroll bar (λ < 1) results in alterations to the position and frequency of words within the topics. This phenomenon is exemplified in Figure 6.

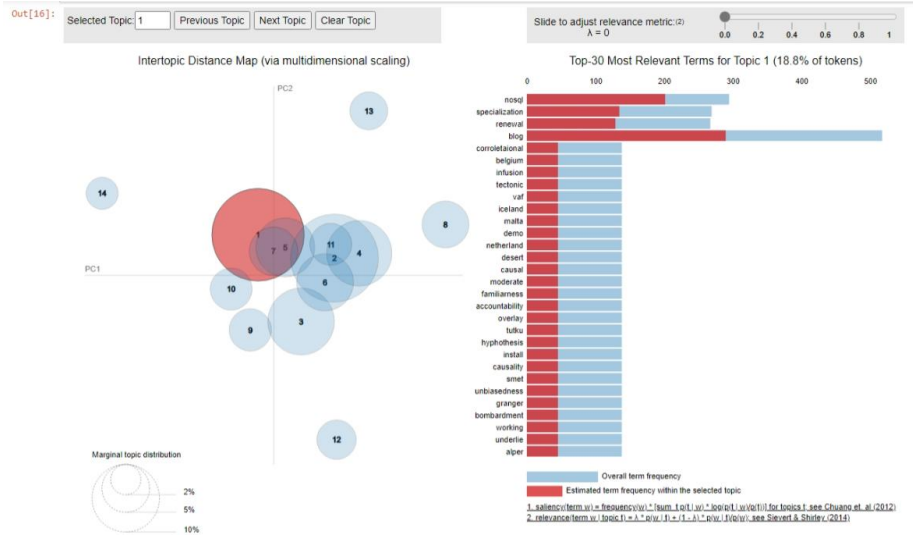
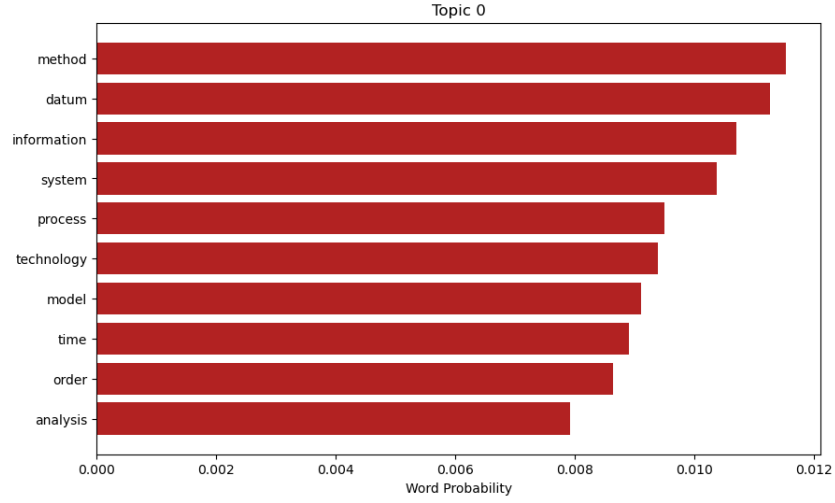


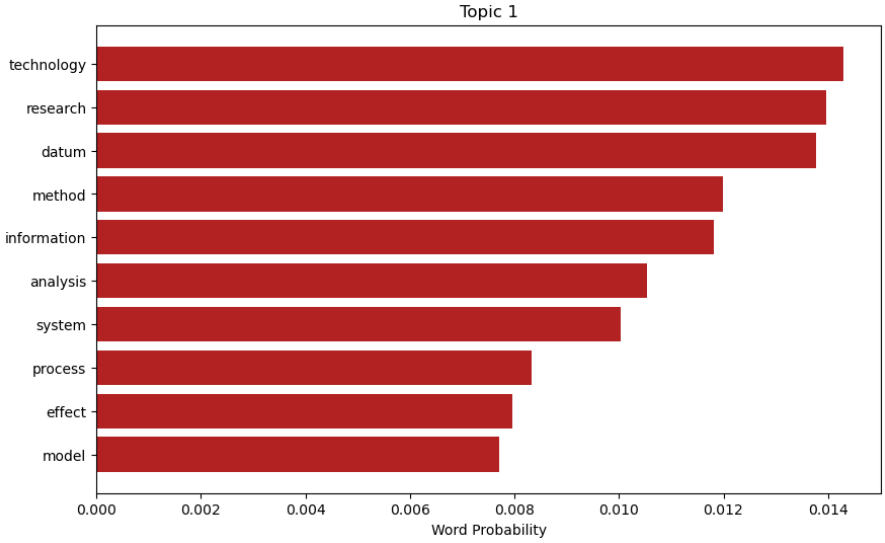
Figure 6. LDA topic model visualization when λ = 0 (λ = 0 iken LDA konu modeli görselleştirilmesi)

In the LDA topic model, which is represented as a cluster, Topic 0 is the predominant topic within the model, as it is the cluster with the most significant area (18,8% of tokens are represented).

4.3. Displaying Topics with a Bar Graph

The Matplotlib library in Python is used to create bar graphs that express the ten most frequently used words in the model's topics. These bar graphs are illustrated in Figure 7 as a visualization of Figure 4.

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research
datum
method
information
analysis
system
process
effect
model
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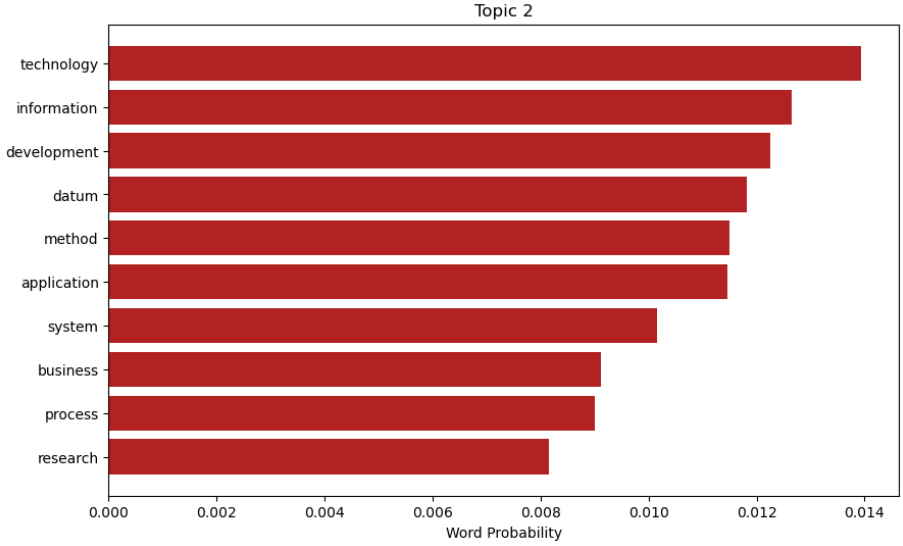
0.004
0.006
0.008
0.010
0.012
0.014
Word Probability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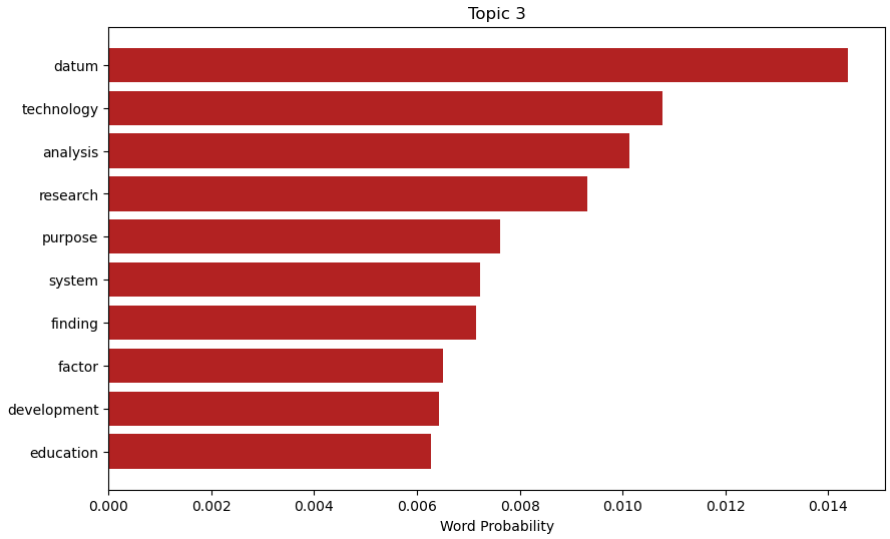
development
datum
method
application
system
business
process
research
0.000
0.002
0.004
0.006
0.008
0.010
0.012
0.014
Word Probability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technology
analysis
research
purpose
system
finding
factor
development
education
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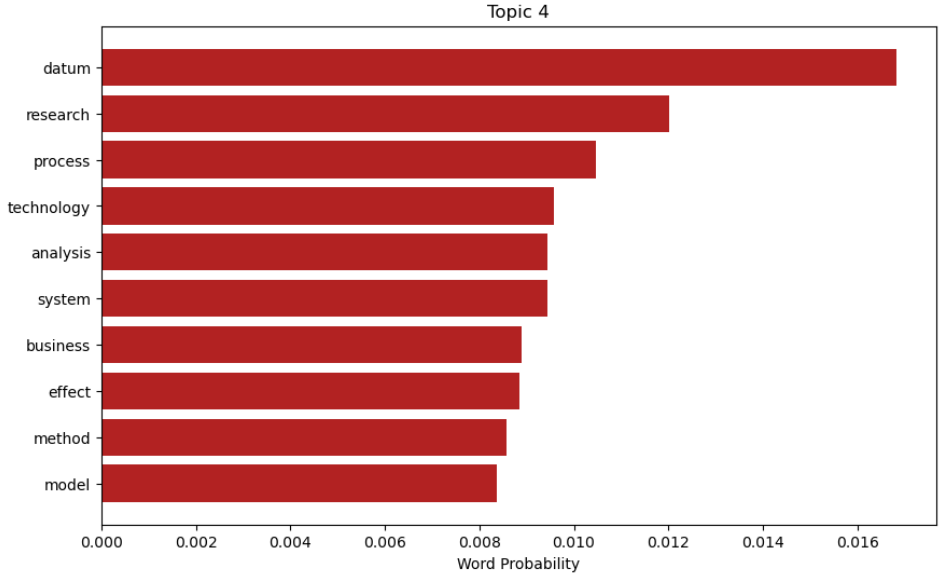
0.004
0.006
0.008
0.010
0.012
0.014
Word Probability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technology
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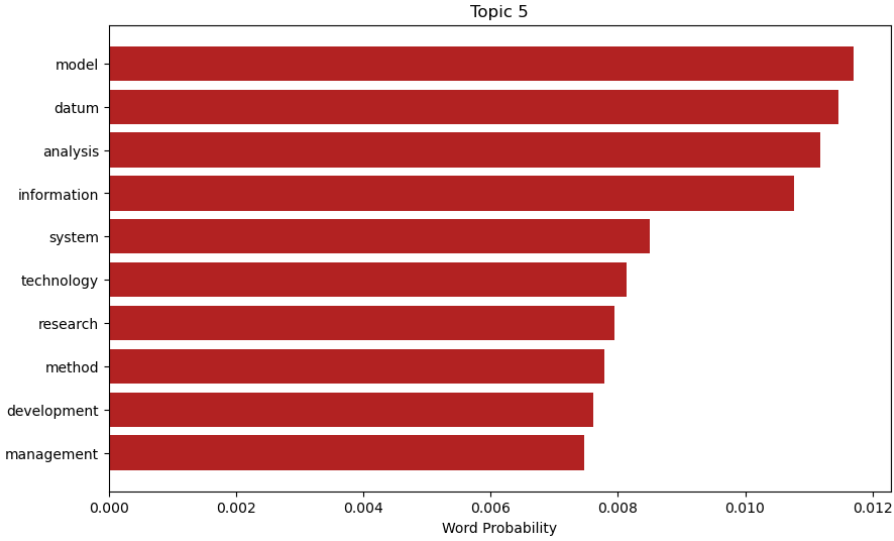
0.016
Word Probability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datum
analysis
information
system
technology
research
method
development
management
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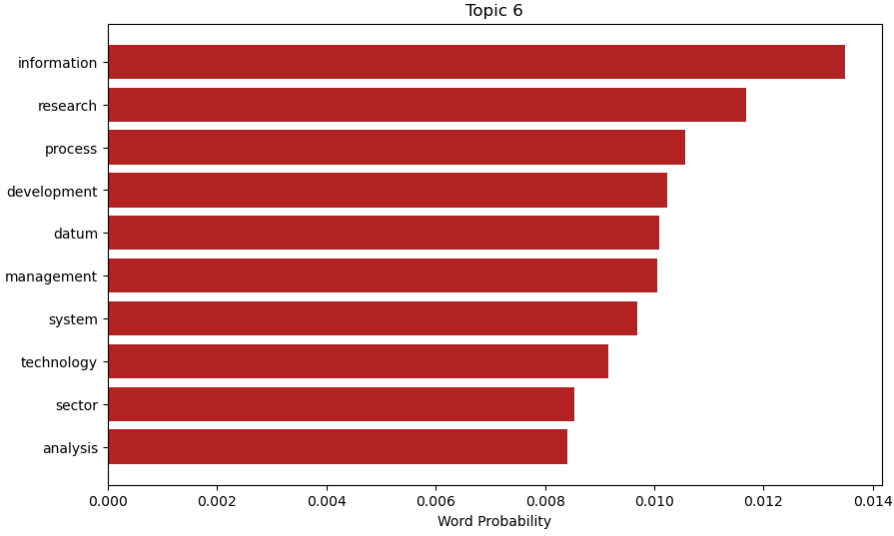
Word Probability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development
datum
management
system
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analysis
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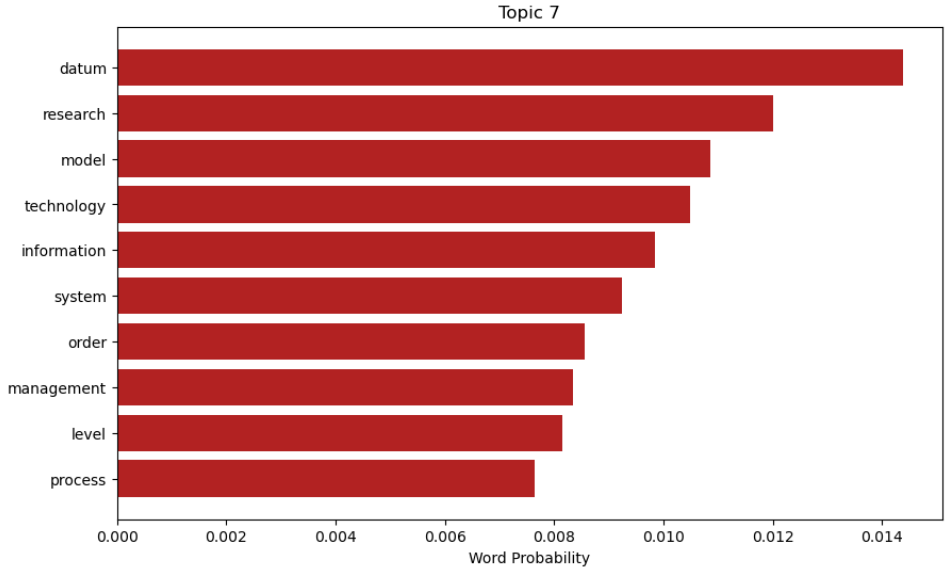
0.010
0.012
0.014
Word Probability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research
model
technology
information
system
order
management
level
process
0.000
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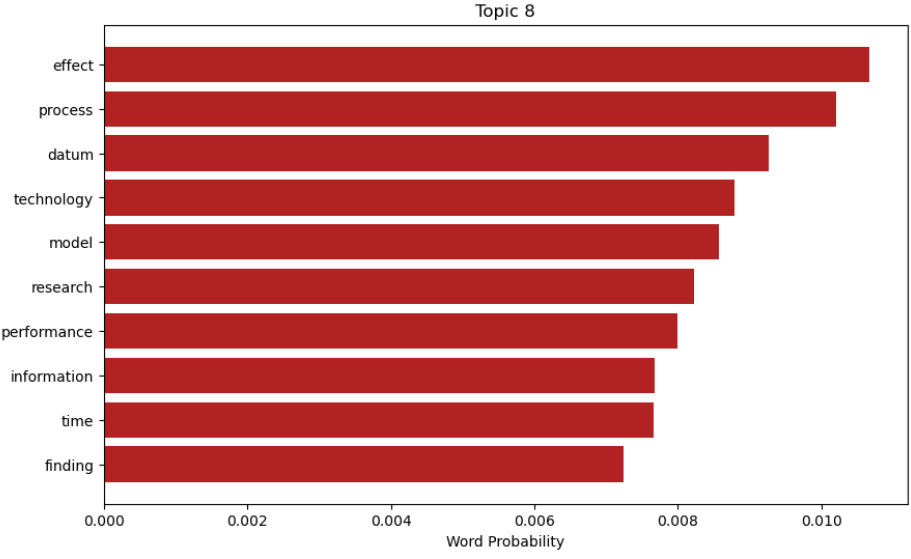
0.008
0.010
0.012
0.014
Word Probability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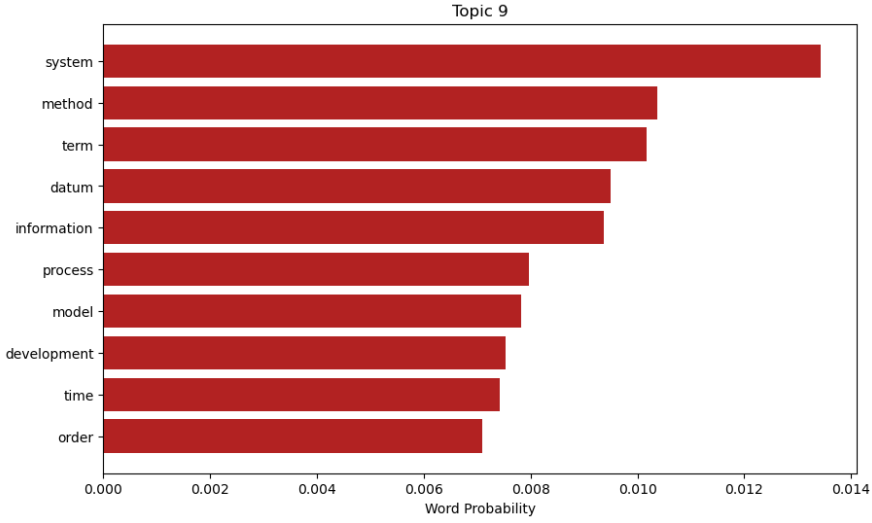
Word Probability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process
model
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order
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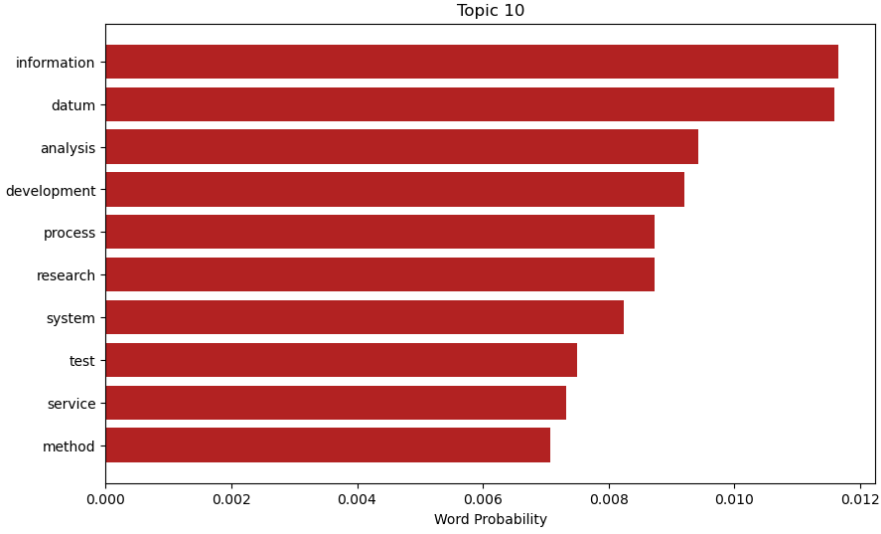
0.014
Word Probability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datum
analysis
development
process
research
system
test
service
method
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0.004
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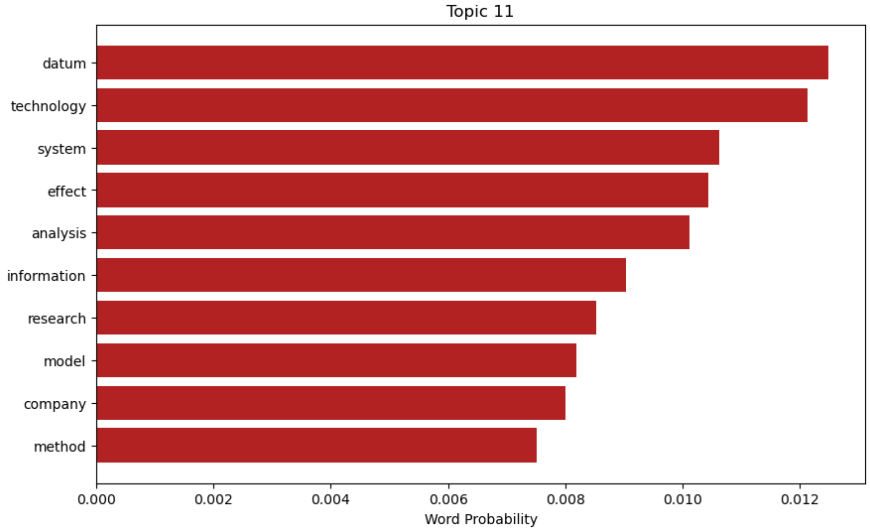
0.010
0.012
Word Probability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research
model
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method
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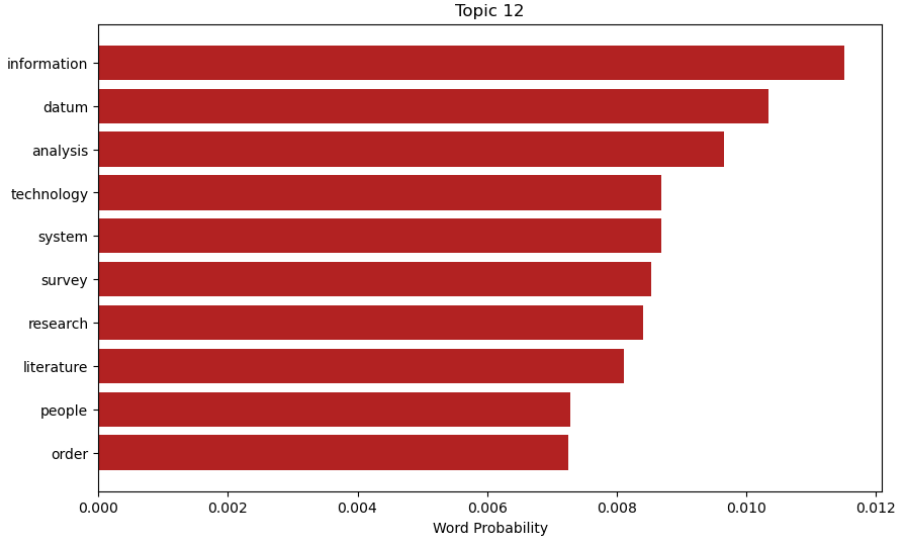
0.002
0.004
0.006
0.008
0.010
0.012
Word Probability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analysis
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survey
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people
order
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Word Probability

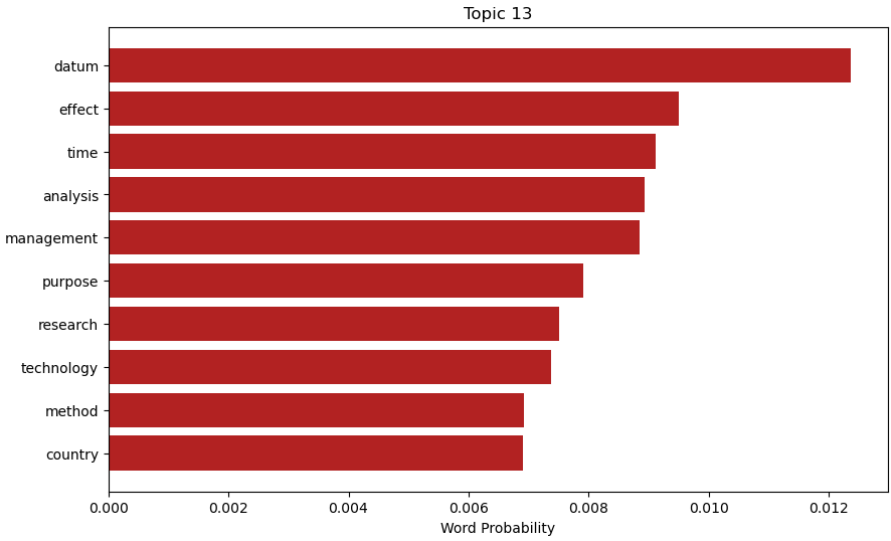
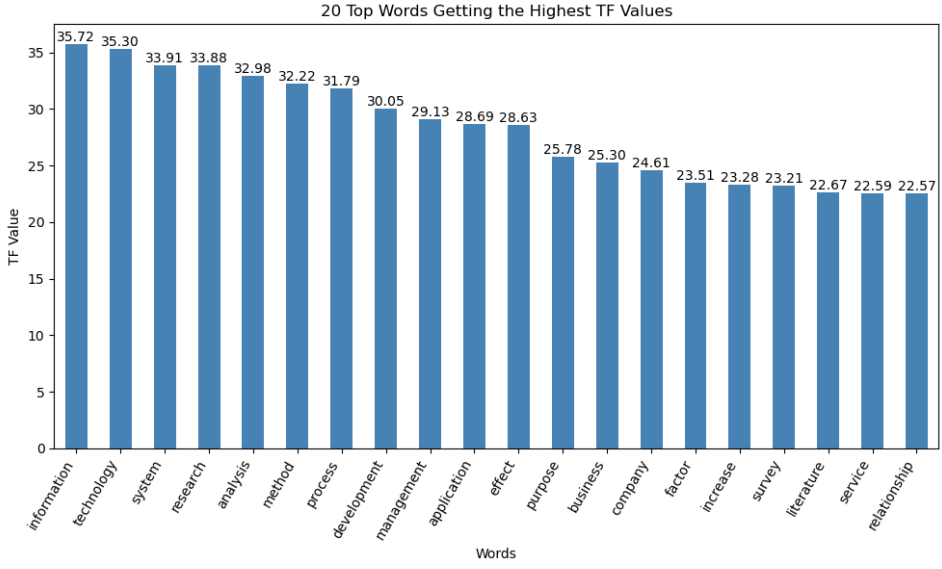


Figure 7. LDA topic model bar graphs (LDA konu modeli bar grafikleri)

4.4. TF, IDF, TF-IDF values for master's thesis abstracts

The TF, IDF and TF-IDF values are presented in Figure 8, with the graph displaying the 20 words with the highest term frequency, inverse document frequency and term frequency-inverse document frequency values, as observed in master's thesis abstracts.



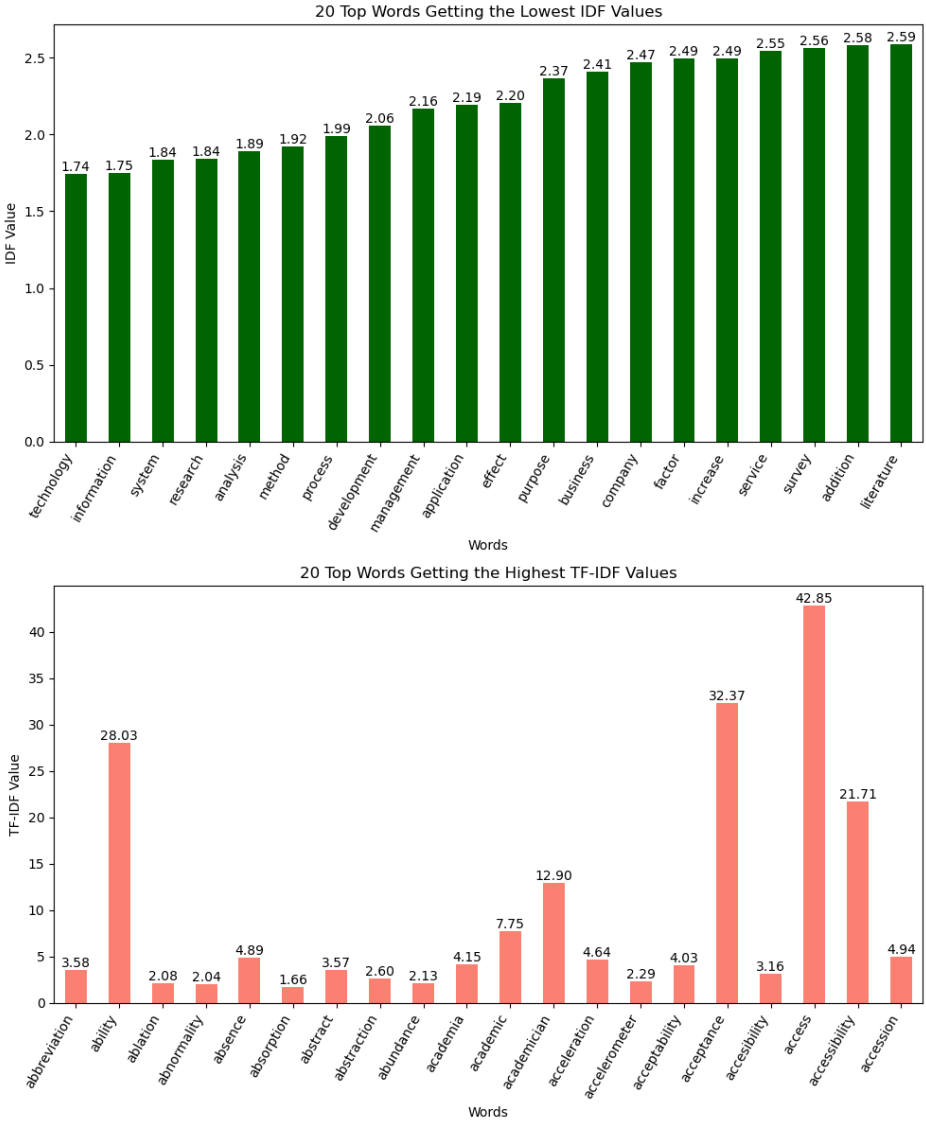


Figure 8. Words with the highest TF, IDF, TF-IDF values in master's thesis abstracts (Yüksek lisans tez özetlerinde en yüksek TF, IDF, TF-IDF değerlerine sahip olan kelimeler)

Figure 8 illustrates that the word with the highest term frequency is 'information', with a TF value of 35,72. Conversely, the word with the highest inverse document frequency is 'iterature' with an IDF value of 2,59. The term 'access' had the highest term frequency-inverse document frequency (TF-IDF) score, recorded at 42,85.

4.5. Creating Word Clouds for the Topics in the LDA Topic Model

Figure 4 presents the word clouds containing the 10 most frequently mentioned words in the topics generated by the LDA topic model. These word clouds were created using Python libraries, specifically the wordcloud and matplotlib packages. The word clouds for the topic model are presented in Figure 9. It is seen that the words in the bar graphs in Figure 7 are the same as the words in the word clouds in Figure 9.

Figure 9. Word Clouds for LDA Topic Model (LDA Konu Modeli Kelime Bulutları)

4.6. Creating a Heatmap of the LDA Topic Model (LDA Konu Modeli için Isı Haritası Oluşturulması)

The output of the Latent Dirichlet Allocation (LDA) topic model can be used to create a visual representation of the distribution of documents (thesis abstracts) across topics, in the form of a heatmap. The LDA topic model takes the topic probabilities in each document and stores these probabilities in a matrix, which is then visualised as a heatmap. The resulting heatmap is presented in Figure 10.

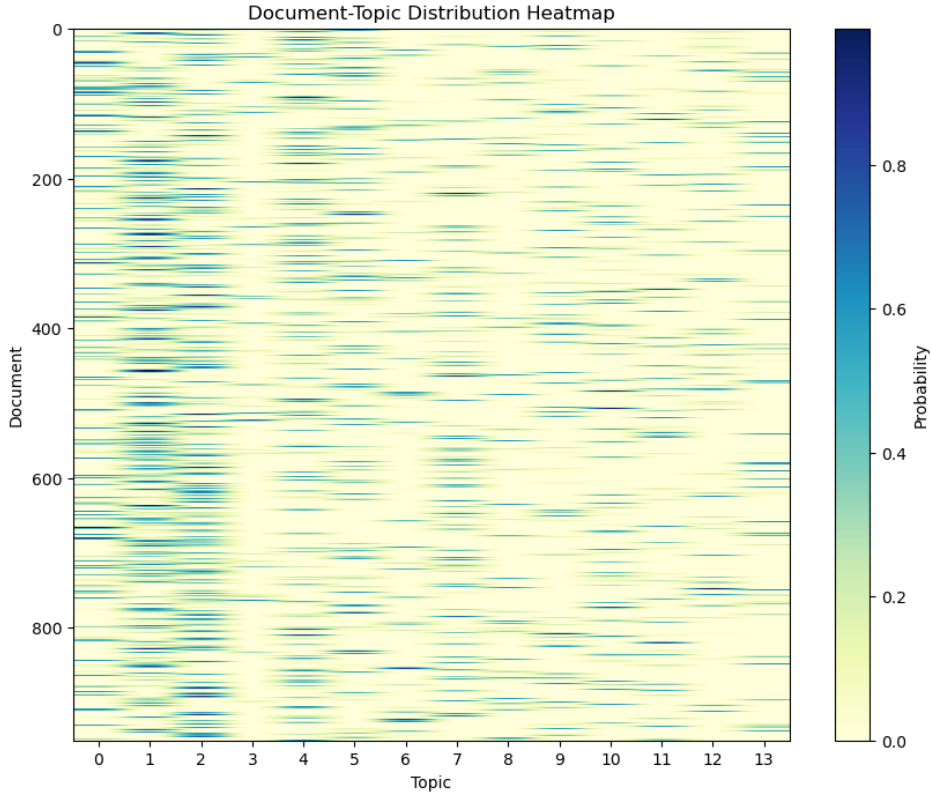


Figure 10. LDA Topic Model Document-Topic Distribution Heatmap (LDA Konu Modeli Belge- Konu Dağılımı Isı Haritası)

The map provides a more accessible and analytically tractable representation of the output of the LDA topic model. The degree of colour intensity in each cell is indicative of the relevance of the document in question to the topic in question. In creating this heat map, the colour palette was set to 'YlGnBu'. The use of dark colours to represent high probability and light colours to represent low probability allows for a clear visualisation of the distribution of topics among documents and the degree of relatedness between documents and topics. The heat map demonstrates that both topics exhibit a high document probability, as indicated

by the high density of dark colors. In this context, the term 'document' refers to the number of words in the original word list from which repeated words have been extracted for each thesis.

5. CONCLUSION

In Latent Dirichlet Allocation (LDA) topic modeling, fit values are used to assess both the effectiveness of the model and the interpretability of the topics it identifies. Higher fit values indicate better model performance and more coherent topics. Application of the LDA algorithm to the dataset revealed that words such as “data,” “model,” “research,” “technology,” and “system” appeared most frequently.

In topic modeling, both the size of the dataset and its internal consistency are important factors. Although the topic models in this study were generated from master’s and doctoral theses in the field of Management Information Systems (MIS), variations in subject matter and content naturally influenced model performance.

A comparison with prior studies discussed in Section 2 yields the following insights:

Çallı et al. [21] analyzed 574 graduate thesis abstracts completed between 2002 and 2020 using the LDA algorithm. In this study, 1170 thesis abstracts completed between 2002 and 2023 were analyzed using the same method, indicating that the number of theses published between 2020 and 2023 exceeded the total published during the previous 18 years. Topic differentiation was also observed, with LDA highlighting themes such as data analysis, decision-making, system analysis, system development, and information management.

Parlina and Kusumarani [22] applied topic modeling to publications in the first three MIS journals indexed in SCOPUS, identifying frequently occurring topics such as business performance, value management, data analysis, training, knowledge management, and model usage. Similarly, the results of this thesis emphasize data analysis, knowledge management, and modeling as prominent themes.

Özköse and Gencer [23] identified terms like “study,” “research,” “analysis,” “use,” “method,” and “algorithm” as dominant in density maps derived from bibliometric analyses of leading MIS journal articles in WoS. Comparing these findings with the topic model presented in Figure 5 reveals a similar pattern, suggesting substantial overlap between the content of graduate theses and international journal articles.

For future research, topic modeling could be extended to include master’s theses completed in 2024, and model performance could be further improved by

employing alternative algorithms such as Top2Vec, Latent Semantic Analysis (LSA), or BERTopic instead of LDA. Additionally, a separate study could focus on analyzing published articles in the field of MIS to complement the insights obtained from theses.

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CHAPTER 4

Colonial Weak State Structures and Terrorist Activities in Sahel Africa: The Cases of Mali, Niger and Burkina Faso

Abdouramane Hamadou[1] & Önder Aytaç Afşar[2]

[1] Master's Student, Department of International Relations, Graduate School of Social Sciences, Selçuk University, Turkey, ORCID: 0009-0005-8169-6234
[2] Assoc. Prof. Dr., Department of International Relations, Faculty of Economics and Administrative Sciences, Selçuk University, Turkey
ORCID: 0000-0003-1394-3975

INTRODUCTION

The Sahel region has become one of the most fragile security areas on the African continent today. The three central states of the region, Mali, Niger, and Burkina Faso, are geographically located in the same security belt and share similar historical, political, and socio-economic dynamics. These countries face common threats: weak state institutions, widespread poverty, ethnic divisions, and increasing terrorist acts. Therefore, considering these three countries together makes it possible to analyze the structural causes of the security crisis in the Sahel in a comprehensive manner. Furthermore, the Alliance of Sahel States (*Alliance des États du Sahel – AES*), established in 2023, demonstrates the will of these countries to unite under a confederation umbrella in line with a common security and development vision. This makes it even more meaningful to approach the study from a regional perspective.

According to the hypothesis of this study, the centralized and externally dependent institutions of French colonial administration created lasting fragility in the post-independence period, which in turn provided a structural basis for the strengthening of terrorist organizations. These fragile state structures, shaped by the legacy of colonialism, faced legitimacy and capacity issues in the modern era; this situation also led to the rapid rise of non-state armed actors in the Sahel region.

In this context, the article examines pre-colonial local political orders, institutional transformations under French rule, and post-independence state policies in a comparative manner. It then analyzes the causes of the security vacuum in the region through the rise of terrorism, coups, and external interventions. The final sections discuss the national, regional, and international impacts of terrorism and explore the potential for regional cooperation using the example of AES.

This analysis aims to reveal that state weakness in the Sahel is not a temporary crisis but a historical and structural legacy. Strengthening state capacity, rebuilding local legitimacy, and reviving national consciousness are critical to controlling terrorism and achieving lasting stability.

1. THE FOUNDATIONS OF THE FRAGILE STATE STRUCTURE IN NIGER, MALI, AND BURKINA FASO

1.1. Overview: Internal Stability And Security In Mali, Niger, And Burkina Faso

In the Sahel region, particularly in Mali, Burkina Faso, and Niger, increasing terrorist activities in recent years pose a serious threat to both regional security and civilian life.. According to 2024 data, Burkina Faso is the most affected

country in the Global Terrorism Index with 8.5 points, followed by Mali with 7.9 and Niger with 7.7 points (Vision of Humanity, 2025). In Burkina Faso, terrorist attacks rose from 303 in 2018 to 2,216 in 2019, corresponding to an average of six attacks per day. In 2021, the total number of attacks was recorded as 2,354. Similar increases are seen in Mali and Niger, with civilian casualties rising from 1,500 in 2017 to 6,000 in 2020 (Ipek, 2024).

Terrorist attacks have profoundly affected the social structure beyond physical losses. Pressure on the local population continues through religiously motivated compulsory *zakat* (Obligatory almsgiving for whealthy muslims) practices and economic targeting; civilians are forced into both internal and external migration. As of 2023, approximately 370,000 people have left their villages in Niger, bringing the total number of people in need of humanitarian aid to 4 million (Zambakarı, 2023). In Mali, 400,000 people left their homes in 2023, with the Tahoua and Tillabéri regions becoming areas where migrants sought refuge in large numbers (Kumar, 2023; Mesa, 2024). Mauritania, meanwhile, hosts 273,000 Malian refugees as of the end of 2024. In Burkina Faso, 1,135 schools were closed between 2011 and 2023, and more than 2 million people have been affected by terrorism and violence (Ipek, 2024).

These regional migration and humanitarian crises are straining not only local livelihoods but also the resources and infrastructure capacity of regional states. Inadequate camps limit access to basic services for refugees living in rural areas, with women and children particularly vulnerable to violence, abuse, and human trafficking. This situation stands out as a structural problem undermining regional stability.

This situation makes addressing the security crisis in Mali, Niger, and Burkina Faso, located in the heart of the Sahel, particularly important. In these countries, which bear the legacy of French colonial rule, the administrative, economic, and security policies implemented since the colonial era have weakened state capacity and enhanced the spread of terrorısm.

1.2 Pre-Colonial Political Order and Local Legitimacy

Before colonialism, institutional structures and political organizations in Sub-Saharan Africa, particularly in Mali, Niger, and Burkina Faso, were quite diverse. These systems were organized through inter-community balance and the complementarity of central and local authorities.

The *Kurukan Fuga* (Manden Charter), established during the Mali Empire founded by Sundiata Keita in the 13th century, was a fundamental tool for ensuring social order and peace. For example, it contained concrete regulations such as the protection of slaves' rights and the establishment of rules regarding land use among ethnic groups. The protection of natural resources and ensuring

the fair use of water and forests were also among the important principles covered by the Kurukan Fuga. However, even though this order was only partially implemented in remote areas of the empire and local chiefdoms, it has been still operated with a significant degree of independence. In sum the *Kurukan Fuga* served as a mechanism for harmony and coordination between the central authority and local structures (Vaucher, 2022).

In Niger, the Kanem-Bornu tradition stood out for its written diplomacy and administrative practices. The Bornu Letters *(Lettres Bornouanes*) documented the diplomatic relations, tax regulations, and military planning carried out by the sultans between the 16th and 19th centuries, revealing the existence of a centralized bureaucratic capacity (Vaucher, 2022). The Diffa region was one of the areas where this centralized administrative approach was most intensely felt. In addition, the historical legacy left by the Songhay Empire, which ruled over the territories of present-day Mali and Niger, paved the way for the emergence of a political structure based on power sharing among multiple centers and local authorities. This prevented the formation of a strong and stable central authority in the region; local dynasties, trading cities, and regional authorities continued to govern according to their own balances of power (Singleton, 2004). Similarly, the Hausa city-states (Kano, Katsina, Zaria, etc.) functioned as local administrative centers capable of independent decision-making, with their own chiefs, military structures, and trade networks. This situation shows that the region already had a political order based on local authorities before French rule.

In Burkina Faso, the Mossi Kingdoms had a structure that combined both central and landbased traditional authority, uniting the village-level land chiefs with the powerful central authority organized around the *Mogho Naba* (Chief). For example, in the kingdoms of Yatenga and Wogodogo, tax collection, military campaigns, and dispute resolution were carried out within a hierarchical order (Gérard, 1986).

All these examples demonstrate that the contemporary fragility observed in the Sahel does not stem from a "stateless" past. On the contrary, during the pre-colonial period in the territories that today constitute Mali, Niger, and Burkina Faso, there existed shared and clearly identifiable forms of political organization. In all three cases, governance was structured around religious and traditional authorities, through which rulers and local communities were bound by institutionalized, legitimacy-based relationships grounded in reciprocal obligations. Current patterns of fragility emerged as a consequence of colonial rule, which disrupted and transformed these common governance arrangements and undermined locally rooted mechanisms of authority and social cohesion. In this regard, pre-colonial political organizations constitute a shared institutional

legacy that is essential for understanding contemporary governance crises and state–society disconnections in Mali, Niger, and Burkina Faso.

1.3 French Colonial Administration and Weak Institutionalization

France brought Mali (then French Sudan) under its control in 1883, Burkina Faso (Upper Volta) in 1899, and Niger in 1900 (Lugan, 2013). It then incorporated these three countries into the institutionalized structure of French West Africa, "*Afrique Occidentale Française (AOF),"* in 1904, establishing a highly centralized administrative system based in Dakar. This structure created a bureaucratic order directly linked to Paris, eliminating the autonomy of local administrations. Thus, it created deep structural legacies that shaped not only the colonial period but also the fragile state structures in the Sahel today.

France eliminated the monarchical-religious governance models in the region and imposed its own administrative template (Conklin, 1998). This model, focused on "centralization and control," clashed with the centuries-old social orders of the Mali Empire, the Bornu Sultanate, and the Mossi Kingdom. Colonial administration also reshaped power relations by manipulating local elites (Feckoua, 1999). Loyal local administrators were appointed, while traditional sources of legitimacy were devalued. Thus, the perception that power originated from external forces rather than the people took root; this external legitimacy persisted after independence, providing an institutional basis for the military interventions and externally supported governance culture seen today in Mali, Niger, and Burkina Faso.

The impact of this intervention on each country is concrete and clear. In Mali, the French administration marginalized the Tuareg communities in the north by assigning military and bureaucratic roles primarily to elites ideologically aligned with France. This exclusion later laid the groundwork for the Tuareg uprisings in Mali in 1963, 1990, and 2012 and also led to Tuareg uprisings in Niger in the 2000s (Solomon, 2021, pp. 37–48).

Furthermore, the drawing of borders is one of the most critical interventions that determined the fate of the region during the colonial period and stands out as a significant factor weakening state structures. In line with the Berlin Conference, the continent was divided by drawing borders without taking into account the histories and cultural ties of local peoples. The fact that only 11% of the borders were determined according to human geography, with the remainder based on geographical lines such as meridians, parallels, and watersheds, divided ethnic and religious groups, creating lasting conflict dynamics (Feckoua, 1999). The most concrete example of this is the Tuareg people; they became a fragmented community, with some living in Mali, some in Niger, some in Algeria, and some

in Libya. (Brunschwig, 1954) This division later formed the basis for identity-based conflicts and led to the spread of terrorism.

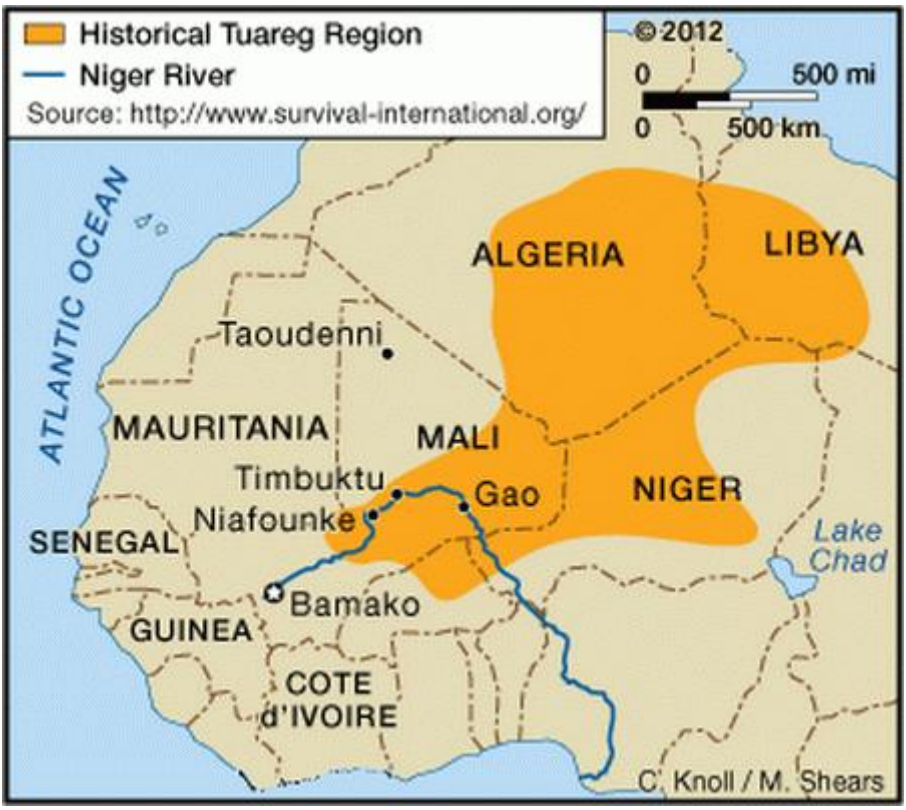

Figure 1: Historical Tuareg Regions (Africa 101 Last Tribes, 2012)

Moreover, one of the most critical interventions of the colonial period was education policy. France established a secular, Western-centered education system in Mali, Niger, and Burkina Faso, pushing local religious authorities into the background. For example, while the *madrasas* of Timbuktu and Djenné in Mali had historically excelled in Quranic education, French schools began teaching modern science, French, and a secular curriculum (Chafer, 2001). Local scholars were excluded from the education system. In Niger, Tuareg and Hausa communities in the Zinder and Agadez regions were directed toward the French curriculum, while madrasas remained limited to religious education. In Burkina Faso, French schools in Mossi communities were run by appointed teachers instead of traditional and religious leaders. This policy undermined the authority of local religious leaders, deprived religious education of official recognition, and created a cultural-identity rift between the state and society (Vaucher, 2022).

This historical division has strengthened the propaganda strategies of radical groups today. Terrorist organizations, particularly Boko Haram, target the education system with the slogan "Western education is haram," and even the name itself points to this historical context. French education policies weakened state-society trust in the long term and fueled radicalization dynamics by separating secular, Western-centric schools from Islamic education. Thus, colonial educational intervention not only transferred knowledge but also served as a means of social control and cultural guidance, paving the way for the terrorism and radicalization processes seen in the Sahel today (Feckoua, 1999).

The colonial administration also established a direct control mechanism over the local population through the "poll tax" (*impôt de capitation*) system, which was enacted by a decision taken in 1900 and implemented in French West Africa ("*Afrique Occidentale Française, AOF"*) starting in 1902. This personal tax was both an instrument that institutionalized the economic exploitation of the region and a symbol of social oppression felt in daily life; those who could not pay the tax were forced to work or punished. This practice led to the state authority being perceived by the people as a "punitive and exclusionary power," leaving a deep legacy of mistrust that carried over into the post-colonial era (Idrissa, 1993).

As a result, the policies developed during the French colonial period such as military pressure, compulsory taxation, centralized administration, the redrawing of ethnic boundaries, manipulation of local elites, and an imposed education system formed the structural foundations of state weakness and terrorism seen today in the Sahel region, particularly in Niger, Mali, and Burkina Faso. The population's historical distrust of the state is inherited from the authoritarian and externally dependent forms of governance of the colonial era. Therefore, terrorist organizations operating in the region are able to gain social support by presenting themselves as "representatives of the resistance against the oppressive order established by foreigners.".

1.4. Post-Independence State Policies

Although the 1956 *Loi-cadre (Framework Law)* reforms ostensibly aimed to create administrative autonomy in colonies, in practice they became a system that re-institutionalized France's post-colonial dominance over the region. Known as the *Loi-cadre Defferre*, this arrangement, while providing for the establishment of local councils and governments, created a model of structural dependency that largely limited the rhetoric of autonomy by keeping control of financial resources, senior administrative appointments, and strategic decision-making processes under Paris's control. The reforms dismantled the West and Equatorial African federations, creating numerous new political units; although these units were given assemblies, strategic areas such as foreign policy, defense, security, and economic sovereignty remained under French control (Harshe, 1980). This

situation led to the formation of Sahel states with limited sovereignty, dependent governance, and weak state capacity from the outset. Niger gained independence on August 3, Burkina Faso on August 5, and Mali on September 22, 1960, the colonial administrative borders became international state borders, and thus this institutional framework shaped by borders continued to determine not only the administrative structure but also the form of centralization of power and the circulation of elites. Hence local administrators educated in the French education system established close ties with the metropolis (Aydoğan & Fidan, 2022). These elites have positioned themselves in decision-making processes not between national interests and local social demands, but often in alignment with Paris-centered external expectations. For example, in Mali, Modibo Keïta, through the French education system and close ties with the metropolis, continued a centralized and elite-focused approach to governance in the post-colonial period (Vallin, 2015). Similarly, in Niger and Burkina Faso where Diori Hamani and Maurice Yameogo established close relations with France forming a ruling class disconnected from the broader social base. Thus, the state in the Sahel has evolved into an exclusionary, centralized, ethnically and geographically selective structure rather than an inclusive one. Exclusion was not limited to the Tuareg; rural groups outside the Fulani, Dawsahak, and Mossi, as well as many communities in the northern plains, were left out of political processes.

Moreover, after the independencies, Mali, Niger, and Burkina Faso were tied to France's financial control through the *CFA Franc* system (*Colonies Françaises d'Afrique*). Established in 1945, the CFA franc is currently valid in eight former French colonies in West Africa, including Mali, Niger, Burkina Faso, Senegal, Benin, Togo, Ivory Coast, and Guinea-Bissau. In Central Africa, there is a separate *CFA franc* system covering Cameroon, Gabon, Congo-Brazzaville, Chad, the Central African Republic, Equatorial Guinea. In both regions, the value of the currencies is pegged to the French franc and monetary policies are largely determined by Paris (Vallin, 2015; Afsar & El-Hayani, 2023). This system has perpetuated economic dependence, directly negatively affected state financial power, and weakened state-society relations by leading to monetary policies being determined in Paris, reserves being held in the French treasury, and the independent decision-making authority of African central banks being severely restricted in Mali, Niger, and Burkina Faso.

Furthermore, France's influence over mineral and energy resources in the Sahel has persisted. French companies such as Elf Aquitaine, Areva/Orano, and TotalEnergies have continued their activities over Niger's uranium, Mali's gold reserves, and the region's natural resources in general, even after independence. For example, although Niger provided approximately 4% of the world's uranium supply in 2022, only a limited portion of the revenues from this strategic resource

has been reflected in the local economy, the country has not been able to escape the paradox of being "rich in resources, poor in people" (Önal & Oumar, 2021). This economic injustice has created not only material but also identity-based and political fractures; it has seriously weakened the sense of belonging to the state among communities living in northern Mali and Niger in particular and has been a significant factor in the rise of terrorism.

This economic fragility, combined with security issues, has created a deeper crisis. The exclusionary nature of the state, its failure to meet the security, justice, and economic expectations of rural communities, and inequalities in resource distribution have made the rhetoric of radical groups more appealing. The alienation of the young population from the state, due more to socio-economic exclusion than ideological reasons, has facilitated the recruitment of terrorist organizations. The process leading to the declaration of Azawad in northern Mali in 2012 is a dramatic result of this exclusion and clearly shows the extent to which state legitimacy has eroded.

On the political level, the Françafrique network has determined the stability of regimes. France's continued close relations with elites in its former colonies have influenced the environmental conditions for the military coups frequently seen in the region. The overthrow of Modibo Keïta in Mali in 1968, the rise to power of Seyni Kountché in Niger in 1974, and the military transformation in Burkina Faso in 1980 show that France has sometimes acted in concert with authoritarian regimes to maintain its influence in the region. Thus, the political order has transformed into a model where military-bureaucratic elites are reproduced instead of democratic institutions strengthening, and where mechanisms of social representation have weakened.

This historical continuity directly supports the study's fundamental hypothesis: France's colonial and neo-colonial practices have weakened the institutional capacity, economic sovereignty, and social inclusiveness of Sahel states, thereby creating a sociopolitical ecosystem conducive to the development of terrorist organizations in the region. The fragmentation of state authority, the proliferation of marginalized communities, and the unequal distribution of economic resources demonstrate that terrorism feeds not only on security vulnerabilities but also on historically produced structural inequalities.

2. SECURITY VACUUM AND THE RISE OF TERRORISM IN MALI, NIGER, AND BURKINA FASO

2.1 Emergence and Spread of Armed Groups in the Sahel

One of the most fundamental problems faced by Sahelian states in the post-independence period is their inability to overcome the weak

institutional structures inherited from the colonial era in the security sector. Centralized and externally dependent state structures shaped under French rule have failed to establish effective governance capacity in geographically vast and socioculturally heterogeneous regions. This situation has both limited the physical and administrative control of central governments across countries and deepened security vulnerabilities. The emergence of terrorism in Mali, Niger, and Burkina Faso can be explained by a combination of historical, economic, geographical, and political factors.

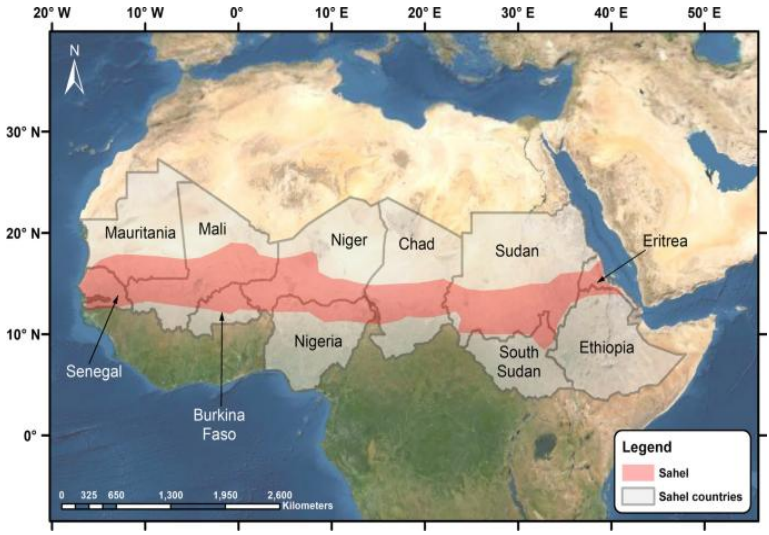

Figure 2: Sahel Countries (Springer Nature, 2025)

The early and intense emergence of terrorism in Mali is largely attributable to the longstanding experience of marginalization among the Tuareg and other Saharan communities residing in the north. During the French colonial period, the north was the region that received the least economic investment and institutional state presence; Tuareg and Arab communities were excluded from both administrative structures and channels of social mobility such as education (Solomon, 2021; Vaucher, 2022). This structure transformed the north into a region "disconnected from the center" and wary of the state, strengthening the communities' quest for autonomy. In this vein , the Common Organization of Saharan Regions "*Organisation Commune des Régions Sahariennes (OCRS)",* established in 1957, had the potential to grant institutional status to certain parts of the Sahara. However, when the project ended in 1963, the Tuaregs became convinced that their hopes for "determining their own political destiny" had been dashed. The Tuareg uprising of 1963–1964, which erupted immediately after this

disappointment, clearly demonstrated that the independent Malian state was unable to respond to the demands of the north. The harsh suppression of the uprising by the Malian army created lasting trauma in many families in the region; the death of the fathers of some of today's armed actors (e.g., Ansar al-Din leader Iyad Ag Ghali). Hence these conflicts accelerated the intergenerational transmission of the memory of the uprising. The new cycles of rebellion in the 1990s and 2006 showed that the distance between the state and society in the north had deepened. In these regions, where state authority was limited, the inadequacy of security services caused young people to feel economically and socially abandoned. According to Apau's security analysis of the Sahel, similar structural weaknesses, gaps in state authority, poverty, lack of security, and political exclusion are quickly filled by armed groups, creating fertile ground for radical organizations (Apau, 2023). This situation is particularly evident in northern Mali: terrorist organizations have offered young people alternative structures that provide income, belonging, and status, while the weak state presence has effectively left the security burden to these organizations.

When Tuareg fighters with extensive combat experience returned to the region after Libya's collapse in 2011, they combined with this socio-political environment, and the MNLA's *Mouvement National pour la Libération de l'Azawad* (National Movement for the Liberation of Azawad) instantly increased its military capacity. The declaration of independence of Azawad in 2012 was the most concrete manifestation of the transformation of a long-standing memory of exclusion into a political and military organization. However, the MNLA was quickly overshadowed by Al Qaeda-affiliated groups (AQIM, Ansar al-Din, MUJAO), demonstrating how vulnerable demands for autonomy in the region were to radicalization. The rapid expansion of terrorist organizations in the north can be seen as a result of the historical exclusion experienced by the Tuareg community and the state's continued weakness in the region (Dağ, 2023; Rauch-Mannino, 2023). Ultimately, the spread of terrorism in Mali is a direct product not only of current security gaps, but also of regional inequalities inherited from the colonial era, fragile governance structures, and generations of political exclusion of the Tuareg.

In Niger, terrorism is experienced on two fronts: from Mali-based groups and from the Boko Haram threat coming from the east. A large part of Niger consists of desert and semidesert areas, arable land is limited (11.79%), and approximately 80% of the population lives on less than $2 a day (Rauch-Mannino, 2023). This economic fragility took shape during the colonial period and then through neocolonialism, as discussed in previous sections. Poverty has left the young population vulnerable to the ideological and religious rhetoric of terrorist

organizations. In addition, political vacuum and external interventions facilitate the organizations' ability to find a social base.

The Charlie Hebdo cartoons and the events that followed in 2015 are a concrete example of this dynamic in Niger. Armed attacks were carried out after the Charlie Hebdo magazine published cartoons mocking the Prophet Muhammad (PBU), resulting in the deaths of 12 people. Nigerien President Mahamadou Issoufou's participation in the unity march in France after this incident was perceived as a symbol of the close ties that post-colonial elites had established with the West and was used as propaganda material by Boko Haram with the slogan of a government close to the West and detached from the people (Olivier de Sardan, 2015). As the majority of Niger's population is Muslim, the organization has created social impact through religious rhetoric and filled this void. This example shows that terrorism feeds not only on security gaps but also on the ideological exploitation of historical elitism and the disconnect between the state and the people. Experienced fighters who infiltrated the region after the Libyan crisis accelerated the spread of Mali-based organizations to northern and western Niger.

In Burkina Faso, geographical vulnerability is at the forefront of the spread of terrorism. The northern and eastern regions serve as transit corridors for groups coming from Mali and Niger; open borders and scattered settlements facilitate the organizations' operational activities. A large part of the country is economically fragile and agriculture-based, and its vulnerability to climate shocks has made Burkina Faso a new recruitment ground for Al-Qaeda-affiliated organizations (Issaev, Korotayev, & Bobarykina, 2022). State capacity remains limited in the northern and eastern regions, making the material and security promises offered by organizations attractive to the young population. Following the Libyan crisis, armed groups infiltrating from Mali and Niger settled in northern and eastern Burkina Faso, increasing the capacity of Al-Qaeda and ISIS-affiliated organizations (Dağ, 2023).

A common feature of these three countries is that terrorism cannot be explained solely from a military or security perspective. The colonial legacy, economic inequalities, geographical conditions, the state's lack of inclusiveness , and regional crises are interrelated factors that have weakened the young population's sense of belonging to the state and enabled radical groups to find a social base. The structural weaknesses created by the French colonial legacy stand out as one of the main reasons for the spread of terrorism in these three countries today.

The spread of terrorism in the Sahel began in the 1990s, first filled by ethnic-based armed movements and then by religious-based jihadist organizations. The Tuareg rebellions in Mali and Niger were initially secular movements based on

demands for regional autonomy; however, the weak response of the state and social exclusion led these groups to develop tactical cooperation with jihadist organizations over time (İpek, 2024). This process is the first example of local grievances turning into ideological radicalization in the Sahel.

During the same period, the Armed Islamic Group (GIA), which emerged during the Algerian civil war, and later the Salafist Group for Preaching and Combat (GSPC), spread from southern Algeria into the Sahel, forming the region's first organized jihadist structures. In 2007, with the GSPC pledging allegiance to Al-Qaeda, the group changed its name to Al-Qaeda in the Islamic Maghreb (AQIM) (Raineri & Strazzari, 2017). It shifted its armed activities in the Sahel to the Mali-Niger-Algeria border area. AQIM's financing has largely relied on kidnapping, ransom, drug and arms trafficking (Baran, 2025).

The 2011 Libyan civil war was a turning point that fundamentally changed the balance of power in the region. The collapse of the Gaddafi regime, along with the spread of weapons stockpiles to the Sahel and the return of thousands of mercenaries, had the effect of completely collapsing the already fragile security architecture. During this period, state authority in Niger and Mali virtually disappeared in the northern regions (Dağ, 2023).

In this chaotic environment, Ansar Dine, founded under the leadership of Iyad Ag Ghali, seized northern Mali in 2012 and declared the "State of Azawad." Shortly thereafter, it merged with AQIM and began implementing a Sharia-based administration. The emergence of the Macina Liberation Front (FLM) in the Mopti region in 2015 and the ISIS-affiliated Islamic State in the Greater Sahara (ISIS-GS) organization in the same year accelerated the spread of terrorism not only within Mali's borders but also into Niger and Burkina Faso (Şefkatli & Şahin, 2023).

In 2017, these groups merged under a single umbrella organization called Jama'at Nusrat alIslam wal-Muslimin (JNIM). JNIM adapted Al-Qaeda ideology to local conditions and adopted a strategy, aiming to increase social support by blending local grievances with religious rhetoric. At the same time, ISWAP (Islamic State West Africa Province), which emerged with the weakening of Boko Haram in eastern Niger, has created a new security threat in the region (Bagayoko, 2021). The AİM of these groups is to establish an Islamic state in the region, but they have failed to gain legitimacy in the eyes of the people due to the non-Muslim methods they employ.

The emergence of all these organizations is linked not only to factors such as regional dynamics but also to the institutional fragility created by the colonial legacy and the elite dependency perpetuated during the Françafrique era. The failure of states to create social belonging has eroded public trust in the state,

allowing radical organizations to gain legitimacy among the people with their promises of "justice and identity." Thus, the weak, externally dependent, and centralized state structure established during the colonial period has become one of the deepest structural causes of terrorism in the Sahel today.

2. 2 French and EU Intervention in Response to Rising Terrorist Activities

The security architecture in the Sahel region appears to have been shaped around external intervention strategies led primarily by the European Union (EU) and France. However, rather than establishing a stable and sustainable security order in the region, these strategies have reproduced the dependency relationships inherited from the colonial era and deepened institutional fragilities.

The European Union's (EU) interventions in the Sahel region are largely shaped around the management of irregular migration and the establishment of regional stability. The Sahel is seen as an important transit point for irregular migration movements, making it imperative for the EU to ensure stability in the region. In this context, one of the EU's most concrete security initiatives in the region is the EUCAP Sahel Mission which was launched in Niger in 2012 and later expanded to Mali. The mission aims to strengthen the capacity of local security sectors and train law enforcement agencies on terrorism, organized crime, and border security. However, local participation has been limited, and projects have mostly been shaped within Brussels-centered bureaucratic frameworks. Thus, the EU's technical assistance has created an externally dependent structure rather than increasing the capacity of local security institutions (EEAS, 2023).

France, on the other hand, seeking to maintain its historical influence, particularly through military operations, to protect its own strategic and economic interests and to exert direct or indirect influence over the resources and security policies of the countries has not left the region (Afsar & El-Hayani, 2023). France has lunched the *Operation Serval* (Serval Operation) on the call of Mali government in 2013. Although it aimed to reestablish state authority in Mali, it quickly transformed into a regional intervention force called Operation Barkhane (2014–2022). Barkhane was conducted in cooperation with the G5 Sahel countries, but in practice, operational decisions were made in Paris. This undermined the Sahel states' perception of sovereignty and led to widespread reactions that France's military presence was "neo-colonial" in nature (Baran, 2025).

Although the G5 Sahel Joint Force (FC-G5S) was established to support the collective security efforts of the countries in the region, it has remained dependent on French and EU funding. This has led to weak regional ownership. Indeed,

military coups in Mali, Burkina Faso, and Niger have demonstrated that the externally supported security architecture has completely lost its legitimacy in the eyes of the people. The new military administrations have rejected Western counterterrorism policies as unsuccessful, self-serving, and perpetuating post-colonial dependency.

As a result, in 2022, the Malian government accused France of "violating the country's airspace" and "providing logistical support to terrorist groups"; these allegations were brought to the United Nations Security Council (Al Jazeera, 2022). Similarly, the Burkina Faso administration canceled all defense agreements with France and characterized the EU's security missions as a "threat to sovereignty" (International Crisis Group, 2023). In Niger, the suspension of all EU programs in 2023 was a clear indication that the influence of external actors on regional security had come to an end (Africa News, 2023).

These developments show that the security order built in the post-colonial period served to protect the interests of external actors rather than developing the institutional capacity of Sahel countries. France's military presence and the EU's civilian missions have failed to achieve concrete success in the fight against terrorism; on the contrary, they have weakened the legitimacy of local institutions and accelerated the public's shift towards anti-Western rhetoric. Therefore, the continuation of post-colonial dependency relations and the failed intervention strategies of external actors have played a decisive role in the deepening of the current security crisis in the Sahel.

2.3 Post-2020 Military Coups and Anti-Colonial Movements in Sahel

Mali, Niger, and Burkina Faso in the Sahel region have historically had political structures shaped by external interventions and neocolonial influences. as stated in the previous chapters, the Françafrique system has enabled France to maintain its political and economic influence in its former colonies (Afsar & El-Hayanı, 2023). Françafrique has encouraged or supported regime changes through local elites and armies (Uchehara, 2014). This system has weakened the legitimacy of states in the region and eroded the bonds of trust between the people and their rulers.

The Alliance of Sahel States (AES) leaders seized power through military coups in response to fragile state structures in the region. The coups in Mali, Niger, and Burkina Faso represent not only a change in leadership but also an effort to reestablish local sovereignty against neocolonial interventions. These coups aimed to increase popular support and the effectiveness of security institutions in the region, paving the way for the re-empowerment of central authority in the fight against terrorism. This process thus concretely demonstrates

how political fragility in the Sahel, combined with neocolonial pressures, triggers terrorism and social tensions.

2.4 Mali: Asimi Goïta and Post-French Transformation

The coup d'état led by Colonel Assimi Goïta on August 18, 2020, exposed Mali's long-standing political fragility and the weakness of its state institutions. The direct trigger for the coup was the failure of the France-led Barkhane Operation to effectively stop terrorist groups in the northern and central regions, which led the public to perceive France as a "colonial continuation." This situation made the trust gap between the center and the north and the state's lack of security capacity more visible. Following the coup, the Goïta administration directly challenged the dependency relationship by canceling all military agreements with France; in 2022, it complained to the UN Security Council about France on the grounds of violating Mali's airspace. Mali Foreign Minister Abdoulaye Diop's accusation that France was "providing logistical support to terrorist groups" (Al Jazeera, 2022) was not only a diplomatic move but also a symbol of the claim to local sovereignty. During the same period, Mali's withdrawal from the G5 Sahel carried a political message against France's influence on the regional security architecture. The Goïta administration has distanced itself from Western-centric alliances by rethinking its security strategy and initiating cooperation with the Russian-backed Wagner Group. This cooperation aims to both strengthen military capacity on the ground and reduce dependence on France and the West. The social dimension of the coup is also noteworthy: the majority of the population supported the coup because long-standing corruption, poor governance, and the security vacuum had eroded confidence in the central authority. While the coup aims to fill this void and reestablish the state's central authority, it has also shifted Mali's security and diplomatic policies toward a pragmatic cooperation axis based on local priorities and regional actors. As a result, the Goïta coup can be seen not only as a change in government, but also as a process of breaking away from dependency relationships, strengthening central authority, and reshaping security strategies on the ground. This process clearly demonstrates how political fragility in the Sahel, combined with neocolonial pressures, triggers social and security crises.

2.5 Burkina Faso: Ibrahim Traoré and the Radicalization of the Sovereignty Discourse

The impact of the coup in Mali paved the way for the change of power in Burkina Faso in 2022. President Roch Marc Christian Kaboré's administration lost the support of the army due to increasing terrorist attacks and allegations of poor governance; he was first removed from office by Colonel Damiba, then by young officer Ibrahim Traoré in September 2022. Traoré adopted the model seen in Mali, arguing that military ties with France constituted a "threat to national

sovereignty" in the eyes of the public. His first act, the withdrawal of French troops from the country, was not only military but also symbolic. During this process, France's presence under Operation Barkhane was ended, and the widespread "anti-French" rhetoric among the young population (Al Jazeera, 2023) became the main source of political legitimacy. Thus, Burkina Faso, one of France's last strategic strongholds in the region, has also distanced itself from Western-centric security policies and entered the "sovereign governance" line.

2.6 Niger: The Fall of Mohamed Bazoum and the Final Link in Françafrique

The coup led by General Abdourahmane Tiani on July 26, 2023 completed the trend seen in Mali and Burkina Faso. Niger was France's last operational base in the Sahel and a strategic partner in terms of uranium resources. However, with the overthrow of the Bazoum administration, all of France's military agreements were canceled, and French troops were withdrawn from the country. The people demonstrated their support for the new administration through protests in front of the French embassy in Niamey, expressing open anger towards France. This situation showed that grassroots resistance to the Françafrique order had become irreversible. The US was similarly criticized for its military bases in Niger, with the Tiani administration stating that these bases "protected Western interests" and demanding the withdrawal of US military presence. Thus, the Sahel has transformed into a multipolar security arena where Western influence is waning and new actors such as Russia (Menguele Menyengue, 2023), which historically has no colonial past with Africa, and Turkey are gaining strength.

CONCLUSION

Security crises and rising terrorism in the Sahel region are not solely due to local governance deficiencies; the legacy of French colonialism and long-term Western political and military interventions constitute the fundamental structural causes of instability in the region. The artificial borders in Mali, Niger, and Burkina Faso, ethnic and cultural divisions, weak central authority, and the local population's lack of trust in the state are reflections of this legacy today. This historical context is critical to understanding modern Sahel crises and explains the origins of developments such as recent coups, terrorist attacks, and waves of migration.

The military coups that took place between 2020 and 2023 exposed the failures of governments in the areas of security and development. The administrations of Assimi Goita, Ibrahim Traoré, and Abdourahmane Tiani failed to meet the security expectations of the people and experienced radical breaks in relations with the West. These processes reshaped not only domestic politics but also regional cooperation and the security architecture. In particular, France's

Barkhane Operation and the presence of other Western powers have created a crisis of legitimacy in the eyes of the people and limited the capacity of local administrations to act independently.

In this context, regional initiatives such as the Alliance of Sahel States (AES) not only provide military coordination but also aim to produce inclusive policies in areas such as development, education, health, and infrastructure. The establishment of the AES demonstrates that purely military solutions are insufficient in the fight against terrorism and that historical structural problems must be taken into account. However, the success of the confederation depends on the institutional capacity, economic resources, and trust relationships with the people of its member countries.

On the other hand, migration movements and humanitarian crises in the region reveal that the security and development problems of the Sahel have not only national but also international implications. Migrations to Europe via Libya are directly linked to the increasing terrorist attacks in Niger and Burkina Faso. This situation reinforces the destabilizing effects of Western policies in the region, both in the past and today.

Consequently, resolving the crises in the Sahel cannot be limited to current governance reforms or military interventions. The historical legacy of colonialism, external interventions, and local social dynamics must be addressed collectively; regional cooperation, national awareness raising policies , and multidimensional development strategies are essential requirements for the long-term stability of the Sahel.

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CHAPTER 5

Bibliometric Analysis of the Green Brand

Fahri Alp Erdoğan[1]

[1] Res. Asst., National Defence University, ORCID: 000-0001-6069-5981

1. Introduction

Every year, 37.4 billion tonnes of CO2 is emitted in the world due to production (IEA, 2024). People are turning to green as a necessity for the future of the world and to live in a clean environment. In addition, United Nations resolutions such as the Paris Climate Agreement, which specifically support green production, also increase the environmentalist orientation. Old- style production procedures lead to increased pollution and environmental damage (Alhartey, 2019). As a result, consumers' environmental awareness has increased (Ha, 2022; Sharma and Choubey, 2022) and customers are more interested in purchasing green brands (Siyal et al., 2021). In comparison to non-sustainable items, sales of consumer goods designated as socially or ecologically responsible increased by more than 28% between 2017 and 2022, per a joint study conducted by McKinsey and NIQ (NIQ,2023). The green environment has emerged as a sensitive issue for consumers, resulting in a variety of green products (Wang et al., 2022; Nguyen et al., 2023). To produce products that are both efficient and kind to the environment, green firms often spend money on R&D. The product needs to be perceived by consumers as keeping the environment clean and green (Ramanust et al., 2020). Businesses therefore focus on green marketing and produce eco- friendly or green products with less harmful effects on the environment (Yudhya, 2016; Tripathi et al., 2016). Such companies pay attention to the sources of the materials and chemicals they use. Although there are many businesses in the market that offer environmentally friendly products, consumers trust fewer products (Alamsyah et al., 2020). However, consumers may not know how green a particular product is from its outward appearance (Zhou et al., 2021). For example, advertisers and brand owners use verbal and visual cues that are assumed to be pro-green, but this can be manipulative (van Niekerk, & Conradie, 2020). A green brand appeals to consumers' positive perceptions (Khan et al., 2021). It aims to influence consumers' mental emotions and make them trust products by offering psychological security (Kim, 2015; Hosseinikhah Choshaly & Mirabolghasemi, 2020). They can also emphasize transparency in their supply chains and operations to gain the trust of consumers who prioritize sustainability. In order to expand green market share, gain differentiated competitive advantages, and build good customer relationships, businesses create a green brand strategy (Darnall, 2008; Zhang et al., 2023). The purpose of this study is to analyze the development of scientific knowledge on the green brand concept. Thus, it is envisaged that it will provide future researchers with the opportunity to see the subject gaps and guide future studies. This study makes the following contributions:

- To strengthen the connections between major research areas and studies on

green branding.

- To develop the theoretical knowledge on green branding to be a crucial part of future research.

Thus, the following research issues are intended to be addressed by this study: (1) Which journals and papers have contributed most significantly to the field of green brand studies? (2) Which writers have had the biggest impact and made the greatest contributions to research on green brands?

2. Literature Review

2.1. Green Brand

A green brand is a set of ideas, beliefs or impressions about a firm's environmental activities (Zhou et al., 2021). In order to lead a green life and achieve sustainable development, it is crucial for the business to develop a green brand (Ren, 2015; Zhang et al., 2023). A green brand exhibits a different character compared to its competitors by having nature at its center (Xu et al., 2021). Creating a green brand can improve corporate image and increase business profits (Ko et al., 2023). A firm labeled as a green brand by consumers has the potential to differentiate itself from competitors in a sustainable market (Bashir et al., 2020). Green brands can engage with their customers through various communication strategies (Leckie et al., 2021). To enable them to meet both social and environmental aspects of consumer needs, green brands can use storytelling (Huang et al., 2022). Efforts to communicate environmental concerns can capture consumers' attention (Krissanya et al., 2023). They can implement projects such as recycling programs, water conservation measures and the use of renewable energy sources.

Green brands are brands that consumers associate with environmental sustainability (Chen et al., 2020). These brands generally focus on minimizing their ecological footprint, using renewable resources, reducing waste, and generally promoting environmental stewardship. The main purpose of consumers choosing green brands is to have the least negative impact on the environment (Souto Maior et al., 2022). Brands and consumers are in a close-knit relationship (Ha, 2021). Therefore, a green brand is shaped by consumers' perception of green knowledge (Kumar et al., 2021). Customers who believe that a product is green will tend to purchase that product over competing products if they perceive that there is no difference between them (Zhou et al., 2021). Consumers who interpret green information at a higher level focus more easily on the social values of green brands (Gong et al., 2020). Green brand embodies consumers' sense of enhancing their social identity (Li and Sun, 2022). Buying a green brand appeals to one's green self-image (Tan et al., 2022). For green brands to expand their

reach, an environment-centered perspective needs to develop (Fontes, et al., 2021).

3. Research Methodology

In this study, academic journals related to green brand were reviewed and the relationships between keywords were determined using bibliometric analysis. Bibliometric analysis is a type of research approach to understand global research trends in a particular field through the output of academic publications in Scopus or WoS database (Alsharif et al., 2020). Bibliometric analysis provides an overall picture of a research field that can be classified by articles, authors, and journals (Merigó and Yan, 2017). The basic assumption of bibliometric analysis is that articles published in scientific journals build their research on previously published similar articles (Van Raan, 2012). In this study, Scopus database was used and English articles were considered as the unit of analysis. "green brand" and "green branding" were used as keywords and 282 articles were accessed. These articles were analyzed through the VOSViewer program. This program is used to create maps to visualize bibliometric network data (Wong, 2018). The subject distribution, most cited studies, journal distribution, author distribution, article distribution by years, article distribution by countries, and the map representation of article distribution by countries were created from the articles obtained from the

Scopus database. The table below provides information about the articles included in the study (Table 1).

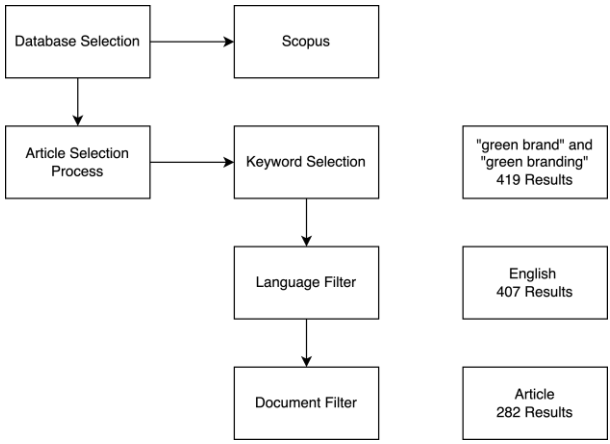

Figure 1. Research Methodology

Description	Results
Time interval	2008:2024
Articles	282
Average Age of Articles	4.87
Average citations per article	25.94
Keywords	829
Number of authors	690
Single author article	40
Co-authors per Article	2.91
International co-authorships %	27.3

Table 1. Information about Articles

It is seen that the average citation of the articles on green brand in Scopus is 25.94, the number of authors is 690, 40 of the studies have single author, and 829 keywords are identified.

4. Findings

Figure 2 shows the distribution of articles by years. As can be seen from the figure, it is seen that the number of articles has increased over the years. It can be concluded that companies and countries have turned towards environmental practices due to the fact that environmental concerns have found a response in society over the years, and that researchers have increased their interest in green marketing. It has been observed that the rate of increase in the studies on the green brand has increased especially between 2021-2022.

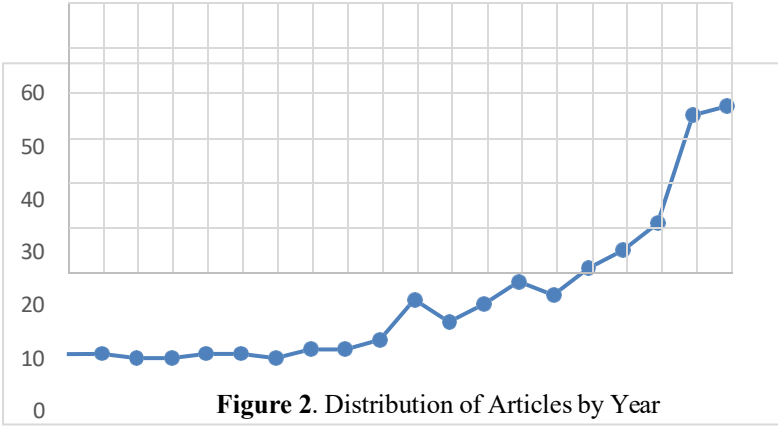

Figure 2. Distribution of Articles by Year

Figure 3 shows the journals in which the articles were published. Sustainability (Switzerland) is the journal in which green brand studies have been published the most. Reasons such as the fact that this journal publishes monthly issues and that

the referee evaluation processes are fast may have affected the number of articles published.

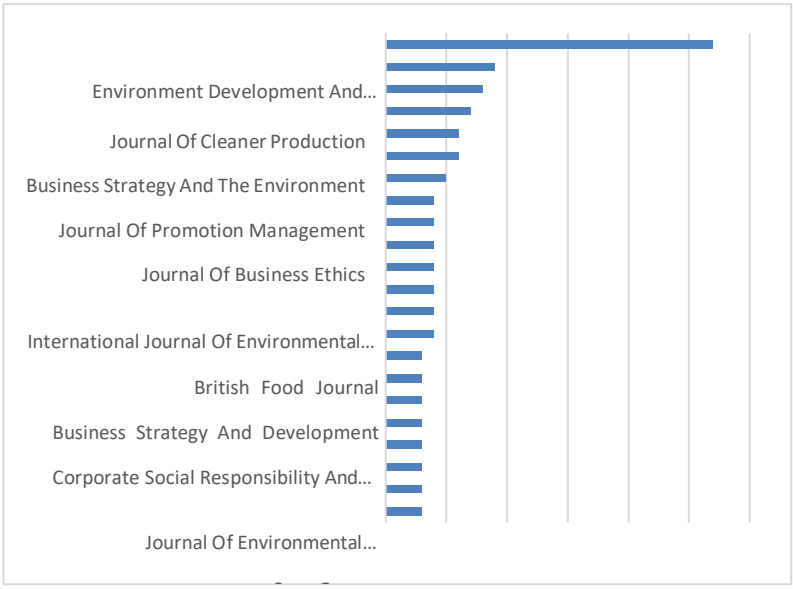

Figure 3. Journal Distribution

Table 2 shows the most cited studies on green branding. It is seen that Yu-Shan Chen's article (2010) has the highest number of citations. In this study, green satisfaction, green trust and green brand value scales were created and the model was tested using these scales. When the works citing this study are examined, these scales are the reason for the intensive citation. The fact that the studies before the publication date were mostly qualitative may have directed the researchers to Chen's article.

Table 2. Most Cited Studies

Author	Title	Year	Citation
Yu-Shan Chen	"The drivers of green brand equity: Green brand image, green satisfaction, and green trust"	2010	748
Patrick Hartmann, Vanessa Ibáñez Apaolaza, Javier F. Sainz Forcada	"Green branding effects on attitude: functional versus emotional positioning strategies"	2005	296

Nevil S. Gandhi, Shashank J. Thanki, Jitesh J. Thakkar	"Ranking of drivers for integrated lean-green manufacturing for Indian manufacturing SMEs"	2018	227
Arpita Khare	"Antecedents to green buying behavior: A study on consumers in an emerging economy"	2015	211
Hashim Zameer, Ying Wang, Humaira Yasmeen	"Reinforcing green competitive advantage through green production, creativity and green brand image: Implications for cleaner production in China"	2020	208
Norazah Mohd Suki	"Green product purchase intention: impact of green brands, attitude, and knowledge"	2016	203
Young Namkung, SooCheong Shawn Jang,	"Effects of restaurant green practices on brand equity formation: Do green practices really matter?"	2013	187
Tapan Kumar Panda, Anil Kumar, Suresh Jakhar, Sunil Luthra, Jose Arturo Garza- Reyes Ipek Kazancoglu, Sonali Sitoshna Nayak	"Social and environmental sustainability model on consumers' altruism, green purchase intention, green brand loyalty and evangelism"	2020	177
Patrick Hartmann, Vanessa Apaolaza Ibáñez	"Green value added"	2006	143
Jialing Lin, Antonio Lobo, Civilai Leckie	"The role of benefits and transparency in shaping consumers' green perceived value, self-brand connection and brand loyalty"	2017	128
Seongho Kang, Won-Moo Hur	"Investigating the Antecedents of Green Brand Equity: A Sustainable Development Perspective"	2012	128

Young Namkung, Soocheong Jang	"Are Consumers Willing to Pay more for Green Practices at Restaurants?"	2017	127
Ian Phau, Denise Ong	"An investigation of the effects of environmental claims in promotional messages for clothing brands"	2007	110
Yi-Chun Huang, Minli Yang, Yu-Chun Wang	"Effects of green brand on green purchase intention"	2014	100
Pui Fong Ng, Muhammad Mohsin Butt, Kok Wei Khong, Fon Sim Ong,	"Antecedents of Green Brand Equity: An Integrated Approach"	2014	100

Figure 4 shows the distribution of researchers conducting green brand studies. According to this, Sharma (6 articles), Guo (6 articles) and Lin (6 articles) are the authors who have the most studies in this field.

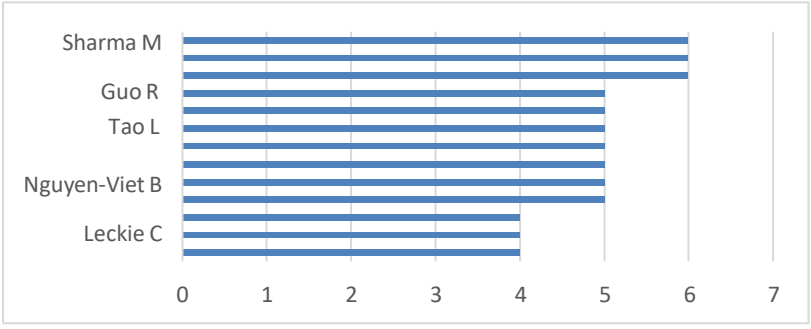

Figure 4. Author Distribution

Figure 5 shows the distribution of publications by country. The People's Republic of China was found to be the country with the highest number of publications. It is followed by India, Pakistan, Taiwan, Taiwan, and the USA, respectively. The reason why China ranks first may be that it is one of the countries with the highest environmental pollution in the world.

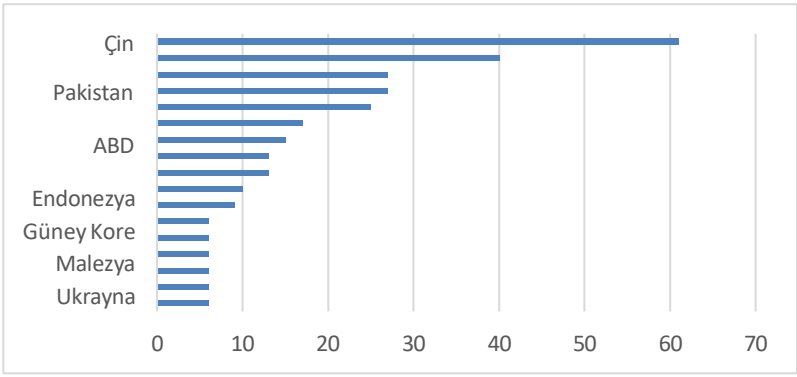

Figure 5. Distribution of Articles by Country

According to the 2022 Environmental Performance Index, India ranks 180th, Vietnam 178th, Pakistan 176th, Indonesia 162nd, and China 160th (EPI, 2022). It seems reasonable that the countries with the worst environmental performance have the most green branding efforts. Researchers may have focused on offering solutions to improve environmental performance based on environmental pollution, which is the main problem they face in their countries.

Figure 6. Distribution of Articles by Country on the Map

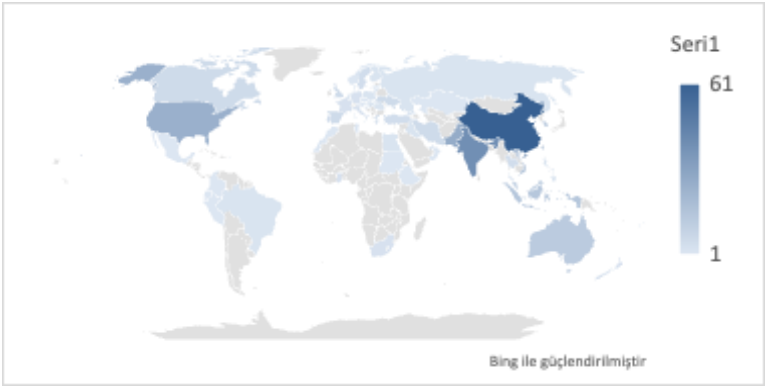

Figure 6 shows the distribution of articles by country on a map. The darker the blue color in the figure, the more active the publishing country is. It has been observed that especially Asian countries show more interest in research on green brand. It is noteworthy that there are more studies on green brand in countries close to China. The reason for the high number of studies on green branding in countries close to China may be that the negative externalities created by China's activities are clearly felt by the nearby countries. Therefore, it may have increased the interest of researchers in these countries.

Table 3. Institutions with the Most Studies

Institution	Number of Articles
Swinburn University of Technology	13
Wuhan University of Technology	12
Shenzhen University	11
National Yunlin University of Science and Technology	9
Sumy State University	9
China University of Earth Sciences	7
Comsats University Islamabad	7
Iqra University	7
Ho Chi Minh City University of Economics	7
Kashmir University	7

Table 3 shows the names of the universities that have conducted the most studies on green branding. Accordingly, Swinburn University of Technology is the university with the highest number of green brand studies. It is seen that predominantly Chinese universities have conducted the most studies on green branding.

4.1. Keyword Analysis

Among the 829 words in 282 articles obtained from the Scopus database, it was determined that the 5 most frequently mentioned words were "green marketing", "green brand", "green brand equity", "green brand image" and "green purchase intention". As a result of the analysis, the first 11 keywords and the frequency of occurrence of these words are shown in Table 4.

Table 4. Keywords in All Publications, Top 11 Words

Keywords	Occurences
green marketing	41
green brand	39
green brand equity	39
green brand image	37
green purchase intention	31
green trust	25
green brand loyalty	23
sustainability	18

green brand positioning	17
green brand trust	15
green satisfaction	13
greenwashing	13
green advertising	12

Three of the most frequently mentioned words (green brand, green brand equity, green brand image) are sub-dimensions of green brand, while "green marketing" is a field that covers green brand. It is seen that researchers frequently associate green brand with "green purchase intention".

Figure 7. Word Cloud

Figure 7 shows the word cloud of the green brand concept. According to the figure, the concepts of green marketing, green trust, green brand image, green brand value come to the fore. Since it is a sub-dimension of green marketing, it seems reasonable to position green marketing in the word cloud of the green brand concept in a large and central place. In particular, it is noteworthy that the concepts of green brand value and image are concepts related to consumer perceptions and are positioned in the center of the word cloud.

4.2. Keyword Clustering Analysis

Using 829 keywords from 282 articles, a cluster analysis was conducted with the VosViewer application. In the analysis, the threshold for keywords to appear together was set as 5 and 26 words were included in the analysis. According to these criteria, the result of the common word analysis showed 5 different clusters and each of these clusters represented the main research areas related to the green brand (Figure 8.). It was seen that the keywords at the center of green brand are "green brand", "green marketing", "green purchase intention", "green trust". Green brand is a sub-dimension of green marketing, its effect on green purchase intention is often examined, and its relationship with green trust is investigated.

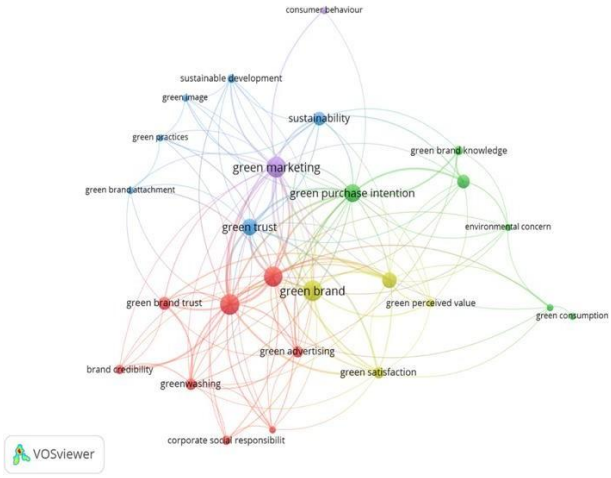

Figure 8. Visualization of the Green Brand Concept

The results obtained from VOSViewer application such as the words in 5 different clusters formed as a result of keyword clustering analysis, the number of links, link strength and frequency of occurrence of these words are given in Table 5-9.

Table 5. Clustering Results - Words in Cluster 1

Cluster 1	Number of Connections	Connection strength	Frequency
brand credibility	7	13	8
corporate social responsibility	6	9	9
green advertising	10	19	12
green brand equity	19	79	39
green brand image	19	66	37
green brand trust	9	20	15
greenwashing	13	24	13
vietnam	10	14	5

Table 2 shows the number of links, link strength and frequency of occurrence of the words in cluster 1. It is seen that the cluster covers concepts related to image, value and trust. It was determined that the connection strength, number of connections, and frequency of occurrence of the concept of "green brand value" were higher than the other concepts in the cluster. Accordingly, the majority of the studies were conducted on this concept and the relationships related to this concept attracted the attention of researchers. The concept of "Vietnam" was found to have the lowest link strength, number of links and frequency of occurrence in the cluster.

Table 6. Clustering Results - Words in Cluster 2

Cluster 2	Number of Connections	Connection strength	Frequency
environmental concern	7	8	5
green brand knowledge	5	13	8
green brand positioning	9	20	17
green consumption	1	1	5
green purchase intention	20	57	31
sustainable consumption	7	8	5

Table 6 shows the number of links, link strength and frequency of occurrence of the words in cluster 2. Accordingly, it is seen that many concepts in this cluster are related to consumption and purchasing. It was determined that the link strength, number of links, and frequency of occurrence of the concept of "green purchase intention" were higher than the other concepts in the cluster. Accordingly, the majority of the studies were conducted on this concept, and researchers may have focused more on understanding the relationship between this concept and green brand. It is seen that researchers are less interested in the concept of "green consumption". It has been determined that the concept of "green consumption" has the lowest connection strength, number of connections and frequency of occurrence in the cluster.

Table 7. Clustering Results - Words in Cluster 3

Cluster 3	Number of Connections	Connection strength	Frequency
green brand attachment	6	7	5
green image	6	7	5
green practices	6	7	5
green trust	15	52	25
sustainability	10	20	18
sustainable development	8	12	7

Table 7 shows the number of connections, connection strength and frequency of occurrence of the words in cluster 3. It has been determined that the link strength, number of links, and frequency of occurrence of the concept of "green trust" are higher than the other concepts in the cluster. It was observed that the researchers were less interested in the concepts of "Green Brand Engagement", "Green Image" and "Green Practices".

Table 8. Clustering Results - Words in Cluster 4

Cluster 4	Number of Connections	Connection strength	Frequency
green brand	15	44	39
green brand loyalty	13	33	23
green perceived value	8	12	6
green satisfaction	11	32	13

Table 8 shows the number of links, link strength and frequency of occurrence of the words in cluster 4. It is seen that this cluster is a cluster emphasizing environmental values and reflecting the consumers' perspective and perceptions of the product. It was determined that the connection strength, number of connections and frequency of occurrence of the concept of "green trust" were higher than the other concepts in the cluster. It was observed that the researchers were less interested in the concept of "Green perceived value".

Table 9. Clustering Results - Words in Cluster 5

Cluster 5	Number of Connections	Connection strength	Frequency
consumer behavior	2	4	5
green marketing	22	75	41

Table 9 shows the number of links, link strength and frequency of occurrence of the words in cluster 5. It was observed that the researchers included green marketing and consumer behavior as common in the studies on green brand.

5. Conclusion

Green branding is a concept that addresses businesses' sensitivity to the environment as a value proposition to consumers (Braimah, 2015; Lee and Chen, 2019). Green brands place a high priority on minimizing their negative impact on the environment in all aspects of their business operations, including raw material sourcing, production procedures, packaging, distribution and disposal. This concept is based on the marketing of various environmental activities and practices to consumers by creating a visible impact on industrial products and services (Sarmiento-Guede et al., 2021; Cuesta-Valin et al., 2021). Looking from the past to the present, it is seen that environmental sensitivities are increasing on the basis of consumers, organizations and countries (Ziabina and Dzwigol-Barosz, 2022). It is observed that this sensitivity is also reflected in academic studies, and the number of articles on the concept of green brand has been increasing rapidly.

In this study, the concepts related to the green brand were identified and the information resulting from academic activities related to this concept was

examined by applying bibliometric analysis. As a result of the bibliometric analysis of the green brand, it was determined that the number of studies has increased over the years, the journal with the highest number of publications is Sustainability, the study by Yu Su Chen in 2010 received the highest number of citations, the most studies were produced in China, the most frequently mentioned keyword is green marketing, and the authors who conducted the most studies are Sharma, Guo and Lin.

As a result of the cluster analysis conducted with keywords related to green brand, it was determined that the key clusters were divided into five different clusters. It was determined that one cluster was formed with concepts such as brand, image and value, one cluster focused on concepts related to consumption and purchasing, and one cluster focused on concepts related to consumer perception. A visual map of the green brand concept was created, and it was seen that the main concepts in this map were green brand, green marketing, green purchase intention and green trust. It is evaluated that the relationship of this concept with green brand trust, green laundering and green advertising is less evaluated and that increasing the studies on the effects of these concepts can fill the gaps in the literature.

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CHAPTER 6

The Relationship between Profitability Ratios and Return Rate of Companies Operating in the BIST Textile and Leather Sector

Ahmet Karaca[1]

INTRODUCTION

The textile industry ranks among the most productive and export-focused sectors in both advanced and developing economies. However, intense competition, high inventory costs, rapid demand shifts, and intense competitive pressures create financial vulnerabilities for companies. This vulnerability makes managing the balance between risk and profit especially important. Economic research shows that the industry faces greater volatility than other manufacturing sectors, both in market and financial risk. As a result, analyzing profitability and financial risk data in the textile industry is crucial for investors, policymakers, and regulators regarding policy interest rates.

In recent years, crises affecting the global economy and long-term issues such as climate change have led to a search for alternatives to advanced international cooperation. At the same time, geopolitical tensions, such as the ongoing uncertainty between Russia and Ukraine, have slowed progress. After weak global growth in 2022, signs of recovery are appearing in 2023. Throughout 2022, global growth slowed significantly in both developed and emerging markets. The sharp increase in energy prices following the Russia-Ukraine conflict, combined with already high prices in 2021, considerably drove up inflation and reduced household net incomes. Despite these hurdles, leather and leather product production grew, reaching record levels in 2022—the sector sources about 70% of its raw leather through imports. The ratios for small and large livestock are roughly 75% and 40%, respectively. Turkey ranks as the world's third-largest importer of small ruminant hides (ham, tanned, or intermediate-dried sheep/lamb breeds), after China and Italy (Textile, Apparel and Leather Sectors Report, 2022).

Leather product exports and imports are mainly driven by producing countries such as Germany, Russia, Italy, and the USA. In terms of leather product exports, China, Italy, Vietnam, and Indonesia are the top importers. The textile, leather, and leather industry sectors are vital to the country's economy, helping reduce the trade deficit. Total exports from these sectors reached $36.4 billion in 2022, making up about 15% of the country's total exports. Turkey's textile exports, which totaled $16.2 billion in 2021, declined by 2.25% to $15.8 billion in 2022, making Turkey the 4th-largest exporter worldwide with a 4% share of the global textile market. Ready-made garment exports grew by 6.4% in 2022 compared to 2021, reaching $19.5 billion, accounting for a 3.5% share of the global market, and placing Turkey as the 6th largest exporter of ready-made garments worldwide. Leather and leather product exports increased by 18.2% in 2022, totaling $2.25 billion. Turkey holds a 0.72% share of this sector and ranks 19th among exporting countries.

In Turkey, the textile and leather processing (THD) sectors are impacted by energy costs and commodity prices such as cotton and petroleum products. Rising prices for these commodities increase production costs and expenses. There is a need for measures to ensure the supply of natural fibers and leather for the THD sectors, and the effects of production are being closely monitored. In other textile dyeing and finishing operations, dye and chemical costs are the main expense components. In dyeing and finishing, energy costs constitute a larger share compared to the overall textile sector and the ready-made clothing, leather, and leather products sectors. In the ready-made clothing sector, fabric is the primary raw material cost, while in the leather and leather products sectors, it is raw and processed leather. The THD sectors play an essential role in the Turkish economy in terms of production volume, export potential, and employment. The sector has a unique global position thanks to its quality products, trend-setting designs, and advanced technology. It ranks among the top sectors in Turkey and worldwide in terms of contribution to GDP and domestic input use. The textile, garment, and leather sectors are highly interconnected. Growth in these sectors is essential for increasing income, promoting gender equality, and expanding women's employment. Together, these sectors account for 29% of manufacturing industry employment, with 53% of those employed in the garment sector being women. Additionally, 31% of women working in manufacturing are employed in the garment sector (Textile, Garment, and Leather Sectors Report, 2022).

The textile and leather industries play a vital role in a country's industrial growth. Investments in these sectors promote the adoption of new technologies to enhance production and boost efficiency. These sectors are among the primary channels through which advanced technologies like automation, robotics, and digitalization enter the national economy. The aim, driven by the sector's importance, is to analyze how economic profitability ratios affect share return rates in the BIST Textile and Leather Index. The relationship between Return on Sales (ROS), Return on Assets (ROA), Return on Equity (ROE), and the work-to-earnings ratio (GO) in listed companies was examined using panel data regression analysis. This study calculated profitability ratios for the variables using 12 years of financial statement data (2013-2024) from the textile and leather industries. Share return rates were determined by dividing the year-end share prices by the previous year's prices. This research is unique and distinguished because it offers a comprehensive understanding of the relationships among variables, including an analysis of long-term data. The study utilizes 13 years of financial data from each of the 15 companies in the textile and leather sectors to generate its findings.

1. FINANCIAL PERFORMANCE

The main goal of businesses is to maximize their value, and their managers aim to support this by making sound investment and financial decisions. Profitability is a key metric for understanding how value is created. It depends on profit margins and the efficient and effective use of assets, which are connected to added value and a stable financial structure. Having sufficient liquidity and the ability to repay debts used for investments are essential indicators, and the outlook for this growth is reflected in financial ratios. Information about financial performance can be gathered by systematically analyzing the resources and details in a company's income statements. Financial ratios make it easier to combine changes in financial performance with marketing and financial data summaries (Brealey et al., 2015: 83).

Assessing financial performance is essential to uncover a program's potential and compare it with competitors. Additionally, the economic structure, strengths and weaknesses, and risk and probability assessments clarify financial performance. Companies can use improvements in financial performance to evaluate past periods, inform decisions for future periods, decide on investment and financing strategies, and continually learn from performance data. They can measure performance by analyzing the scientific changes in the data from their regularly published financial statements (Uygurtürk and Korkmaz, 2012: 96).

The influence of macroeconomic growth on financial performance helps decision-making centers plan better and identify potential solutions. Changes in macroeconomic indicators, such as the inflation rate, interest rate, and exchange rate, reflect the flexibility of the financial system (Aydeniz, 2009: 264).

From a marketing perspective, they reach markets by satisfying customers more efficiently and effectively than their competitors. The concepts of efficiency and effectiveness are applied precisely in this way. Effectiveness measures how well customer needs are met, while efficiency assesses how economically viable business conditions are while meeting those needs. This distinction emphasizes that performance depends not only on two basic delay times but also on internal and external factors influencing specific courses of action. For instance, high product reliability, a quality-related performance dimension, can lead to increased customer satisfaction. Regarding efficiency, an increase in failures and warranty replacements can lead to higher costs incurred (Neely and Gregory, 1995: 80).

Therefore, a person's level of performance depends on the range and effectiveness of higher-level functions, and thus:

•Performance can be perceived as the process of the action taking place and the results of its effectiveness.

•Performance pricing can be taken as a measure used for the execution of an action.

•A performance measurement system is a set of criteria used to evaluate both the results and effectiveness of processes. As these definitions demonstrate, performance remains a broad topic (Neely and Gregory, 1995: 80).

A significant number of investors and analysts have begun to focus on how financial performance affects the value of sustainable growth, such as return on assets (ROA), return on equity (ROE), and profitability ratio (ROS) (Johnson and Soenen, 2013: 365-366). At the same time, other potential indicators for improvement, like advertising expenditure, research and development expenditure, cash conversion ratio, and earnings manipulation, are also being considered (Iyakaremye, 2015: 9). Many studies on business performance have examined how financial performance impacts different organizations (Tafri et al., 2009: 1321).

2. LITERATURE

Akkaya (2008) uncovers cause-and-effect relationships between randomly selected variables of capital structure, assets, and profitability from the leather-textile sector, whose shares were traded on the Istanbul Stock Exchange (ISE) between 1997 and 2006. In the study, Tobin's Q and leverage ratios were used as indicators of business performance, and the explanatory power of the other identified independent variables for these two measures was highlighted. The analysis revealed a positive and significant relationship between Tobin's Q ratio and the beta, mdv, and scale variables. In contrast, a negative and significant relationship was found with the growth variable. It was observed that an increase in the business's systematic risk (beta) led to higher excess profitability and a higher market performance of profitability. Additionally, an increase in market value raised Tobin’s Q levels, which in turn drove up the company's stock price.

In Turkish literature, Ezin (2022) presents a comparative analysis of the overall situation in the 13th-century textile manufacturing industry, focusing specifically on the TCMB sector's financial statements for 2009-2020. The study examines liquidity, economic structure, activity, and profitability ratios in both the primary manufacturing sector and the textile sub-sector. Additionally, entropy and TOPSIS analyses are conducted to evaluate the performance of 13 BIST textile, clothing, and leather sector companies from 2019 to 2021. The ratio analysis results indicate that the textile manufacturing sector's conversion of inventories to cash and the collection of receivables are below the sector averages. The entropy analysis highlights the significance of profitability and financial structure ratios as key criteria. The TOPSIS analysis concludes that BOSSA has

maintained the highest performance over the years, while HATEKS and KORDS show the lowest.

Koçyiğit (2023) examined the financial processes of textile trading on the Istanbul Stock Exchange during 2017–2021 using Data Envelopment Analysis and found that market efficiency was particularly influenced by short-term debt ratios and asset turnover ratios. The analysis used input-focused (CCR) and (BCC) Data Envelopment Analysis models, along with the Scaling Efficiency (SE) technique. The study identified efficient and inefficient combinations based on the analysis results.

Similarly, Şeyranlıoğlu (2025) conducted a ranking of financial performance and portfolio composition in the textile and leather sectors using Multi-Criteria Decision-Making methods. The findings showed that average market rates and profitability ratios together influenced performance. This study examines the financial performance of 22 companies operating in the textile, apparel, and leather sectors on the Istanbul Stock Exchange (BIST) from 2019 to 2023, using the MPSI (Modified Preference Selection Index) and RAPS (Ranking Alternatives Based on Environment Similarity) methods. While the weights for the criteria are determined using the MPSI, the financial performance rankings are expanded using the RAPS method. According to the MPSI criteria, the most significant losses are net profit margin, debt/equity ratio, and net operating profit margin. In contrast, the least important are the current ratio, acid-test ratio, cash ratio, and inventory turnover ratio. Based on the RAPS method, BLYCT, RUBNS, ARSAN, and SNPAM are among the best-performing companies, while SKTAS, BRKO, MNDRS, RODRG, DAGI, KORDS, and ATEKS are among the worst-performing.

Elden Ürgüp (2021) examined the relationships between financial performance and payment transactions based on the financial statements of companies operating in the textile, clothing, and leather sectors listed on the Istanbul Stock Exchange (BIST) from 2015 to 2020. In the first phase of the three-phase analysis, the brightness weights of the selected criteria were determined using the SWARA method; in the second phase, the performance ranking was calculated using the MARCOS method; and in the final phase, the relationship between the performance scores from the evaluation model and payment transactions was analyzed. SNPAM was identified as a successful company according to the performance evaluation model for 2015, 2016, 2017, and 2018. Based on the correlation analysis, no significant relationship was found between payment returns and financial performance across the years, except in 2020.

Akgün (2022) performed an internal analysis of the profitability of firms within the Istanbul Stock Exchange (BIST) Textile and Leather Index. This study covered 17 of the 20 firms in the index for which financial data from 2013 to

2021 were available. Asset transfer was identified as the independent variable, along with 11 other financial or independent variables, including short-term debt repayment capacity, capital adaptability, characteristics, and size. The analysis, conducted through panel regression, revealed that operating profit margin, asset-to-working capital ratio, asset turnover ratio, inventory turnover ratio, and accounts receivable turnover ratio positively influenced profitability. In contrast, the economic leverage ratio, debtor/equity ratio, and current ratio also contributed to increased profitability.

Yıldırım (2022) conducted a two-stage System GMM analysis of annual financial data from 20 textile companies listed on the Istanbul Stock Exchange (BIST) between 2013 and 2020 to identify factors influencing profitability in the textile, clothing, and leather (TGD) sector. The analysis showed ongoing correlations among profitability and lagged profitability, the financial leverage ratio, firm capacity, economic growth, manufacturing industry capacity utilization rate, and the inflation rate. It indicated that lagged profitability, firm size, economic development, and inflation positively affected profitability, while financial leverage and interest accumulation negatively affected profitability.

Akusta and Gün (2025) assess the effectiveness of meta-models in predicting financial distress within the Turkish textile industry. The study uses a meta-model built on economic data from 2013 to 2023, incorporating K-Nearest Neighbors (KNN), Ridge, Random Forests, Gradient Boosting Machines (GBM), and Support Vector Machines (SVM) as baseline models, with XGBoost as the meta-learner. The results indicate that the meta-model surpasses an independent XGBoost classifier, especially in reducing false negatives and low downgrades, which are vital for early detection of financial trouble. However, the study also notes challenges in interpretation due to model selection bias, the complexity of hyperparameter tuning, and fragmentation within the approach. The findings emphasize the potential of the meta-model for sector-specific financial risk forecasting and suggest avenues for improving model transparency and generalization.

Waheed et al. (2025) examined the profitability of the Pakistani textile industry, focusing on firms traded on the Pakistan Stock Exchange, and how profitability measures like net profit margin (ROS), return on assets (ROA), and return on equity (ROE) are influenced by variables such as cash flow, brightness cycle, firm speed, and current ratio. The analysis used panel data from 76 textile companies from 2018 to 2022 and applied random-effects models. The results indicate that leverage significantly impacts ROA and ROE, and that holding less cash benefits ROA and ROS, while longer cycles improve ROE. ROE cycles are not affected by negative factors, and neither ROA nor ROS is impacted.

Yaşar (2020) examines the financial performance of 20 textile companies listed on the Istanbul Stock Exchange (BIST) using 17 financial ratios for the years 2016, 2017, and 2018. Data were collected from documents and income statements published on the Public Disclosure Platform (KAP) using the AHP, TOPSIS, VIKOR, and BORDA methods. AHP was employed to assign weights to the main and sub-criteria, while TOPSIS and VIKOR were used to rank the companies' financial performance. According to the BORDA method, the companies with the best financial performance were YATAS in 2016, KORDS in 2017, and DESA in 2018.

3. DATA AND METHODS

This study aims to evaluate profitability ratios for the BIST Textile and Leather Index and analyze share price trends. The relationship between profitability ratios and share price trend ratios was examined using panel data regression analysis. Profitability analysis of the companies was conducted with Return on Sales (ROS), Return on Assets (ROA), and Return on Equity (ROE). At the same time, the share transfer ratio (RR) was calculated as the natural logarithm of the ratio of the year-end share price of the buildings to their previous period's holding price. Panel data regression analysis was used to assess the variables, with the variables listed in Table 1 included as both independent and dependent variables.

Table 1. Dependent and Independent Variables

Dependent Variable Stock Rate of Return (RR)
Independent Sellers Return on Sales (ROS), Return on Assets (ROA) and Return on Equity (ROE)

The company's stock return has been calculated as the logarithm of its return. Logarithmic return change series are determined by taking the natural logarithm of the price increase during a specific period, divided by the price level of the previous period. The time series are computed as follows (Azim et al. 2015, p. 69; Özdemir, 2011):

$$R_t = \ln\left(\frac{Pt}{Pt-1}\right) \qquad (1)$$

The financial performance of the businesses was calculated using profitability ratios derived from financial statement data from 2011 to 2020. The ratios used

include Return on Equity (ROE), Return on Assets (ROA), and Profitability from Sales (PSC).

Return on Equity: Net Profit/Equity (2)

Return on Equity (ROE) is calculated by dividing net profit by equity. This ratio measures the return generated on the shareholders' invested capital. It reflects the net profit after tax that shareholders receive in exchange for their investment.

Return on Assets: Net Profit/Total Assets (3)

Return on assets is calculated by dividing net profit by total assets. This ratio shows how effectively an investment's profitability and allocation are managed.

Sales Profitability: Net Profit/Net Sales (4)

Profitability from sales is determined by dividing net profit by net sales. This ratio measures the profit margin earned from sales. It reflects the net return after taxes on each unit of sales generated by the business.

Based on the research goal, the following hypotheses were formulated:

H1 = There are relationships between companies' profitability ratios and stock return rates.

The panel data regression model is described with freedom number 3 (Gujarati, 2006, p. 219; Das, 2019, p. 43).

$$Y_{it} = \alpha_{it} + \beta_{kit} X_{kit} + \mu_{it} \quad (5)$$

Here, Y is the dependent variable, X *is the independent variable*, α *is* the constant parameter, β *is* the slope parameter, and μ *is* the error term.

I subscript time,

The subscript 't' indicates time (Altunışık 2010; Tafri vd. 2009).

Table 2. BIST Textile and Leather Sector Companies Featured in the Research

No	Code	Company Name
1	ARSAN	ARSAN TEKSTİL TİCARET VE SANAYİ A.Ş.
2	BLCYT	BİLİCİ YATIRIM SANAYİ VE TİCARET A.Ş.
3	BOSSA	BOSSA TİCARET VE SANAYİ İŞLETMELERİ TAŞ.
4	DAGI	DAGİ GİYİM SANAYİ VE TİCARET A.Ş.
5	DERIM	DERİMOD KONFEKSİYON AYAKKABI DERİ SANAYİ VE TİCARET A.Ş.
6	DESA	DESA DERİ SANAYİ VE TİCARET A.Ş.

7	HATEK	HATEKS HATAY TEKSTİL İŞLETMELERİ A.Ş.
8	KRTEK	KARSU TEKSTİL SANAYİİ VE TİCARET A.Ş.
9	KORDS	KORDSA TEKNİK TEKSTİL A.Ş.
10	LUKSK	LÜKS KADİFE TİCARET VE SANAYİİ A.Ş.
11	MNDRS	MENDERES TEKSTİL SANAYİ VE TİCARET A.Ş.
12	RODRG	RODRİGO TEKSTİL SANAYİ VE TİCARET A.Ş.
13	SKTAS	SÖKTAŞ TEKSTİL SANAYİ VE TİCARET A.Ş.
14	YATAS	YATAŞ YATAK VE YORGAN SANAYİ TİCARET A.Ş.
15	YUNSA	YÜNSA YÜNLÜ SANAYİ VE TİCARET A.Ş.

Table 2 shows the activities in the BIST Textile and Leather Sector that have been traded for 10 years or more and are included in the analysis.

Table 3. Sales Profitability of Companies in the BIST Textile and Leather Sector

YEARS	ARSAN	BLCYT	BOSSA	DAGI	DERIM	DESA	HATEK	KRTEK
2013	0,09	0,22	0,05	-0,32	0,01	0,02	-0,01	-0,12
2014	0,42	0,12	0,02	0,21	0,02	0,02	0,03	-0,12
2015	0,15	0,17	0,06	0,04	0,03	-0,02	0,02	-0,10
2016	0,09	0,04	-0,02	-0,03	0,02	-0,09	0,15	-0,07
2017	0,17	0,10	0,02	0,00	0,00	0,00	-0,05	0,00
2018	0,06	0,14	0,10	-0,06	0,00	0,02	0,06	0,04
2019	0,20	0,26	0,09	0,04	-0,02	0,04	0,13	0,01
2020	0,40	0,22	0,05	0,07	-0,02	0,01	0,07	0,06
2021	0,55	0,32	0,24	-0,05	0,01	0,11	0,11	0,13
2022	0,24	0,24	0,16	0,03	0,02	0,11	0,05	0,09
2023	2,03	1,15	0,34	0,11	0,01	0,29	-0,29	0,12
2024	6,25	0,06	0,09	-0,05	0,02	0,11	-0,23	-0,19
Mean	0,89	0,25	0,10	0,00	0,01	0,05	0,00	-0,01
Max.	6,25	1,15	0,34	0,21	0,03	0,29	0,15	0,13
Min	0,06	0,04	-0,02	-0,32	-0,02	-0,09	-0,29	-0,19

Table 3. Sales Profitability of Companies in the BIST Textile and Leather Sector (Continued)

YEARS	KORDS	LUKSK	MNDRS	RODRG	SKTAS	YATAS	YUNSA	Mean
2013	0,02	-0,04	0,05	-0,13	-0,26	0,01	0,06	-0,02
2014	0,05	0,13	0,04	-0,10	-0,19	0,03	0,10	0,05
2015	0,06	0,06	-0,08	0,01	-0,11	0,03	0,02	0,02
2016	0,07	0,50	0,00	0,00	-0,12	0,03	-0,14	0,03

2017	0,07	0,03	0,07	0,01	-0,14	0,09	0,05	0,03
2018	0,07	-0,01	-0,06	0,07	-0,20	0,08	0,08	0,03
2019	0,07	0,12	-0,01	0,06	-0,05	0,07	0,01	0,07
2020	0,03	0,07	-0,05	-0,07	-0,19	0,10	0,03	0,05
2021	0,10	0,27	-0,12	-0,08	0,01	0,09	0,08	0,12
2022	0,07	0,21	0,13	0,02	-0,07	0,04	0,15	0,10
2023	0,01	0,51	0,25	0,31	-0,01	0,07	0,36	0,35
2024	-0,04	-0,15	0,00	0,00	-0,26	0,01	0,02	0,38
Mean	0,05	0,14	0,02	0,01	-0,13	0,05	0,07	
Max.	0,10	0,51	0,25	0,31	0,01	0,10	0,36	
Min	-0,04	-0,15	-0,12	-0,13	-0,26	0,01	-0,14	

Table 3 shows that among the 15 companies with the highest sales profitability ratios, ARSAN ranked first with 0.89, BLCYT second with 0.25, and LUKSK third with 0.14. On an annual basis, the highest average sales profitability ratios were recorded in 2024 (0.38) and 2023 (0.35), while the lowest values were recorded in 2015, 2016, 2017, and 2018 (0.02 and 0.03). Although a recovery was observed in 2019, the pandemic led to another decline in 2020.

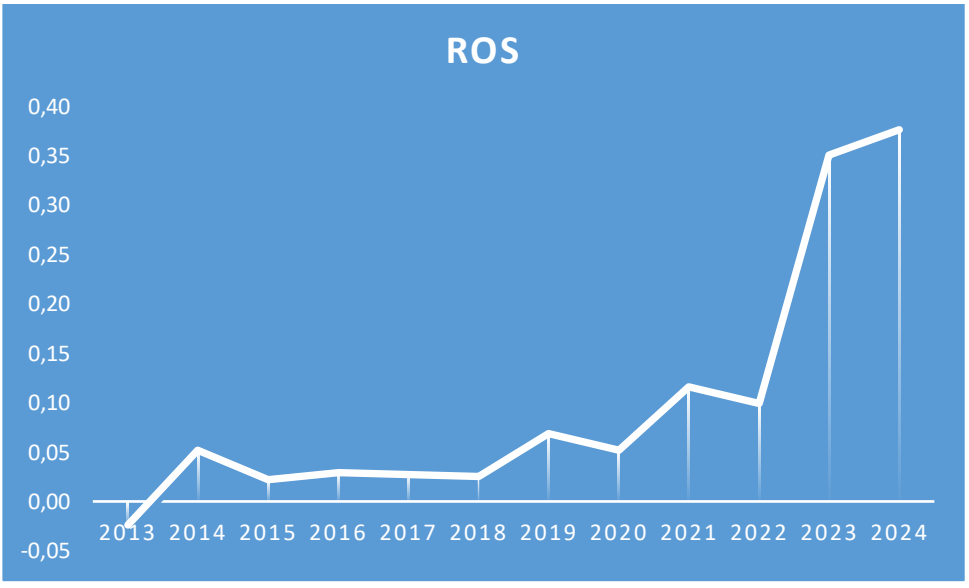

Figure 1. Average Annual Sales Profitability of Companies in the BIST Textile and Leather Sector

Figure 1 shows that the average profitability of sales by year was low in 2015, 2016, 2017, and 2018. Still, in 2019, the textile sector's turnover reached its highest level in the history of the manufacturing industry. The 2019

manufacturing industry turnover calendar showed an increase compared to 2018. In 2020, our sector's foreign trade experienced a revival in January, February, and March due to the shift in the order cycle to China; however, as the pandemic spread globally and buyers canceled their orders, exports declined towards the end of March (Sector Reports - 2020). As a result of these events, high levels were observed in 2023 and 2024.

In 2014, the global economic slowdown also contributed to a decline in the annual stability of Turkey's total exports. In 2015, developments in international monetary policy, geopolitical developments, the Syrian civil war, and the fragile state of external demand continued to pose risks to the recovery process. The internal conflict in Ukraine at the beginning of 2014 and the negative economic impact on Russia, one of the parties to the conflict, the decline in commodity prices in 2015, the depreciation of the Ruble, followed by the plane crisis (November 2015), and the explosion in Russia from Turkey negatively affected the sector. Similarly, the Ukrainian market was also negatively impacted. In response to these developments in Russia, the leather products sector carried out intensive work in 2015 through trade delegations to continue diversifying its market. Alternative routes were identified for the traditional Russian market, and different geographical regions were added. Increasing geopolitical instability, the pandemic, the climate crisis, and rising energy prices strengthen the long-term sustainable growth regime. The transition to a sustainable, resilient, and inclusive economic model, coupled with digital and green transformation, demonstrates the need for ambitious investments and financial reforms (Sector Reports - 2022).

Table 4. Return on Assets of Companies in the BIST Textile and Leather Sector.

YEARS	ARSAN	BLCYT	BOSSA	DAGI	DERIM	DESA	HATEK	KRTEK
2013	0,05	0,07	0,02	-0,18	0,02	0,02	-0,01	-0,09
2014	0,16	0,06	0,01	0,13	0,02	0,03	0,02	-0,06
2015	0,06	0,07	0,03	0,03	0,03	-0,02	0,02	-0,05
2016	0,04	0,02	-0,02	-0,02	0,01	-0,07	0,05	-0,05
2017	0,08	0,06	0,01	0,00	0,00	0,00	-0,03	0,00
2018	0,03	0,09	0,07	-0,05	0,00	0,03	0,04	0,03
2019	0,09	0,18	0,07	0,03	-0,02	0,05	0,07	0,01
2020	0,16	0,08	0,04	0,03	-0,02	0,00	0,03	0,04
2021	0,25	0,11	0,18	-0,03	0,01	0,07	0,05	0,09
2022	0,12	0,11	0,11	0,02	0,04	0,12	0,03	0,08
2023	0,15	0,19	0,22	0,07	0,02	0,28	-0,11	0,10
2024	0,09	0,01	0,15	-0,01	0,05	0,08	-0,06	-0,12
Mean	0,11	0,09	0,08	0,00	0,01	0,05	0,01	0,00
Max.	0,25	0,19	0,22	0,13	0,05	0,28	0,07	0,10
Min	0,03	0,01	-0,02	-0,18	-0,02	-0,07	-0,11	-0,12

Table 4. Return on Assets of Companies in the BIST Textile and Leather Sector (Continued)

YEARS	KORDS	LUKSK	MNDRS	RODRG	SKTAS	YATAS	YUNSA	Mean
2013	0,02	-0,01	0,04	-0,09	-0,12	0,01	0,06	-0,01
2014	0,04	0,04	0,03	-0,06	-0,10	0,03	0,11	0,03
2015	0,05	0,02	-0,06	0,01	-0,06	0,03	0,02	0,01
2016	0,06	0,10	0,00	0,00	-0,06	0,05	-0,13	0,00
2017	0,06	0,01	0,05	0,00	-0,07	0,13	0,06	0,02
2018	0,06	-0,01	-0,05	0,04	-0,10	0,11	0,09	0,03
2019	0,05	0,06	-0,01	0,05	-0,02	0,09	0,02	0,05
2020	0,02	0,03	-0,04	-0,04	-0,06	0,12	0,03	0,03
2021	0,05	0,09	-0,07	-0,05	0,00	0,12	0,07	0,06
2022	0,05	0,08	0,08	0,01	-0,03	0,06	0,19	0,07
2023	0,01	0,17	0,13	0,14	0,00	0,09	0,22	0,11
2024	-0,03	-0,04	0,00	0,00	-0,15	0,01	0,01	0,00
Mean	0,04	0,05	0,01	0,00	-0,06	0,07	0,06	
Max.	0,06	0,17	0,13	0,14	0,00	0,13	0,22	
Min	-0,03	-0,04	-0,07	-0,09	-0,15	0,01	-0,13	

Table 4 shows the average return on assets for companies in the textile and leather sectors. ARSAN ranked first with an average return on assets of 0.11, followed by BLCYT with 0.09 and BOSSA with 0.08. The lowest return on assets was recorded by SKTAS with -0.06, followed by DAGI, KRTEK, and RODRG with an average of 0.00, and DERİM, HATEK, and MNDRS in third place. Annual return on assets results show the highest average of 0.11 in 2023, but the lowest average of 0.00 in 2024.

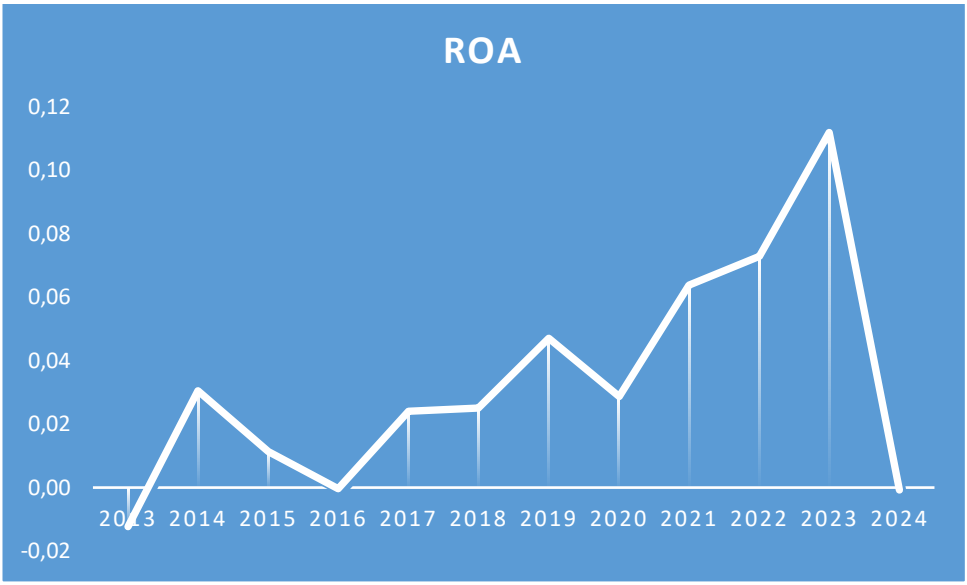

Figure 2. Average Annual Return on Assets of Companies in the BIST Textile and Leather Sector.

The average return on assets ratios shown in Figure 2 clearly illustrate the annual changes in profitability. The highest return on assets ratio was recorded in 2023, while the lowest ratios were observed in 2013, 2016, and 2024. In 2014, the global economic slowdown also contributed to a decline in the annual stability of Turkey's total exports. In 2015, developments in international monetary policy, geopolitical developments, the Syrian civil war, and the fragile state of external demand continued to pose risks to the recovery process. The internal conflict in Ukraine at the beginning of 2014 and the negative economic impact on Russia, one of the parties to the conflict, the decline in commodity prices in 2015, the depreciation of the Ruble, followed by the plane crisis (November 2015), and the explosion in Russia from Turkey had a negative impact. A similar situation occurred in the Ukrainian market.

Table 5. Return on Equity of Companies in the BIST Textile and Leather Sector.

YEARS	ARSAN	BLCYT	BOSSA	DAGI	DERIM	DESA	HATEK	KRTEK
2013	0,09	0,08	0,04	-0,39	0,07	0,05	-0,01	-0,25
2014	0,28	0,09	0,02	0,22	0,08	0,07	0,03	-0,20
2015	0,11	0,12	0,07	0,06	0,14	-0,06	0,03	-0,26
2016	0,07	0,03	-0,03	-0,02	0,08	-0,27	0,08	-0,30
2017	0,09	0,10	0,13	0,00	0,02	0,00	-0,05	-0,02
2018	0,04	0,14	0,42	-0,08	-0,02	0,11	0,06	0,18

2019	0,15	0,21	0,29	0,05	-0,08	0,19	0,09	0,05
2020	0,21	0,09	0,14	0,05	-0,07	0,02	0,05	0,13
2021	0,30	0,13	0,48	-0,05	0,04	0,22	0,09	0,32
2022	0,34	0,21	0,42	0,10	0,29	0,50	0,10	0,44
2023	0,12	0,14	0,23	0,10	0,05	0,31	-0,13	0,12
2024	0,10	0,01	0,07	-0,07	0,18	0,12	-0,13	-0,28
Mean	0,16	0,11	0,19	0,00	0,06	0,10	0,02	-0,01
Max.	0,34	0,21	0,48	0,22	0,29	0,50	0,10	0,44
Min	0,04	0,01	-0,03	-0,39	-0,08	-0,27	-0,13	-0,30

Table 5. Return on Equity of Companies in the BIST Textile and Leather Sector (Continued)

YEARS	KORDS	LUKSK	MNDRS	RODRG	SKTAS	YATAS	YUNSA	Mean
2013	0,03	-0,02	0,09	-0,12	-0,44	0,03	0,21	-0,04
2014	0,07	0,07	0,08	-0,10	-0,52	0,10	0,31	0,04
2015	0,08	0,04	-0,15	0,02	-0,41	0,10	0,06	0,00
2016	0,10	0,18	-0,01	0,00	-0,26	0,16	-0,76	-0,06
2017	0,10	0,02	0,16	0,01	-0,47	0,29	0,23	0,04
2018	0,13	-0,01	-0,29	0,11	-0,58	0,25	0,31	0,05
2019	0,12	0,12	-0,07	0,11	-0,23	0,22	0,06	0,09
2020	0,05	0,06	-0,13	-0,10	-0,27	0,32	0,10	0,04
2021	0,12	0,21	-0,26	-0,10	0,01	0,25	0,26	0,13
2022	0,13	0,29	0,26	0,04	-0,12	0,37	0,95	0,29
2023	0,01	0,17	0,14	0,33	-0,01	0,15	0,21	0,13
2024	-0,06	-0,06	0,00	0,00	-0,28	0,02	0,01	-0,02
Mean	0,07	0,09	-0,02	0,02	-0,30	0,19	0,16	
Max.	0,13	0,29	0,26	0,33	0,01	0,37	0,95	
Min	-0,06	-0,06	-0,29	-0,12	-0,58	0,02	-0,76	

Table 5 shows that, among the companies in the field, BOSSA ranked first with a return on equity of 0.190, YATAS ranked second with an average of 0.189, and YUNSA ranked third with an average of 0.16, all having high return on equity ratios. In 2022, with an average of 0.29, the company generated the most value for its global partners. Between 2023 and 2021, the years with the second-highest profitability were 2023 and 2021; the years with the most significant losses for partners were 2016, 2024, and 2013, respectively.

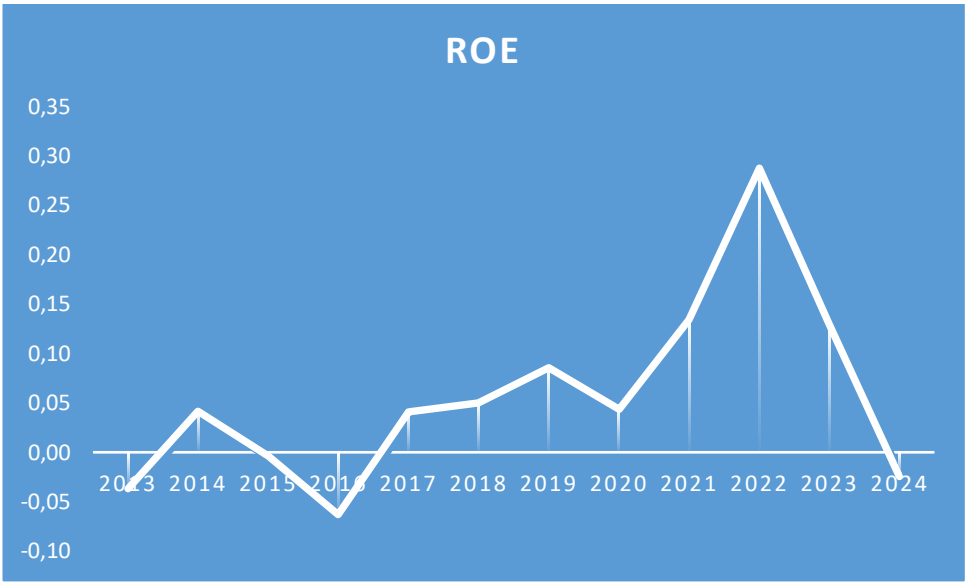

Figure 3. Average Annual Return on Equity of Companies in the BIST Textile and Leather Sector.

Figure 3 clearly illustrates the trends in return on equity over the coming years. The highest return on equity for companies occurred in 2019, 2022, and 2014, while the lowest occurred in 2016, 2024, and 2013, respectively.

Table 6. Return Rates of Companies in the BIST Textile and Leather Sector

YEARS	ARSAN	BLCYT	BOSSA	DAGI	DERIM	DESA	HATEK	KRTEK
2013	1,17	0,50	0,88	0,51	1,49	0,88	0,67	0,53
2014	1,43	1,31	2,43	1,74	1,00	1,57	1,11	1,43
2015	0,70	0,90	0,59	1,80	1,14	0,73	1,08	0,51
2016	1,00	0,97	1,20	0,57	1,24	1,13	1,08	0,86
2017	1,14	1,35	1,58	1,80	0,98	1,11	1,38	4,21
2018	1,00	0,86	1,58	0,55	1,17	1,90	0,77	0,69
2019	2,00	3,08	1,30	1,98	0,78	2,32	1,79	2,50
2020	2,06	1,60	2,00	3,23	1,43	2,27	2,10	2,79
2021	1,39	2,13	2,27	0,32	0,72	0,84	1,13	0,92
2022	3,33	1,41	2,34	2,68	2,54	7,14	2,23	3,72
2023	0,78	0,73	1,14	1,06	1,46	1,44	0,87	0,91
2024	2,35	1,06	1,51	2,28	2,50	1,23	1,18	1,49
Mean	1,53	1,32	1,57	1,54	1,37	1,88	1,28	1,71
Maximum	3,33	3,08	2,43	3,23	2,54	7,14	2,23	4,21
Minimum	0,70	0,50	0,59	0,32	0,72	0,73	0,67	0,51

Table 6. Return Rates of Companies in the BIST Textile and Leather Sector (Continued)

YEARS	KORDS	LUKSK	MNDRS	RODRG	SKTAS	YATAS	YUNSA	Mean
2013	0,71	0,67	0,71	1,48	0,54	0,67	0,77	0,81
2014	1,61	1,83	2,08	0,40	1,69	1,82	1,38	1,52
2015	1,07	0,69	0,62	1,24	0,62	1,68	0,64	0,93
2016	1,37	1,45	1,20	1,48	0,99	2,24	0,71	1,17
2017	1,19	1,21	1,38	1,21	0,87	5,39	1,80	1,77
2018	1,30	0,97	0,88	0,63	0,79	0,55	0,96	0,97
2019	1,29	1,90	1,81	0,98	1,74	1,61	2,35	1,83
2020	1,21	3,33	2,33	7,46	2,30	1,87	1,43	2,49
2021	2,03	1,75	0,70	1,38	0,69	0,83	0,89	1,20
2022	3,07	1,82	4,07	1,85	2,84	3,04	6,91	3,27
2023	0,80	1,94	0,97	1,52	0,90	0,72	1,71	1,13
2024	0,94	1,49	1,18	1,51	1,14	1,13	0,69	1,44
Mean	1,38	1,59	1,49	1,76	1,26	1,80	1,69	
Maximum	3,07	3,33	4,07	7,46	2,84	5,39	6,91	
Minimum	0,71	0,67	0,62	0,40	0,54	0,55	0,64	

The statistics in Table 6 show that the highest recorded stock return rates were achieved by DESA, YATAS, and RODRG, with average stock returns of 1.88, 1.88, and 1.88, respectively. The companies with the lowest stock return rates were SKTAS (1.26), HATEK (1.28), and BLCYT (1.32). The highest stock return rate tracked over the years was 3.27% in 2022, with an average of 2.49%, followed by 1.83% in 2019, with an average of 1.83%.

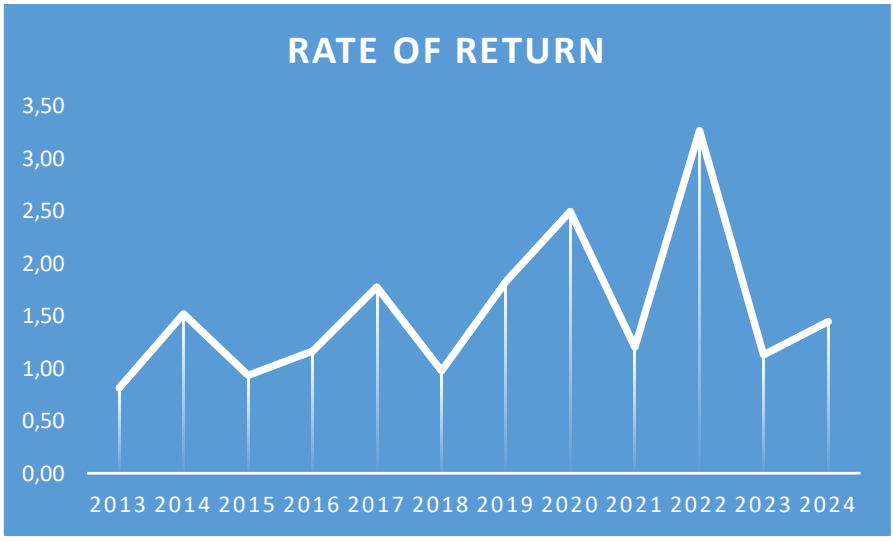

Figure 3. Stock Return Rate of Companies in the BIST Textile and Leather Sector.

Figure 3 shows the trend of stock return rates over the last 13 years, with each change representing a specific pattern. The highest return rates occurred in 2022, 2020, and 2017, respectively, while the lowest rates were recorded in 2013, 2015, and 2018.

4. PANEL DATA ANALYSIS AND FINDINGS

Panel data analysis is a method of examining lists of the same or different units over time. This type of data analysis combines time-series and cross-sectional methods, providing a more comprehensive and dynamic understanding. While panel data incorporates unit variability, additional statistics, reduced prediction bias, multivariate coupling, and more comprehensive estimation, it also presents challenges such as biased estimation of error models, data collection problems, and the generally short time span (Gujarati, 2006, p. 219).
The study's model is expressed by freedom number 6.

The research model;

Model 1 **:** $LOG\_RR_{it} = \beta_0 + \beta_1 ROA_{it} + \beta_2 ROS_{it} + \beta_3 ROE_{it} + \alpha_i + u_{it}$ (6)

LOG_RR_{it} Return Rate

β_0 **:** Constant coefficient

β_{1ROA}: Return on Assets

β_{1ROS}: Return on Sales

β_{1ROE}: Return on Equity

μ_{it} : Error term

The research;

H1 = There is a relationship between companies' profitability and stock return rates.

Table 7. Descriptive Statistics for Variables.

Variables		Mean	Standard Deviation	Min	Max	Number of Observations
logRR	overall	0.27	0.5507	-1.1375	2.0090	N=180
	between		0.0880	0.0928	0.4078	n=15
	within		0.5441	-1.0748	1.9841	T=12
ROS	overall	0.09	0.5086	-0.3213	6.2488	N=195
	between		0.2335	-0.1317	0.8876	n=15
	within		0.4556	-0.7251	5.4607	T=12
ROA	overall	0.03	0.7366	-0.1830	0.2765	N=195
	between		0.0440	-0.0642	0.1077	n=15
	within		0.0600	-0.1617	0.2607	T=12
ROE	overall	0.05	0.2018	-0.7556	0.9546	N=195

between	0.1210	-0.2977	0.1901	n=15
within	0.1642	-0.8623	0.8479	T=12

Table 7 presents descriptive statistics for the variables included in the study. The overall mean for stock return rate (RR) was 0.27 with a standard deviation of 0.5507; the overall mean for return on sales (ROS) was 0.09 with a standard deviation of 0.5086; the overall mean for return on assets (ROA) was 0.03 with a standard deviation of 0.7366; and finally, the overall mean for return on equity (ROE) was 0.05 with a standard deviation of 0.2018. Other detailed information regarding the variables is provided in the table.

Table 8. Driscoll and Kraay Regression Analysis with Standard Errors and Fixed Effects.

logo	*Coef.*	*Std. Err.*	*z-Statistic*	*Prob.*
ROE	1.1434	0.1145	9. 9.98*	0.000
ROS	0.0280	0.0102	2.74*	0.006
ROA	-0.2972	0.2586	-1.15	0.250
Cons	0.2043	0.0281	7.26*	0.000
Wald X^2	401.27			
(3)	0.0000	Number of	180	
Probe > X^2		obs. Number		
	FGLS	of groups	15	
	regression			
Method				

Note : * indicates a significance level of 1%.

When Table 8 is examined Wald X^2 statistic with a probability value of 0.0000 indicates that the model as a whole is significant, while probability values of ROE and ROS variables and the constant coefficient being less than 0.05 indicate that the values taken by these variables are statistically significant.

P =0.2043+1.1434+0.0280+ □□i

The variables included in the model change; a 1-unit increase in ROE results in a 1.1434 increase in the return on equity (RR), and this change is consistently significant. A one-unit increase in ROS results in a 0.0280 increase, which is also significant. The constant coefficient was calculated as 0.2043, and the result is considered important.

5. CONCLUSION AND RECOMMENDATIONS

The research results show that among the textile and leather sectors managed over 15 years, ARSAN ranked first with a profitability ratio of 0.89, BLCYT second with 0.25, and LUKSK third with 0.14. On an annual basis, the highest average sales profitability ratios were recorded in 2024 (0.38) and 2023 (0.35), while the lowest values were recorded in 2015, 2016, 2017, and 2018 (0.02 and

0.03). Although a recovery was observed in 2019, the pandemic led to another decline in 2020.

In the textile and leather sectors. ARSAN ranked first with an average return on assets of 0.11, followed by BLCYT with 0.09 and BOSSA with 0.08. The lowest return on assets was recorded by SKTAS at -0.06, followed by DAGI, KRTEK, and RODRG at 0.00, and DERİM, HATEK, and MNDRS in third place. Annual return on assets results show the highest average of 0.11 in 2023 and the lowest average of 0.00 in 2024. The highest return on assets was recorded in 2023, while the weakest returns were recorded in 2013, 2016, and 2024. The global economic slowdown in 2014 also contributed to a decline in the annual stability of Turkey's total exports. In 2015, developments in international monetary policy, geopolitical events, the Syrian civil war, and the fragile state of external demand continued to pose risks to the recovery process. The internal conflict in Ukraine at the beginning of 2014 and the negative economic impact on Russia, a party to the conflict, the decline in commodity prices in 2015, the depreciation of the Ruble, followed by the plane crisis (November 2015), and the explosion in Russia from Türkiye all had a negative impact, with similar effects on the Ukrainian market.

In the textile and leather sector, BOSSA ranked first with a return on equity of 0.190, followed by YATAS with an average of 0.189 and YUNSA with an average of 0.16. In 2022, with an average return on equity of 0.29, the company generated the most value for its global shareholders. While 2023 and 2021 were among the years with the second-highest profitability, the years with the most significant losses for shareholders were 2016, 2024, and 2013, respectively. The companies with the highest average return on equity were DESA, YATAS, and RODRG, with returns of 1.88. The companies with the lowest average return on equity were SKTAS (1.26), HATEK (1.28), and BLCYT (1.32). The highest average stock return rate tracked over the years was 3.27% in 2022, followed by 2.49% in 2020 and 1.83% in 2019, placing it in third place.

When the results of the panel data regression analysis of the variables included in the study were examined, it was found that there is a positive relationship between return on equity (ROE) and return on sales (ROS) and return rate (RR), and this relationship is statistically significant. However, there is a negative relationship between return on assets (ROA) and return rate (RR), and the result is statistically insignificant. It was observed that a one-unit increase in return on equity (ROE) causes a 1.1434 increase return rate (RR), and this change is statistically significant. A one-unit increase in return on sales (ROS) causes a 0.0280 increase return rate, and this increase is statistically significant. The constant coefficient was calculated as 0.2043, and the result was found to be statistically significant.

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CHAPTER 7

Reasoning Techniques in Large Language Models

Erhan Ustaoğlu[1]

[1] Assoc. Prof. Dr., Marmara University, Management Information Systems
ORCID: 0000-0002-9077-4370

1. Introduction

The question “whether machines can reason” can be traced back to Turing’s seminal work “Computing Machinery and Intelligence” in which he argued against the idea that there are theoretical limits to what any formal system or discrete-state machine can prove or answer. He advocated that while certain questions may exist which the machine cannot answer, this does not necessarily mean the machine is incapable of giving correct answers, which involves more generalized intelligence (Turing, 1950). The question was discussed in terms of mathematics and philosophy thereafter whether human brain could be considered as a machine and hence think as the brain does (Lucas, 1961; Benacerraf, 1967).

Apart from the philosophical debates, many studies were conducted to achieve or mimic human-like reasoning in the field of machine learning in symbolic artificial intelligence era in which the knowledge is encoded using abstract, discrete symbols that stand for objects, concepts, or relationships. Minsky introduced the concept of frames as a key structure for organizing knowledge in AI systems, moving beyond simple logic or semantic networks. He represented a situation like "going to a restaurant" through a data structure. Reasoning was achieved by selecting an appropriate frame and filling in its slots (e.g., the name of the restaurant, the waiter, the food) allowing the machine to quickly make reasonable, but potentially retractable, assumptions (Minsky, 1975). Then concept of a script, which is a specific type of frame like a fixed sequence of actions, was developed representing knowledge about routine events (e.g., the "Restaurant Script"). Scripts allowed a machine to make inferences about unstated actions and fill in gaps when understanding stories or dialogue. If a person reads, "Mary went to a restaurant and she left happily," the script allows the AI to infer that Mary ordered, paid, and ate. Similar reasoning attempts could be considered to be foundational to early Natural Language Understanding (NLU) systems (Schank & Abelson, 1975).

Newell and Simon proposed a physical symbol system which is a machine that can process complex structures of symbols and has the necessary and sufficient means for general intelligent action. This provided the philosophical and theoretical foundation for most of the symbolic AI research during this period. It explicitly equated intelligence with the ability to represent and manipulate symbols in which reasoning was fundamentally a heuristic search process within a space of symbolic representations (Newel, & Simon, 1976). Another study investigated how machines can learn and reason by drawing analogies between different situations. The proposed system attempts to map the structure and relationships of a known situation to a new, less understood situation to derive new conclusions or solve problems. This was a move toward more flexible and human-like reasoning which allowed the AI to leverage past

experience, suggesting that reasoning isn't just about following fixed rules but also about finding relevant precedents and transforming them to fit a new context (Winston,1980).

Introduction of the backpropagation algorithm marked a radical shift from the rule-based, symbolic approach, proposing that reasoning could emerge from the collective, parallel activity of simple, interconnected units. This was a crucial method for training multi-layer ANNs which allowed the network's weights to be adjusted based on the error of the output, enabling the network to learn complex, non-linear representations and patterns from data. The backpropagation calculated the gradient for every single weight in the network, allowing the model to "reason" about how its internal structure should be modified to improve performance (Rumelhart et al., 1986). Brooks also argued against the dominant Symbolic AI paradigm, proposing that true intelligence requires embodiment and interaction with the real world. He introduced the Subsumption Architecture for robotics, a layered control system where low-level, reactive behaviors subsume or govern higher-level, deliberative reasoning. He suggested that detailed, internal symbolic representations are often unnecessary; an agent can reason by reacting to its current sensory inputs directly (McCarthy, 1990).

The last decade of twentieth century highlighted a key shift in the field of machine reasoning, moving away from the reliance on Symbolic AI, which is based on rules and logic, towards a greater emphasis on neural networks and embodied approaches. Embodied cognition brought the perspective that abstract logical reasoning alone is insufficient for general intelligence, hence for a machine to truly reason, its internal symbols must be grounded in the physical world through perception and action that led to research in behavior-based robotics and situated AI (Harnad, 1990). This period also saw how the machine learning methods matured. Friedman introduced Multivariate Adaptive Regression Splines (MARS), a non-parametric regression technique. This method automatically modeled complex, non-linear relationships in high-dimensional data by creating piecewise linear functions. It was significant because it provided a data-driven way to model complex systems, offering an alternative to traditional linear models and fixed-rule symbolic systems, thus supporting inductive reasoning from data (Friedman, 1991). This era was also the period when studies appeared which tried to link the neural networks and symbolic paradigms. It was proven that a specific type of recurrent neural network (RNN) with analog activations and a bounded number of neurons could simulate a Universal Turing Machine that demonstrated that neural networks, often associated with sub-symbolic processing, were theoretically capable of performing any computation, including complex symbolic reasoning tasks (Siegelmann & Sontag, 1992).

First decade of 21th century was characterized by the dominance of statistical machine learning and a strong push towards combining the strengths of symbolic logic with probabilistic methods. This phenomenon helped handle real-world uncertainty and complex relations. A lot of studies were conducted moving towards hybrid systems and probabilistic modeling, driven by the increase in computational power and the availability of large unstructured datasets. The focus shifted from proving logical theorems to making robust, real-time predictions using statistical AI. Pure machine learning algorithms, which reason inductively from data, became the most successful approach for many practical problems. This paved the road to successful commercial products. Building upon the successful boosting algorithms Random Forests method was introduced and widely applied in many fields. This method combined the predictions of many weak models achieving highly accurate and robust reasoning (Breiman, 2001).

Kernel Methods like Support Vector Machines, which are based on kernel trick for solving non-linear classification problems, became dominant for classification and regression in the first decade of 21th century. They provided a good way to find the optimal boundary for separating data points, offering a form of statistical reasoning that was highly effective (Hofmann et al., 2008). The foundational work for overcoming the limitations of shallow neural networks occurred in this decade too. Important studies, which showed training deep neural networks effectively, were published. Unsupervised pre-training techniques were applied in order to initialize the network weights layer by layer, solving the problem of vanishing gradients. These fundamental works enabled the complex, hierarchical reasoning which shows the direction of modern AI (Hinton, 2002; Hinton et al., 2006; LeCun, 2010).

Some foundational development in abstract reasoning of AI took place in the second decade of 20th century. AI's ability to handle deeper architectures, which is a prerequisite for the complex, layered representations needed for high-level abstract reasoning in all subsequent deep learning models, was improved. These advancements allowed models to learn hierarchical features, which underpin modern neural network-based reasoning (He et al., 2016). Introduction of the transformer architecture and the self-attention mechanism was the most important innovation of the decade enabling the current generation of LLMs and is still crucial to their emergent reasoning ability, as it allows the model to weigh the importance and relationships between different parts of the input sequence. Most of the studies from then on focused on the reasoning abilities of the LLMs (Vaswani et al., 2017). Chain-of-Thought (CoT) prompting technique, which dramatically improved the complex reasoning, arithmetic of LLMs, was a pivotal work in this field. The core idea was explicitly prompting the model to output a step-by-step thinking process before the final answer. Therefore, the model's

performance on intricate tasks is significantly enhanced, getting nearer to human-like reasoning (Wei et al., 2022).

2. Reasoning in AI and Large Language Models

The transition from explicit, rule-based reasoning to implicit, data-driven one corresponds actually the transition from classical AI to large language models based on deep learning algorithms. This shift can be characterized as moving from Symbolic AI to a statistically learned Connectionist/Generative AI. Symbolic AI was based on the Dual Process Theory of cognition, aiming explicitly for slow, logical, deliberate thinking. In this type of reasoning, knowledge was represented using explicit, human-defined symbols in which formal logic rules are deployed. Reasoning was deductive or rule-based and this was achieved by systematically manipulating these symbols according to strict, predefined logical rules. This guaranteed correctness and required less data. On the other hand, it aroused ambiguity with real-world raw data and scalability issues (Liang et al., 2025).

Large Language Models, which are based on neural networks, are sophisticated and intuitive systems. Their reasoning stem from massive-scale training, not explicit programming. Knowledge is implicitly encoded in the billions of weights and biases within the neural network which can be considered as black box. Reasoning is achieved by statistical pattern matching in the form of next-token prediction. The model statistically determines the most probable next word or token in a sequence. This is the reasoning step based on patterns learned from the vast training corpus.

LLMs, despite their ability to address immense volume knowledge and problems, are vulnerable in case of complex, multi-step or symbolic problems, because they would jump to the most likely answer rather than reasoning over intermediate steps. This very phenomenon opens a new research field where thousands oof theoretical and experimental studies are conducted each year. The most prominent methods and techniques, which are subjects of such research are explained in the following sections.

2.1 Chain-of-Thought (CoT) Prompting

CoT prompting is a technique that makes LLMs to generate a series of intermediate natural language reasoning steps before producing the final answer. The technique effectively converts a single, complex problem into several sub steps, which are more manageable. This way of operation simulates a step-by-step thought process, which is particularly effective for multi-step problems. The problems or questions are prompted to LLMs as decomposed smaller and sequential steps rather than a standard prompt which asks for the direct answer (Wei et al., 2022).

LLMs generate intermediate steps towards answer or solution of a problem, and is able to manage the complexity hence avoiding errors that would occur from jumping straight to the final answer. Let's consider the following very simple arithmetic problem;

Sarah bought 4 bags of apples with 3 apples in each bag. She ate 2 apples. How many apples are left?

Without the CoT prompting LLM would possibly return the wrong answer as 5. However, if the LLM is prompted with examples of similar problems together with the thought process, it generates the correct answer.

- Input: The bakery started with 24 loaves of bread. They sold 15 in the morning and 5 in the afternoon. How many loaves are left?
- Thought: First, calculate the total number of loaves sold: 15 + 5 = 20. Then, subtract the sold loaves from the starting amount: 24 - 20 = 4.
- Answer: 4
- Input: John had 12 marbles. He won 6 more, but then lost 3. How many marbles does John have now?
- Thought: First, calculate the marbles won: 12 + 6 = 18. Then, subtract the marbles lost: 18 - 3 = 15.

Answer: 15

Then, the model is expected to generate the reasoning and the final answer:

- Thought: First, calculate the total number of apples bought: 4 x 3 = 12. Then, subtract the apples eaten from the total: 12 - 2 = 10.
- Answer: 10

The original method, in which the prompt includes a few examples of input questions paired with a manual, step-by-step reasoning chain that leads to the correct output, is called Few-Shot CoT. A simpler, more powerful variation introduced later, zero-shot CoT, requires no examples, simply appending the phrase, "Let's think step by step," to the prompt (Kojima et al., 2022). Many variations CoT are shown to boosts performance significantly on tasks requiring arithmetic, common-sense and symbolic reasoning, especially in models with billions of parameters, where this ability emerges naturally (Yu et al., 2023).

2.2 Self-Consistency (SC) Sampling

Self-Consistency (SC) Sampling was introduced as a decoding strategy which addresses the variability and potential pitfalls of relying on a single Chain-of-Thought reasoning path (Wang et al., 2023). It was inspired by the human

tendency to consider multiple approaches before providing a solution, SC prompts the LLM to generate multiple, diverse reasoning paths for the same problem. Once several CoTs are generated, the model then selects the most consistent answer (the one that appears most frequently across all generated paths) as the final output.

The technique starts generate multiple paths by using CoT prompts to generating different reasoning paths and their respective final answers. Then, the final answers are grouped and their occurrences are counted. The final predicted answer is given as the one which is the majority vote among all generated answers. Consider the following math problem;

A train travels 240 km at a constant speed. How long does the trip take if its speed is 80 km/h?

The problem can be solved using SC sampling, where multiple diverse reasoning paths are generated and the most common final answer is chosen.

Reasoning 1 (linear)

- Distance = 240 km
- Speed = 80 km/h
- Time = distance ÷ speed = 240/80=3240/80 = 3240/80=3 hours
  Answer: 3 hours

Reasoning 2 (unit-breakdown)

- At 80 km/h, the train covers 80 km each hour.
- 240 km → 240/80=3240/80 = 3240/80=3 hourly segments.
  Answer: 3 hours

Reasoning 3 (proportional)

- 80 km takes 1 hour
- 240 km = 240/80=3240/80 = 3240/80=3 times that distance
  Answer: 3 hours

Reasoning 4 (wrong)

- Mistakenly uses 80/240=1/380/240 = 1/380/240=1/3
- Thinks time is “one-third hour”
  Answer: 0.33 hours

Most common answer = 3 hours is chosen as the final one.

SC is robust against individual reasoning errors while different logical paths might contain individual flawed steps, the correct final answer is the one that the model is statistically most certain about, even if it arrived there via different (and sometimes imperfect) reasoning sequences.

2.3 Self-Correction / Self-Refinement

Self-Correction is an iterative technique through which the LLM is instructed to review and refine its own initial output for improving accuracy. The process involves feeding the initial response and its reasoning (e.g., a CoT) back into the LLM, along with a prompt which asks it to critique its own response. This can be considered as an editing or debugging process. Self-refinement uses an iterative loop (Madaan et al., 2023). The LLM produces an initial output. Then it is prompted to critique its own output based on the original task criteria. The LLM uses its initial output and the critique/feedback to generate a refined, second-generation output. This can loop multiple times.

Self-refinement improves output iteratively across rounds, using intrinsic feedback that consists of using internal scores, checking coherence, self-generated critiques. The model can also use external tools or feedback (e.g., running code, querying a database, or checking against a "verifier" model) to evaluate and correct its answer. Human preference signals, reward models trained by humans are also utilized in feedback mechanism.

On the other hand, some studies highlight that LLMs may struggle with intrinsic self-correction, often failing to recognize or correct fundamental reasoning errors without external feedback (Huang et al., 2024). However, methods that incorporate verifiers or external tools have shown strong results.

Methods, which improve self-correction using machine-generated natural language critiques, have also been introduced. Generally, a separate small model that is trained by reinforcement learning to generate feedbacks are employed and shown that they could achieve considerable improvement across i.e., code generation benchmarks (Akyürek et al., 2023; Scarlatos et al., 2024; Xie et al., 2025).

2.4 Tree-of-Thought (ToT) & Graph-of-Thought (GoT)

These two advanced methods replace the linear sequence of CoT with a more complex structure, hence allowing the model to explore multiple reasoning paths concurrently and evaluate their potential. ToT models the LLM's thought process in a tree structure. Unlike a single Chain-of-Thought, where the model commits to one path, ToT deploys branching. At each step, the model generates multiple potential reasoning steps, and then an evaluator function (often another call to the

LLM) prunes or scores these branches based on their likelihood of leading to the correct final answer. By combining the generation and evaluation of intermediate thoughts with search algorithms, ToT enables a systematic lookahead and backtracking process. This can significantly boost the performance on tasks which require planning and strategic exploration (Yao et al., 2023).

GoT can be seen as generalization of ToT by modeling the reasoning process as an arbitrary graph, in which individual thoughts are nodes and the edges constitute the relationships. This allows different reasoning paths to merge and is more flexible than a tree. This structure enables sophisticated thought transformations, such as aggregating information from disparate paths or cyclically refining an idea. GoT is particularly effective for highly interconnected, complex problem-solving where information needs to be cross-referenced. In tasks like sorting and synthesis GoT is shown to outperform ToT (Besta et al., 2023).

2.5 Step-Back Prompting

Step-Back Prompting is a two-step prompt engineering approach which encourages the LLM to abstract a high-level concept from a specific question before answering the question. The LLM is first prompted to take a step back and generate a general principle in the form of a fundamental concept, or a high-level question that underlies the original specific query. Once the model generates this abstract concept, it is then prompted for applying this high-level principle to solve the original problem (Zheng et al., 2023). This approach helps the model ground its reasoning in general principles. Therefore, the risk of making errors is reduced that would be helpful when dealing with complex or detailed tasks.

The LLM is prompted first with the question "What is the Ideal Gas Law and how does it relate pressure, volume, and temperature?" instead of directly asking "What is the new pressure of an ideal gas if the temperature is doubled and the volume is halved?". The model uses the abstract principle (the answer to the step-back question) as a guide to formulate the correct reasoning path and to solve the original problem. Step-Back Prompting has been shown to have performance gains across challenging reasoning tasks in science, technology, engineering, and Math. By focusing on the core principles first, the model is less likely to get lost in low-level details or apply an incorrect formula. It helps LLM activate a broader domain knowledge and hence reduces recency bias (Sun et al., 2024).

3. Reasoning Using External Resources

There are techniques or architectures other than Internal Reasoning which relies solely on the knowledge and logic contained within the LLM's own pre-trained weights. These methods have been introduced to overcome CoT's knowledge limitation by employing an external knowledge base to provide

factual grounding. Two of the most common methods deployed are Retrieval Augmented Generation and Reasoning and Acting which are described in this section.

3.1 Retrieval-Augmented Generation (RAG)

RAG is an architectural innovation which integrates an external knowledge base into the LLM's generation process. This improves its factual grounding and ability to handle proprietary or real-time data. RAG introduces a retrieval step before generation. When a query is received, the system first retrieves the most relevant documents from an up-to-date, external knowledge base. This knowledge base is kept usually in a vector database. The search methodology in vector databases is a similarity search, which finds data points in the database that are closest to a query vector in a high-dimensional space.

The retrieval process is built on vector embeddings, distance metrics, and approximate nearest neighbor (ANN) Algorithms. Firstly, all data, text, images, audio, etc. and the search query into vector embeddings, which are dense, fixed-length lists of vectors that capture the semantic meaning and context of the original data. Once everything is a vector, the database needs a way to quantify how similar two vectors are. This is done using a distance or similarity metric. Then, by using ANN search, the most relevant results can be retrieved. The retrieved data are then inserted directly into the prompt as context augmentation. The LLM generates its response based on both its internal parameters and this external context (Lewis et al., 2020).

RAG addresses the problem of hallucination in generative AI. The responses created by LLMs are then verifiable and up to date through the external evidence. This could be crucial for domain-specific applications like medical, legal, corporate knowledge bases.

3.2 Reasoning and Acting (ReAct)

Reasoning and Acting (ReAct) or Tool-Augmented Reasoning is deployed to integrate external components to overcome the inherent limitations of LLMs, such as performing precise calculations or accessing up-to-date information. The LLM learns to generate not only natural language reasoning steps but also actions in a predefined format (e.g., a function call) to use external tools like a search engine, a calculator, or a code interpreter. The key framework introduced in by Yao et al. interweaves an intermediate reasoning step and action to solve a task. LLM generates an internal monologue reflecting previous observations to plan its next step. The model then, executes a function call (e.g., search query, calculator). Thereafter, it receives the result of the tool's execution (e.g., a search snippet or a numerical result) and constitutes its final response (Yao et al.,2022, October). Tool-Augmented Reasoning approach dramatically improves the

model's factual correctness and mathematical accuracy, moving beyond purely probabilistic pattern matching to perform reliable, verifiable operations. It could be crucial for complex tasks requiring real-time data or precision.

ReAct framework is also a powerful and influential technique used to enhance the capabilities of AI agents powered by LLMs. The framework guides the LLM to alternate between two steps in an iterative loop. Firstly, the agent thinks about the task, breaks it down into sub-steps, and plans the next action. This often happens through an internal natural language text output by the LLM (Chain-of-Thought). The agent then decides to use an external tool (like a search engine, a code interpreter, or a database query) to gather information or execute a step. The result of the action then (the tool's output) is then fed back to the LLM, which triggers the next cycle of reasoning. This cycle continues until the agent determines it has enough information to provide the final answer (Wiesinger et al., 2024).

4. Research Trends in Reasoning of Large Language Models

Especially after the introduction of CoT reasoning, studies in the field of reasoning of LLM has been rapidly advancing, moving beyond simple pattern matching to developing more structured, human-like, and verifiable multi-step problem-solving capabilities. This trend has primarily focused on enhancing an LLM's reasoning at the moment of query (inference time) without requiring extensive re-training that has the goal of maximizing the reasoning power of an existing model. This allows the generative AI to become more efficient in more complex tasks like mathematics, science, technology and software generation without paying high cost for the fine tuning of LLMs. On the other hand, research area of enhancing capabilities of LLMs using external knowledge (i.e. RAG) is also advancing rapidly.

As the scientific research around LLMs gain pace, it has become more meaningful to investigate recent research trends in order to shed light on the future of research in this field. Therefore, the number of studies of the methods and techniques, which are explained in Section 2 and 3, are investigated using Google Scholar database. As the time period of research, the dates between 2022 and 2025 are chosen as to cover the era of CoT. The search is conducted using "Reasoning Technique" in title and "LLM" in the text of research article in order to spot the research done specifically in this area and related to the LLMs.

The results show that RAG is the most studied subject regarding reasoning in LLMs appearing in the title of the researches, which is followed by CoT. When the research subjects are considered as internal reasoning techniques including CoT, Self-Consistency Sampling, Self-Correction, Self-Refinement, Tree-of-Thought, Graph-of-Thought, Step-Back Prompting and as external reasoning

techniques including Retrieval Augmented Generation and Reasoning and Acting, the following chart in Figure 1 depicts the shares of the researches. It should be noted that the research numbers include only these methods and techniques given in Section 2 and 3 of this study and may not reflect the exact picture of this research area. Nevertheless, the subjects covered in this study are the main research areas regarding enhancing LLMs. The results of the search are shown in Figure 1.

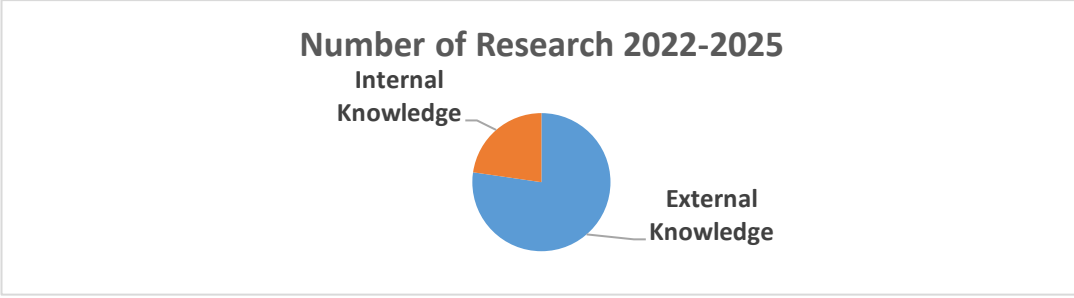

Figure 1 Research Numbers of Internal and External Knowledge Base

Regarding reasoning enhancements by internal knowledge, CoT is still the leading methodology. The research on other techniques using similar methods is very low compared CoT indicating that no other method is as powerful as CoT yet, Figure 2.

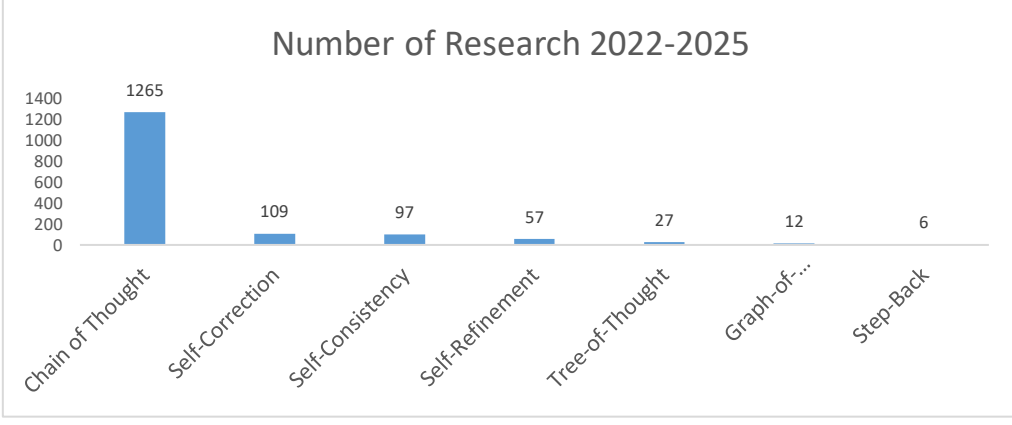

Figure 2 Research Numbers of Internal Knowledge

5. Conclusion

LLMs, which are trained on vast datasets of text and capable of capturing the complexity and subtle nuances of human language, are being more and more into our lives every day. Capabilities of LLMs make them the engine behind true conversational AI, enabling applications like advanced virtual assistants, customer service chatbots, and interactive learning tools. A single LLM trained on broad data can be adapted via fine-tuning or prompting to a wide range of downstream tasks. This versatility drastically accelerates AI development across diverse fields, such as Natural Language Processing (NLP), Code Generation or Multimodal Tasks.

Although LLMs are versatile models, they come also with their limitations. LLMs can generate completely incorrect or fabricated information, called hallucinations, even if they sound very plausible because they predict the next most likely token and don't retrieve facts from a real-time knowledge base. Since they're are trained on massive datasets scraped from the internet, they can inherit human biases or toxic outputs. Moreover, LLMs operate on a static snapshot of data collected during their training hence they cannot access real-time or dynamic information. While they can solve complex problems, they often struggle with abstract, multi-step logical reasoning tasks or common-sense questions.

All of the shortcomings of LLMs have been the most studied fields by researchers recently. Hallucinations and outdated knowledge problems are addressed by equipping LLMs with an external, up-to-date knowledge base, which is a method called Retrieval Augmented Generation (RAG). RAG enables LLM retrieve relevant and updated information and include it in the prompt before answering, grounding the response in reality. Failing to reason over complex tasks is another challenge for LLMs that is addressed by Chain-of-Thought (CoT) prompting. CoT prompting break down a complex task into sequential, logical steps, which guides the model's internal reasoning. This makes its outputs more reliable, consistent meanwhile less sensitive to minor prompt changes.

This research showed that RAG and CoT together with its variation had become most studied subjects in the recent years. This is also a confirmation that hallucinations and complex tasks challenges remain as the most critical aspects of LLMs to be improved.

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CHAPTER 8

Analysis of Migrants' Intention to Stay in Middle Eastern Countries Using the Critic-Based Maut and Topsis Methods

Tuğba Gökdemir[1]

[1] Araş. Gör. Dr., Bursa Uludağ Üniversitesi, ORCID:0000-0001-6584-2557

1. İNPUT

Through this study, the level and nature of the impact of factors affecting migrants' intention to stay in these countries will be examined. Furthermore, by filling the gap in the literature, it will contribute to policymakers developing strategies to increase the tendency to stay or to leave. It is known that migrants' preference to stay in a country is NOT ONLY dependent on individual decisions but is also related to conditions such as the living conditions, political stability, and humanitarian services offered by countries. The study's findings show that Turkey has the highest retention intention among these four countries, followed by Jordan and Iraq, which have a medium level, and Lebanon, which has a lower level of suitability.

This article evaluates migrants' intention to stay through a multidimensional analysis, considering economic, social, political, and humanitarian aspects, based on data from the 2024 World Migration Report published by the International Organization for Migration (IOM). The article aims to examine migrants' intention to stay using CCMV methods in light of current data. The American School's TOPSIS and MAUT methods from the MCDM methods were used in the analysis of the study. These methods were chosen because they provide practical and understandable results in complex decision-making processes, enabling decision-makers to obtain more accurate and efficient results.

This article evaluates migrants' intention to stay through a multidimensional analysis, considering economic, social, political, and humanitarian aspects, based on data from the 2024 World Migration Report published by the International Organization for Migration (IOM). The article aims to examine migrants' intention to stay using CCMV methods in light of current data. The American School's TOPSIS and MAUT methods from the MCDM methods were used in the analysis of the study. These methods were chosen because they provide practical and understandable results in complex decision-making processes, enabling decision-makers to obtain more accurate and efficient results.

2. LITERATURE REVIEW

Numerous studies on the intention to stay/settle have revealed that institutional, economic, and cultural factors are decisive in migrants' decisions to stay long-term or permanently in their destination countries, return to their home countries, or migrate again to third countries.To be continued, 2021; Barbiano di Belgiojoso (2016)).

Jensen and Pedersen (2007) applied logistic regression analysis using the Danish Statistics Agency's panel database on immigrants. The findings suggest that labor market integration has a positive impact on the decision to stay.

Danzer and Ulku (2011) examined the effect of integration on income and the determinants of each integration component (economic, political, and social integration) on a sample from the Turkish community living in Berlin.

De Haas and Fokkema (2011) employed a multivariate logistic regression method to examine the relationship between the return and integration of four refugee groups in Italy and Spain.

The first (2017) investigated immigrants' intentions to settle and remain using multivariate logistic regression. It found that highly educated immigrants intended to emigrate due to concerns about the country of residence, but that satisfactory employment had a positive effect on their intention to remain.

Dalla Valle et al. (2020) proposed a Bayesian approach to model binary response data based on generalized logistic regression and analyzed the migration of migrants to the European Union. The findings emphasized that increased migration has significant social, cultural, and economic impacts on EU countries and that policymakers need to accurately assess people's attitudes toward migration when designing integration policies.

Yang et al. (2020) found in their study that the distinction made by the companies they examined between domestic and foreign labor had a significant impact on the intention to migrate or remain.

Hof et al. (2021) developed the "migrant retention framework" conceptual model to explain the intention to stay among EU migrants living in Europe. After the CEO. (2021) analyzed the settlement and return patterns of German immigrants throughout their lives using multivariate logistic regression. The results obtained indicate that highly skilled immigrants tend to return earlier and that their migration intentions are influenced more by individual living conditions than by economic success or failure.

Bekaert vd. (2021) found that social networks significantly influence migrants' desire to stay or leave, with international networks encouraging migration and local networks encouraging settlement. They also found that economic integration in the destination country did not significantly influence migration desires; instead, acceptance by the community, as well as factors such as access to local opportunities and satisfaction, increased the intention to stay. Barbiano di Belgiojoso, widow of. (2023) examined changes in migrants'

intentions regarding settlement in Italy using three different logistic regression models. They found that family status, financial stability, and ties to the country of origin and destination country are critical factors that significantly influence intentions to settle and remain.

The common thread among these studies is that they show migrants' intentions to stay are linked to multidimensional factors (economic, social, political, humanitarian). However, many existing studies have focused on Western countries or large urban centers in East Asia. There has been limited interest in the unique migration structure of the Middle East. Furthermore, studies generally utilize structural equation modeling, regression analysis, and qualitative methods. However, there are very few studies conducted using CKKV approaches that can evaluate the relative importance of these variables simultaneously (Zavadskas & Turskis, 2011). Therefore, this study aims to contribute to the literature by addressing similar factors (economic, social, political, and humanitarian) together and evaluating migrants' intention to stay in the country using CSDV methods, thereby filling the existing research gap.

3. METHODOLOGY

The MAUT and TOPSIS AHP methods based on CRITIC used in the study are conceptually examined in this section. Multi-Criteria Decision Making Method Research in the field of electromagnetism dates back approximately three centuries, extending to the correspondence between Benjamin Franklin and Joseph Priestley in 1772. (French, 2023, s. 1) Over the past 50 years, CCS has become a widespread topic with several 'sub-disciplines' centered around new methodologies. (French, 2023, s. 2) The CBA aims to rank alternatives based on their merits and derive a solution from this ranking. It aims to minimize the decision-maker's subjectivity as much as possible with the help of mathematical support. Without MCDM methods, decision-makers often rely on intuition, making it difficult to manage when there are numerous alternatives and criteria. MCDM methods are important strategies for evaluating various fields. (Jovanovic, Šarac, & Čačić, 2024, p. 2).

The reason for choosing the CKKV method in this analysis is that it is suitable for the complex and multidimensional nature of decisions regarding the suitability of immigrants to remain. These decisions are too multidimensional to be explained by objective analyses based solely on economic indicators.

Therefore, the multidimensional analysis provided by CCA offers a more appropriate and robust analysis than traditional statistical methods (Gökdemir & Emel, 2025). Regression analysis and other statistical methods have limitations,

such as the linear assumption problem and multidimensionality, when applied to decisions made by migrants. However, the suitability of refugees to stay is a non-linear, complex process (Bansak, Hainmueller, & Hangartner, 2016). Furthermore, when making comparisons between countries with different socio-economic structures, such as Turkey, Lebanon, Jordan, Iraq, and Syria, the MCA enables an understanding of the variability between criteria. It ensures a comprehensive assessment by simultaneously addressing the social, economic, political, and humanitarian dimensions of migrants. One of the most critical and complex processes in addressing CCA issues is determining the weight of the criteria. The weights assigned to the criteria indicate their relative importance. The most straightforward approach used in many studies is to assign equal weight to the criteria. However, the final evaluation results depend primarily on the weights of inappropriate criteria (Gökdemir & Emel, 2023). For this reason, the CRITIC method, one of the objective weighting methods, was used in the study to determine the criterion weights.

3.1. CRITIC Method

The CRITIC method was first introduced in 1995 by Diakoulaki and colleagues. The primary objective of the CRITIC method is to determine the relative importance of various criteria by utilizing correlations. The CRITIC method is a valuable tool for decision-makers responsible for evaluating multiple alternatives using multiple criteria. It ensures a comprehensive evaluation of criteria and improves the understanding of their relative importance (Farid et al., 2024, p. 4).

Certain steps are required for the CRITIC method to be applied. In the problem $m\ number\ of\ alternatives$ $(A\ i\ (A\ 1, A\ 2, A\ 3\ \dots\ A\ m)$ ve $n\ evaluation\ criteria$ $(C_j\ (C_1, C_2, C_3, \dots\ C_n))$Assuming , the following steps are applied (Gaur et al., 2023, p.227).

Step 1: Creating the Decision Matrix

$$X = [x_{ij}]_{m\times n} \begin{bmatrix} x_{11} & \cdots & x_{1n} \\ \vdots & \ddots & \vdots \\ x_{m1} & \cdots & x_{mn} \end{bmatrix} \quad (i = 1,2,\dots,m)\ ve\ (one, two, \dots, n)$$

x_{ij} i. It presents the level of distinctiveness according to the j. criterion of the alternative.

Step 2. Normalization of the Decision Matrix

The formula used for normalization does not distinguish between useful and useless criteria.

$$x_{ij}^{*} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})} \quad (i = 1,2,\dots,m) \;\; ve \;\; (one, two, \dots, n) \qquad E(1)$$

x_{ij}^{*} *i Alternative's j. criterion*shows the normalization level.

Step 3. Criterion weights are determined using standard deviation and the correlation between other criteria. The weight of the criteria is calculated as follows:

$$C_j = \sigma_j \sum_{j'=1}^{n} (1 - r_{jj'}) \qquad E(2)$$

$$w_j = \frac{C_j}{\sum_{j=1}^{n} C_j} \qquad E(3)$$

$C_j \;\; j \,.n$the quantity of information in the message,

$\sigma_j \;\; j.$ is the standard deviation of the feature,

$r_{jj'} \;\; j.and\; jth$ is the correlation coefficient between the attributes and

w_j is the weight value of the criteria.

3.2. TOPSIS Method

Hwang and Yoon (1981) initially proposed the TOPSIS method to aid in selecting the best alternative among a finite number of criteria. The well-known classical AHP method, TOPSIS, has attracted considerable interest from researchers and practitioners, with this interest in the TOPSIS method growing exponentially. (Behzadian, Otaghsara, Yazdani, & Ignatius, 2012, s. 1) The standard TOPSIS method attempts to select alternatives that are simultaneously the closest to the positive ideal solution and the farthest from the negative ideal solution. The positive ideal solution maximizes the benefit criterion and minimizes the cost criterion; conversely, the negative ideal solution maximizes the cost criterion and minimizes the benefit criterion. (Behzadian, Otaghsara, Yazdani, & Ignatius, 2012). Steps of the TOPSIS method: (Jovanovic, Šarac, & Čačić, 2024, p. 4)

Step 1: Creating the Normalized Decision Matrix

$$n_{ij} = \frac{x_{ij}}{\sqrt{\sum x_{ij}^2}} \qquad E(4)$$

$n_{ij} -$ Normalized value

x_{ij} – Original value

To convert minimization values to maximization;

$$n_{ij} = 1 - \frac{x_{ij}}{\sqrt{\sum x_{ij}^2}} \qquad E(5)$$

Step 2: Creating the Weighted Normalized Decision Matrix

$$v_{ij} = w_{j*n_{ij}} \qquad E(6)$$

w_j – Weight coefficient for criterion j.

Step 3: Determining the ideal positive and ideal negative solutions

1. Ideal solution

$$a^* = \{(maxv_{ij}|maxA_j), (minv_{ij}|minA_j), i = 1,2, \dots, m\} \quad E(7)$$

2. Negative ideal solution

$$a^- = \{(minv_{ij}|maxA_j), (maxv_{ij}|minA_j), i = 1,2, \dots, m\} \quad Eighth$$

Step 4: Calculating partial distances

a_i^* distance from the ideal solution

$$S_i^* = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^*\right)^2}, i = 1,2, \dots, m \qquad E(9)$$

a_i^- distance from the negative ideal solution

$$S_i^- = \sqrt{\sum_{j=1}^{n} \left(v_{ij} - v_j^-\right)^2}, i = 1,2, \dots, m \qquad E(10)$$

Step 5: Calculating the proximity to the ideal solution

$$C_i^* = \frac{S_i^-}{S_i^* + S_i^-} \qquad E(11)$$

Conditions:$1 \geq C_i^* \geq 0$

$$a_i = A^* \rightarrow S_i^* = 0 \rightarrow C_i^* = 1$$

$$a_i = A^- \rightarrow S_i^- = 0 \rightarrow C_i^* = 1$$

3.3. MAUT Method

The Multi-Attribute Utility Theory (MAUT) method, a type of multi-attribute utility theory, was first applied by Ralph L. Keeney in his 1974 article titled

"Multiplicative Utility Functions." Following Keeney, James S. Dyer and colleagues published "Multi-Criteria Decision Making, Multi-Attribute Utility Theory" in 1992 and found different research topics and developments exciting for management science in their articles titled "The Next Ten Years." (Scholz, Franz, & Hinz, 2017, p. 44) In 1999, Tim Bedford and Roger Cooke presented the theory and methodology of a new general model for applying the MAUT method. Subsequently, many researchers have applied the MAUT method to their studies on ranking and selection prioritization. In the MAUT method, alternatives are evaluated based on the evaluation of their attributes. Each attribute is defined by a single-attribute utility (SAU) function that provides a utility value between 0 and 1. The SAU functions are then integrated into a multi-attribute utility (MAU) function that calculates the utility values for all alternatives. (Scholz, Franz, & Hinz, 2017, p. 44) In the MAUT method, the key element is to derive a multi-criteria benefit function, which requires single benefit functions and their corresponding weighting factors. (Kim & Song, 2009, p. 146). When applying the MAUT method, the following steps are followed: (Özomay, 2023, pp. 4-5)

Step 1: Identifying Alternatives and Criteria

($\boldsymbol{a}_{\mathrm{n}}$): Different options or alternatives to be evaluated in solving the decision problem.

($\boldsymbol{x}_{\mathrm{i}}$)Features or criteria to be used in evaluating alternatives.

Step 2: Calculating the Weights

Weights (w_{i}) Each criterion's overall impact is calculated. Here, the sum of the weights must be **1**.

$$\sum_{i=1}^{m} w_i = 1 \qquad E(12)$$

Here, (w_{i}) i. The weight value of the criterion, and m indicates the total number of criteria.

Step 3: Entering the Criteria Values

In this step, the performance of each alternative in each **criterion** is determined. Criteria can be of two types:

Quantitative criteria: These are measurable criteria based on numerical data.

Qualitative criteria: These are criteria based on non-numeric values and are subjective.

Step 4: Normalization Process

The calculated values are placed in the decision matrix and the normalization process is initiated. In the normalization process, the best value for each criterion is considered to be **1** and the worst value is considered to be **0**. The following equation is used to calculate the other values.

$$u_i(x_i) = \frac{x_i - x_i^-}{x_i^+ - x_i^-} \qquad E(13)$$

The terms used in this equation are shown below.

Here:

x_i^+: The best value for the relevant criterion

x_i^-: Worst value for the relevant criterion

x_i: The value of the current alternative

Step 5: Calculating Benefit Values

After normalization, the **utility value** of each alternative is determined. The utility function Equation (14) is as follows:

$$U(x) = \sum_{i=1}^{m} u_i\,(x_i) * w_i \qquad E(14)$$

Here:

$U(x)$: The total benefit value of the alternative

$u_i\,(x_i)$: Normalized benefit value for each criterion and alternative

w_i i. weight value of the criterion

4. DATA AND MODEL

Each factor value can be obtained based on its relative importance, the scope of the analysis, and the analyst's subjective judgment. However, if an unbiased ranking is desired, objective importance weights should be considered. For this reason, the CRITIC method, an objective weighting method, was used as the basic method in this study. The CRITIC method was chosen over the ENTROPY method (Li & Mo, 2015), which is widely used and considers only the intensity

of opposition, because it takes into account the relationship between each decision criterion. (Gökdemir & Emel, 2023, p. 608) Additionally, the reason for selecting the TOPSIS method is that it is the most popular method belonging to the American School. The reason for selecting the MAUT method is that it yields excellent results in solving complex and detailed problems.

Criterion Selection

K1: Economic Factors: Includes variables such as the labor market, cost of living, unemployment, and economic stability. Economic theories (Ravenstein, 1885; Lee, 1966) argue that economic opportunities drive migration movements. These economic factors are decisive in migrants' decisions to stay, as they directly affect their future quality of life.

K2: Social Factors: Includes variables such as social assistance, social cohesion, social tensions, social pressure, and infrastructure. Bourdieu (1986). According to the theory of social capital, social networks increase access to economic and political opportunities. Immigrants encounter problems such as discrimination, xenophobia, and social exclusion in their social integration processes. In their decision to stay, feeling a sense of belonging to the country they have come to and the acceptability of society are important.

K3. Political Factors: Includes variables such as immigration policies, citizenship rights, political stability, and political pressures. According to Castles and Miller's (2003) migration theory, states' immigration policies have a direct impact on the quality of life. Political stability and security play an important role in decisions to stay.

K4. Human Factors: Includes variables such as access to healthcare, food, and shelter, and basic humanitarian aid. The World Health Organization (WHO) (2018) defines migrants' access to health as a fundamental human right. Human factors determine migrants' quality of life and directly influence their decisions to stay.

5. APPLICATION AND FINDINGS

The CRITIC method was employed to assign criterion weights, while the MAUT and TOPSIS methods were utilized to conduct a comparative analysis by ranking the criteria. Data about the CRITIC, TOPSIS, and MAUT techniques were calculated in Microsoft Excel and presented in the form of graphs and tables for evaluation.

Decision Matrix

The study evaluates migrants' intention to stay in terms of economic, social, political, and humanitarian factors. The decision matrix used to analyze migrants' intention to stay was created by converting qualitative information into quantitative form. This scoring was developed based on qualitative analyses included in the World Migration Report 2024, as well as the opinions of migration experts, informed by CCAV methods and relevant academic literature.

Table 1: Decision Matrix

Alternatives/ Criteria	Economic Factors	Social Factors	politics Factors	Humanitarian Factors
Turkey	6.8	7.5	6.5	7.2
Lebanon	4	3.8	3.2	3.9
Jordan	6	6.2	5.3	6.7
Irak	4.3	5	4.1	5.5

5.1. CRITIC Method Results

The CRITIC method determines objective weights by considering the conflict and variance between criteria. If the variance between criteria is high and the correlation is low, that criterion is considered to have high information content and receives a higher weight.

Table 2. Weight Results

	Economic Factors	**Social Factors**	**Politics Factors**	**Humanitarian Factors**
w_j	0,33	0,15	0,17	0,35

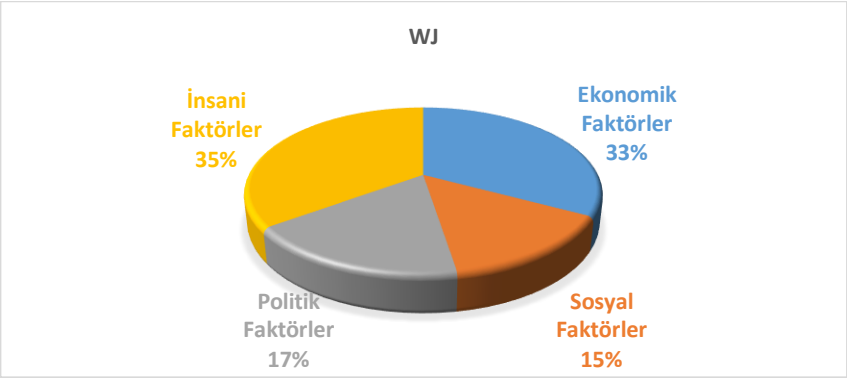

Figure 1 Weight Results Graph Display

The weights obtained indicate that basic needs and economic factors shape migrants' intentions to stay. The fact that human factors rank higher than all other criteria demonstrates that migrants' basic living needs are of critical importance.

Human Factors (0.35) has been the criterion with the highest weight. It appears that human conditions are the decisive criterion in migrants' intention to remain in the country. This situation shows that migrants primarily value humane living conditions.

Economic Factors (0.33) rank second in importance. Factors such as livelihoods, job opportunities, and economic stability play a significant role in the intention to remain in the country. Economic security increases the likelihood of staying.

Political Factors (0.17) rank third. This indicates that elements such as political stability, governance structure, and security have a moderate impact on the return rate. It has been determined that human and economic factors are paramount in the intention to stay, while political stability is of secondary importance.

Social Factors (0.15) is the criterion with the lowest weight. This situation demonstrates that social factors alone are insufficient for the intention to stay in the country, but can be effective when combined with other criteria.

5.2. TOPSIS Method Result

Table 3: Weight Results

Weights of criteria				
wj	K1	K2	K3	K4
	0.33	0.15	0.17	0.35

Table 4. Decision Matrix

Alternatives/ Criteria	**Economic** Factors	**Social** Factors	**Politics** Factors	**Humanitarian** Factors
Turkey	0.6294	0.6476	0.6587	0.6038
Lebanon	0.3702	0.3281	0.3243	0.3271
Jordan	0.5553	0.5353	0.5371	0.5619
Irak	0.398	0.4317	0.4155	0.4612

Table 5. Weight Decision Matrix

Alternatives/ Criteria	**Economic Factors**	**Social Factors**	**Politics Factors**	**Humanitarian Factors**
Turkey	0.2077	0.0971	0.112	0.2113
Lebanon	0.1222	0.0492	0.0551	0.1145
Jordan	0.1833	0.0803	0.0913	0.1967
Irak	0.1313	0.0648	0.0706	0.1614

Table 6: Normalized Decision Matrix

Alternatives/ Criteria	Economic Factors	Social Factors	Politics Factors	Humanitarian Factors
Turkey	1	1	1	1
Lebanon	0	0	0	0
Jordan	0.7143	0.6486	0.6364	0.8485
Irak	0.1071	0.3243	0.2727	0.4848

Table 7: Positive And Negative İdeal Solutions

Alternatives	S_i^*	S_i^-	C_i^*	Ranking
Turkey	0	0.1491	1	1
Lebanon	0.1491	0	0	4
Jordan	0.039	0.113	0.7432	2
Irak	0.1053	0.0526	0.3334	3

Table 8: Ranking Results

Positive ideal and negative ideal solutions				
	K1	K2	K3	K4
A^*	0.2077	0.0971	0.112	0.2113
A^-	0.1222	0.0492	0.0551	0.1145

Turkey's high TOPSIS score indicates that it is the country closest to the ideal solution for migrants. Lebanon's low score indicates that the country is close to a negative ideal solution for migrants due to economic crises, unemployment, and social discrimination.

5.3. MAUT Method Result

Table 4: Marginal Utility Score

Alternatives/ Criteria	Economic Factors	Social Factors	Politics Factors	Humanitarian Factors
Turkey	1.0048	1.0048	1.0048	1.0048
Lebanon	0.0000	0.0000	0.0000	0.0000
Jordan	0.3893	0.3059	0.2920	0.6165
Irak	0.0068	0.0649	0.0452	0.1550

Turkey's high MAUT score indicates that economic opportunities and human rights are very important in migrants' perception of benefits. Lebanon's low score in the MAUT method shows that migrants consider living there to be of low benefit, due to the effects of political instability and economic crises.

5.4. Evaluation of TOPSIS-MAUT-VIKOR Results

Since both methods have different advantages, analyzing their results together provides a multi-layered and robust approach. Comparing the results of multiple methods rather than using a single method creates a more reliable decision-making process. Therefore, the consistency and reliability of the obtained rankings

Additionally, a ranking was created using the VIKOR method for verification purposes, and the results were compared.

Table 5. Comparison of TOPSIS-MAUT-VIKOR Ranking Result

TOPSIS Ranking	MAUT Ranking	VIKOR Ranking
1	1	1
4	4	4
2	2	2
3	3	3

According to the results, Turkey ranks highest as the country closest to the ideal solution, while Lebanon ranks lowest as the country furthest from the ideal solution. The results obtained using the VIKOR method are found to be consistent with the ranking results obtained using the TOPSIS and MAUT methods. This indicates that the criteria used and the weights assigned are meaningful and consistent.

6. DİSCUSSİON

Turkey occupies a central position in migration flows as a regional transit country. Keleş (2021) notes in his study that Turkey is preferred over other countries in the region in terms of social capital, urbanization, and employment. Güngör (2018) analyzed the intentions of skilled migrants to stay or return in his study and showed that Turkey's social policy and economic stability are effective in influencing the intention to stay.

When we examine the countries included in the study;

Jordan has long been an important refuge for Syrian refugees. De Bel-Air (2021) notes that Jordan has established a system that supports the temporary rather than permanent residence of refugees through its circular migration policies and temporary shelter policies. However, recent studies (Joint Data Center, 2023) have observed a softening in the Jordanian public's attitudes and behavior toward refugees. This confirms that humanitarian factors are an important element in the intention to stay.

Lebanon is a negative example in terms of migrants' intention to stay due to its economic and political fragility. De Bel-Air (2017) emphasizes that although Lebanon has historically been a preferred destination for migrants, it lacks the conditions conducive to their intention to stay and return.

Although Iraq is a country that has experienced post-war emigration, it is also a country that receives a limited amount of immigration. Chatelard (2009) states that there was a significant brain drain from Iraq between 1990 and 2003 and that

the country still has low attractiveness due to ongoing instability. This situation supports the view that Iraq is the country with the lowest performance in terms of economic and humanitarian factors. Turkey is the country in the region with the most advantageous position in terms of its intention to stay; Jordan has a temporary but manageable intention to stay. At the same time, Iraq and Lebanon are unsuitable for migrant permanence due to economic and political weaknesses. These results are broadly consistent with those obtained using TOPSIS, MAUT, and VIKOR in the study.

7. RESULT

Migration is a dynamic concept shaped by multidimensional factors, including economic opportunities, social integration possibilities, political stability, and humanitarian living conditions. Middle Eastern countries offer a two-sided analysis in this context, as they are both destinations and sources of migration. Studies conducted in Turkey, Jordan, Lebanon, and Iraq reveal that migration flows are primarily driven by security and economic factors. However, countries exhibit varying levels of attractiveness in terms of "intention to stay." For example, a study examining the relationship between Syrian refugees' intention to stay in Germany and their level of social integration reveals that social integration has a direct impact on the intention to stay (Alheiwidi et al., 2022). A study analyzing the tendency of immigrants to remain in Europe found that institutional and social factors are more decisive than economic factors (King & Vullnetari, 2021). Similarly, a study examining the intention to stay among foreign workers in Japan reveals that social rights, job opportunities, and living conditions are the primary factors influencing their decision to remain (Watanabe et al., 2021). In line with these studies, the findings of this study indicate that the intention to stay in Middle Eastern countries is directly related to the living conditions offered by these countries, as well as economic, social, political, and humanitarian factors.

The analysis results show that Turkey is the country with the highest intention to stay among migrants due to its strong performance in human factors and economic resilience. Jordan and Iraq ranked second in terms of intention to stay based on the factors examined. Lebanon ranked last due to economic and political instability. The findings are consistent with other studies examining factors affecting migrants' intention to stay (Qin, 2022; Alheiwidi et al., 2022) and demonstrate that CCA methods are applicable in migration studies. The analysis results revealed that, in line with the European migration literature, the factors of "economic resilience" and "political stability" are the criteria with the highest

weight in determining the intention to stay and the attractiveness of migration (Haas, 2020; Papademetriou & Benton, 2021).

The weights assigned to the criteria used in the study were determined as follows: economic (0.33), social (0.15), political (0.17), and humanitarian (0.35), reflecting regional realities. Turkey's ranking in first place can be explained by both its emergence as a regional "migration management center" and the impact of joint migration policies pursued with the EU (EU-Turkey Agreement, 2016).

The CRITIC method has determined that the most important factors influencing migrants' intention to stay are humanitarian and economic conditions. While the political situation is important, it is not decisive, and the impact of social factors remains minimal. Policymakers need to consider these weights when determining their policies for migrants' intentions to stay or return.

For this reason, the study contributes to the assessment of migrants' propensity to stay in Middle Eastern countries. Also, it enables policymakers to identify social and economic strategies that will strengthen their intention to stay.

Future studies may consider time constraints and various regional dynamics. Other comparative studies may help address the social and cultural factors that shape migrants' long-term settlement decisions and intentions to stay.

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CHAPTER 9

Soybeans from the Perspective of the Poultry Industry: A Commercial and Economic Assessment

Nihan Öksüz Narinç[1]

[1] Assoc. Prof. Dr., Akdeniz University, ORCID: 0000-0001-7650-0085

1. INTRODUCTION

Soybean (Glycine max), with its high protein content and balanced essential amino acid profile, stands out as one of the indispensable raw materials of the modern poultry feed industry (Baker et al., 2011; Yin et al., 2011). Currently, approximately 60% of the plant-based protein sources used in the global feed sector are directly supplied by soybean and its derivatives, clearly demonstrating the strategic importance of soy (FAO, 2023; USDA, 2023). Soybean meal contains on average 44–48% crude protein, 1–2% crude fat, 5–6% crude ash, and approximately 30% nitrogen-free extract (NRC, 1994; Ravindran et al., 2017; Kong & Adeola, 2016). This rich composition allows soybean meal to stand out in feed formulations both as a source of amino acids and due to its high energy value. In particular, by providing a well-balanced structure in terms of essential amino acids, especially lysine and methionine, it reduces the need for synthetic amino acid supplementation and offers an advantage in ration costs (Emmert & Baker, 1997; Leeson & Summers, 2020).

In the poultry industry, feed inputs constitute a significant portion of production costs, and fluctuations in soybean prices as well as changes in the supply chain are directly reflected in the costs of meat and eggs (Javadi et al., 2024; Turkish Feed Industry Report, 2019). According to global demographic projections, the world population is expected to reach approximately 9.7 billion by 2050, which is projected to lead to a substantial increase in the demand for animal protein (FAO, 2023; Godfray et al., 2018). The rising demand also increases the feed industry's need for soy-based protein. Moreover, soybean production and supply—particularly in major producing countries such as Brazil, the United States, and Argentina—are closely monitored due to their environmental impacts. Soy cultivation is known to be associated with environmental risks such as deforestation, loss of biodiversity, and greenhouse gas emissions (Garnett et al., 2013). Therefore, sustainable soybean production and traceable supply chain management are of critical importance for food security and the continuity of animal production (Poore & Nemecek, 2018).

Soybean meal is commonly used in poultry diets in two variants: 44 CP (with hulls) and 48 CP (dehulled, higher protein content). In broiler diets, the 48 CP soybean meal, which has a lower fiber content and higher protein level, is more frequently preferred. The metabolizable energy (ME) value ranges between 2250–2450 kcal/kg, while the corrected metabolizable energy (AME) value is between 2300–2500 kcal/kg; these values may vary depending on processing methods. In broiler diets, soybean meal is typically included at levels of 25–35%, and optimal results are achieved with amino acid supplementation. Especially during the growing periods, soy provides an advantage in maintaining the balance of lysine and methionine (NRC, 1994; Ravindran et al., 2014). In layer diets,

soybean meal is used at levels of 18–22%, directly improving performance parameters such as egg mass, shell strength, and internal quality (Leeson & Summers, 2020). Its natural amino acid profile reduces the need for synthetic amino acids, thereby lowering costs (Emmert & Baker, 1997).

In countries like Türkiye, where oilseed production is limited and there is a high dependency on imports, fluctuations in global soybean prices are rapidly reflected in feed ration costs and producer profitability (Turkish Feed Industry Report, 2019; USDA, 2023). Volatility in exchange rates and disruptions in the international supply chain can affect not only the feed sector but the entire animal production chain. Therefore, supporting domestic soybean production, evaluating alternative protein sources, and developing sustainable supply strategies have become increasingly important. Although various studies have been conducted on alternative plant-based protein sources (such as sunflower meal, canola meal, and cottonseed meal), soybean currently maintains its position in the short and medium term due to its nutritional value and economic advantages.

Soybean and its products, due to their nutritional value as well as economic and logistical advantages, constitute the primary raw material of the poultry feed sector (Ravindran et al., 2017). Amidst increasing population, food security concerns, sustainable production, and global trade dynamics, continuity of soybean supply and price stability will remain critically important for animal production and food security. The aim of this study is to compile scientific and sectoral research related to sustainable soybean production and import, as well as the development of alternative protein sources.

2. WORLD SOYBEAN PRODUCTION, TRADE AND ECONOMIC SITUATION

Global soybean production is largely controlled by a few countries, with the United States, Brazil, and Argentina accounting for approximately 80% of the global market (USDA, 2024). These countries, owing to their agricultural infrastructure, ecological advantages, advanced technological capabilities, and intensive international trade activities, are the key determinants of global soybean supply. In recent years, Brazil in particular has dramatically expanded its soybean cultivation areas and has become the world's largest exporter in this field. This increase has played a critical role in both national economic development and the global feed and food sectors (Valdes et al., 2023).

The rapid growth of soybean production in Brazil is attributed to factors such as the efficient use of vast agricultural lands, technological advancements supported by national policies, and competitive advantages related to logistics and production costs. The central-west and southern regions of the country—particularly the states of Mato Grosso and Paraná—account for a large share of

national production, with Mato Grosso being the leading region in soybean cultivation (Valdes et al., 2023; Arias et al., 2017). However, this expansion has also led to environmental pressures and habitat transformation associated with the increase in agricultural land. The expansion of soybean cultivation areas, especially in high-biodiversity ecosystems such as the Cerrado, has sparked debates regarding its environmental impacts (Piras, 2021; Rausch et al., 2019).

The United States has long been one of the world's leading soybean producers, distinguished by its highly efficient farm structure. The primary reasons for such high productivity in U.S. soybean production include advanced agricultural mechanization, modern breeding techniques, and climate-controlled agricultural policies (USDA, 2024). In addition, comprehensive crop insurance and support policies implemented in the United States help protect producers against market fluctuations. Soybean prices in the U.S. are mainly established on the Chicago Board of Trade (CBOT) futures market, and these prices serve as a fundamental reference for global soybean trade. Consequently, changes in weather conditions, yield forecasts, and stock levels in the United States are quickly reflected in international soybean markets through price expectations, increasing global price volatility (Irwin & Sanders, 2012; Carter et al., 2017; USDA, 2022).

Argentina, particularly in the export of processed soybean products—most notably soybean meal—holds a leading position in the world. The foundation of Argentina's prominence in the soybean sector lies in its robust crushing (processing) industry, advanced port infrastructure, and export-oriented production strategies. A significant portion of soybeans produced in the country is processed domestically into soybean meal and soybean oil, positioning Argentina advantageously on a global scale in value-added soybean products (USDA, 2024). However, fluctuations in soybean production and export volumes can be observed during periods of currency crises and macroeconomic instability in Argentina. Additionally, export taxes and periodic trade restrictions imposed on soybeans and their derivatives can lead to volatility in global soybean and soybean meal prices (OECD-FAO, 2023).

The dominance of these three countries in global soybean production poses a significant dependency risk for the feed and food sectors worldwide; any disruption at the production, logistics, or political level can have a substantial impact on global prices and supply chains (OECD-FAO, 2023; USDA, 2024). Therefore, production diversification, sustainability practices, and market monitoring mechanisms hold strategic importance for both producer and importing countries.

Global soybean production has experienced significant growth over the past 20 years, increasing by approximately 45% (OECD-FAO, 2023). The main factors underlying this increase include the widespread adoption of modern seed

breeding techniques, the use of advanced irrigation and fertilization technologies, precision agriculture practices, and innovations in farm management systems (Qaim & Kouser, 2013; Liu et al., 2020). Soybean, especially with the proliferation of genetically improved high-yield varieties, has become a strategic crop in global agriculture in terms of both cultivated area and yield per unit area.

An examination of production data reveals that global soybean production was approximately 268 million tons in 2012, rising to 353 million tons in 2020. As of 2024, global soybean production is estimated to exceed 390 million tons (USDA, 2024). This growth is largely attributable to developments in major producing countries such as Brazil, the United States, and Argentina. In countries like Brazil and the United States, productivity per unit area has reached high levels, with yields of 350–400 kg/da (3500–4000 kg/ha) (USDA, 2024). The use of modern agricultural machinery, integrated pest management, precision fertilization, and advanced irrigation systems have played a significant role in achieving these high yields (Qaim & Kouser, 2013; Liu et al., 2020).

However, the rapid increase in global soybean production has also brought significant environmental debates to the forefront. In particular, the expansion of soybean cultivation areas in Brazil is associated with deforestation, habitat loss, and land use changes in ecologically sensitive regions such as the Amazon and Cerrado. The conversion of forested lands into agricultural areas leads to a reduction in biodiversity and, due to the decreased carbon storage capacity, contributes to increased global greenhouse gas emissions (Nepstad et al., 2014; Rausch et al., 2019). These environmental impacts have attracted increasing attention not only from academic circles and non-governmental organizations but also from international trade actors, multinational food companies, and consumers. As awareness of the environmental footprint of global food systems grows, sustainability has become an important competitive factor in soybean supply chains (Garnett et al., 2013). In this context, various policy instruments and voluntary initiatives have been implemented in recent years—especially in leading soybean-producing countries like Brazil—to promote sustainable agricultural practices, establish traceable and transparent supply chains, and expand certification systems. These approaches, which aim to reduce the environmental impacts of land use, seek to establish a more balanced relationship between agricultural production and environmental sustainability (Poore & Nemecek, 2018). The rapid growth in global soybean production has been made possible by advances in agricultural technologies; however, the environmental consequences of this growth—particularly in terms of deforestation and ecosystem degradation—have necessitated the development of new sustainability-oriented policies. In the future, maintaining yield increases in a

sustainable manner while minimizing environmental impacts will be among the most important priorities of the global soybean sector.

Global soybean trade exhibits a highly concentrated market structure, with a significant portion of trade volume controlled by a limited number of multinational companies. In particular, the so-called "ABCD" group—Archer Daniels Midland (ADM), Bunge, Cargill, and Louis Dreyfus Company—are key actors in the global trade of soybeans and soybean products. These companies manage a substantial share of global soybean trade and have a considerable impact on global price formation processes (Murphy et al., 2012). The power of the ABCD companies in the sector stems not only from their trade volumes but also from their high levels of vertical and horizontal integration. These firms operate across an extensive supply chain network, spanning from soybean production to storage, transportation, port operations, crushing facilities, processing industries, and the global distribution of final products. With their advanced logistics infrastructure, financial capacity, and global information networks, they achieve competitive advantages both in producing countries and importing markets, thereby shaping the structure of global agricultural commodity markets (Clapp, 2019).

The soybean supply chain is highly complex and integrated. At the initial stage of the chain are the soybean producers, primarily large-scale commercial farms. The soybeans produced are collected by local or international exporters and transported to ports. In the next phase, soybeans are processed in crushing facilities, where they are separated into major by-products such as soybean oil and soybean meal. The resulting soybean meal is further processed, particularly in feed mills, for use in rations for poultry, cattle, and other animal species. Ultimately, these feeds reach poultry producers and become a fundamental input for animal production (OECD-FAO, 2023). Any logistical, production, or trade disruptions at any stage of this supply chain can cause significant volatility in global soybean prices. For example, weather-related yield losses in producing countries, strikes affecting port infrastructure, trade restrictions, or technical failures in crushing facilities can disrupt the flow of the chain and lead to rapid price fluctuations (Murphy et al., 2012). In 2020, the COVID-19 pandemic caused slowdowns in global logistics and container shortages, resulting in sudden increases in the prices of soybeans and other agricultural commodities (OECD-FAO, 2023). Furthermore, the financial and commercial realities of the global supply chain present risks of dependency and vulnerability for small-scale producers and developing countries. While the major companies that shape market conditions are decisive in price formation, imbalances in the supply chain directly affect feed costs in importing countries and, consequently, the prices of animal products (Clapp, 2019). Therefore, issues such as sustainability,

transparency, and diversity in the soybean supply chain have become some of the most important strategic topics for the sector (Murphy et al., 2012). In conclusion, the control of global soybean trade and supply chains by a few large multinational companies contributes to economies of scale and efficiency in the sector, but it also introduces various risks for supply and price stability. In the future, the effects of climate change, trade policies, logistics investments, and sustainability standards on the supply chain will become even more decisive.

Soybean is currently a strategic commodity in the global agricultural markets. The worldwide increase in population, urbanization, and rising income levels have particularly driven up the consumption of animal protein, significantly raising the demand for plant-based protein sources in the feed industry. In this context, soybean has become a fundamental input both for direct human nutrition and, especially, for animal feed production (Gale, 2015). According to FAO data, global soybean trade volume has shown a rapid increase over the past two decades. While global soybean trade was approximately 60 million tons in 2000, it rose above 160 million tons by 2020, and approached around 170 million tons during the 2023–2024 period (FAO, 2023). The primary determinant of this growth is China's dominant role in global soybean imports. Indeed, in the 2020s, China has become the largest importer, accounting for about 60% of global soybean imports (USDA, 2024).

There are several structural reasons behind China's high dependence on soybean imports. Chief among these are the country's limited domestic soybean production capacity and the rapid growth of the pork and poultry sectors. Especially since the 1990s, accelerated urbanization and income growth in China have led to a notable rise in animal protein consumption, which has strongly stimulated the demand for feed-grade soybeans (Gale, 2015). A significant portion of domestically produced soybeans in China is used directly for food purposes, while the high-protein raw materials required by the feed industry are largely met through imports. This structure increases China's dependence on foreign sources for soybeans and soybean meal used in the feed sector (Liu et al., 2020). The increasingly industrial nature of livestock production has made the use of high-protein, consistently high-quality soybean products in feed rations essential. In this regard, genetically modified (GM) soybean varieties are widely preferred in the Chinese feed industry due to their high yield and protein content (Qaim, 2020). In line with rising demand, China's soybean imports increased from about 1 million tons in 1995 to over 90 million tons by 2022 (USDA, 2024). Brazil, the United States, and Argentina are the main suppliers in China's soybean imports (USDA, 2024). China's high dependence on soybean imports exerts a decisive influence on global price volatility and trade orientations. Even relatively minor changes in China's import policies or purchasing strategies can

cause significant fluctuations in global soybean prices. This phenomenon was clearly observed when China redirected its imports to Brazil during periods of trade tensions with the United States. Furthermore, environmental factors such as climate change, drought, and extreme weather events affect yields in major producing countries, making global soybean trade balances increasingly sensitive (FAO, 2023). In recent years, the Chinese government has begun implementing policies aimed at both diversifying import sources and promoting domestic soybean production. However, given the current production–consumption balance, these policies are not expected to significantly reduce China's import dependency in the short term. In conclusion, soybean plays a critical role in the global food and feed system, and China's high and steady demand for this commodity continues to be a key factor shaping global price formation and trade dynamics.

3. INTERNATIONAL PRICING OF SOYBEANS

International soybean prices are determined within a multi-layered and dynamic price formation mechanism. This mechanism is shaped by the simultaneous interaction of several factors, including price discovery in futures markets, basis formation in physical markets, international transportation costs, crushing margins in the processing industry, and exchange rate movements in importing countries.

I. CBOT Soybean Price: The Chicago Board of Trade (CBOT) is one of the primary futures trading platforms where price discovery in the soybean market occurs. Prices formed on the CBOT are sensitive to global supply and demand expectations, weather conditions and production forecasts, stock dynamics, trade policies, and financial transactions in the market; thus, they serve as a reference price in physical soybean trade (Irwin & Sanders, 2012; Carter et al., 2017).

II. Country-Specific Basis: The basis, which is added to the CBOT price, refers to the premium or discount of a specific country's port/plant delivery price relative to futures prices. The basis can vary depending on local supply and demand conditions, storage/port capacity, domestic logistics costs, and especially disruptions in transportation. Therefore, even if the CBOT price remains unchanged, actual import costs can differ significantly between countries (Caffarelli & Sparger, 2017; Hart & Olson, 2017).

III. Freight Cost: Freight cost refers to the maritime transportation expenses incurred when shipping soybeans from the exporting country to the importing country. Freight rates are affected by factors such as vessel availability, fuel prices, port congestion, global supply chain disruptions, and geopolitical risks. In recent years, increases in international freight prices during periods of global

market shocks have raised import costs, thereby exerting upward pressure on agricultural commodity prices (Ferguson & Ubilava, 2022; FAO, 2023).

IV. Crush Margin: The crush margin is the difference between product revenues and raw material costs in the process of crushing soybeans into soybean meal and soybean oil. Improvements in processing industry margins can increase crushing demand, thereby influencing soybean demand and price formation; margins fluctuate according to energy costs, capacity utilization, and by-product prices (Plato, 2001).

V. Exchange Rate: Since soybeans are predominantly priced in US dollars in international trade, the value of the local currency against the dollar in importing countries is a key determinant of final import costs. Exchange rate fluctuations can quickly affect feed and food costs in import-dependent economies; thus, domestic market prices may rise or fall independently of changes on the CBOT (Gilbert, 2010; FAO, 2023).

In recent years, increased exchange rate volatility and rising international freight costs have led to a rapid escalation in feed and animal product costs, especially in countries that are dependent on soybean imports. In countries with a feed production structure reliant on imported inputs, the depreciation of local currencies against the US dollar and the rise in transportation costs are directly reflected in domestic market prices for key raw materials such as soybeans and soybean meal. This situation creates significant upward pressure on the prices of meat, milk, and eggs through increased feed costs (Gilbert, 2010; FAO, 2023).

Additionally, the fact that international soybean prices are largely determined on the CBOT futures market makes prices highly sensitive to global supply and demand shocks. Global production forecasts, stock levels, climate-related risks, and changes in trade policies lead to rapid fluctuations in CBOT prices, making price stability in importing countries even more fragile. Disruptions in global supply chains and sudden increases in freight costs are among the factors that further amplify this price volatility (FAO, 2023).

As a result, the formation of international soybean prices is influenced by numerous interconnected factors, and external variables such as exchange rates and freight costs have a direct and substantial impact on feed and food prices in import-dependent countries. This structure makes it more difficult to ensure food price stability in these countries and exposes agricultural production costs to greater vulnerability from fluctuations in global markets (Kilian, 2009; FAO, 2023).

4. SOYBEAN PRODUCTION, CONSUMPTION, AND IMPORT DEPENDENCY IN TURKEY

Turkey, while possessing certain potential for soybean production due to its agroecological conditions, currently falls far short of meeting its total domestic demand. According to data from the Turkish Statistical Institute (TÜİK), soybean production in Turkey has been around 300–350 thousand tons in recent years, accounting for less than 10% of the country's total national requirement (TÜİK, 2024). Given the high demand for protein-rich raw materials in the feed industry and increased production in the livestock sector, the majority of Turkey's soybean—and especially soybean meal—needs are met through imports. Indeed, data from FAO and USDA indicate that Turkey is a net importer of soybeans and soybean products, with domestic production meeting only a limited proportion of demand (FAO, 2023; USDA, 2024). This high level of import dependency increases the sensitivity of feed and animal product costs in Turkey to global price fluctuations, exchange rate movements, and changes in freight costs. Therefore, external dependency in soybean supply emerges as a structural vulnerability factor in Turkey's agriculture and food sector.

In Turkey, soybean production is primarily concentrated in regions with advanced irrigation facilities and warm climate conditions. The main production areas include Çukurova, provinces under the Southeastern Anatolia Project (GAP), and, to a limited extent, the Black Sea coastal strip. An examination of provincial crop production statistics from TÜİK reveals that the Çukurova Region—which includes the provinces of Adana and Mersin—holds the largest share of Turkey's soybean production (TÜİK, 2024). Favorable temperature conditions, a long vegetation period, and a well-developed irrigation infrastructure in the Çukurova Region enable the cultivation of soybeans both as a primary and a secondary crop, thereby increasing the region's significance in national production. In the Southeastern Anatolia Region, particularly around Sanliurfa and nearby areas, soybean cultivation has gained growing importance in parallel with the expansion of irrigation investments. Reports from the Ministry of Agriculture and Forestry and the FAO indicate that supporting alternative oilseed production in the GAP region has contributed to the expansion of soybean planting areas (FAO, 2023; T.C. Ministry of Agriculture and Forestry, 2022). In the Black Sea coastal area, however, due to climatic conditions and land structure, soybean production remains limited and is mainly carried out to meet local needs. Overall, soybean production in Turkey displays a regionally concentrated pattern, and the development of irrigation infrastructure stands out as a key factor determining production patterns.

The limited level of soybean production in Turkey is the result of the combined effects of economic, structural, and technical factors. Soybean requires

regular and adequate irrigation during its growth period; however, in many regions of Turkey, insufficient irrigation infrastructure, limited water resources, and high energy costs associated with irrigation significantly constrain production. Reports published by the Ministry of Agriculture and Forestry and the FAO indicate that rising irrigation costs for water-dependent crops have a direct impact on cultivated areas (T.C. Ministry of Agriculture and Forestry, 2022; FAO, 2023). In addition, recent price increases in key agricultural inputs such as seeds, fertilizers, crop protection products, and energy have reduced the profitability of soybean production. Particularly, the dependence on imports for fertilizer and energy inputs causes exchange rate fluctuations to be quickly reflected in production costs, leading farmers to avoid cultivating crops like soybean, which have limited prevalence (OECD, 2022; FAO, 2023). Another major obstacle to soybean production is competition with alternative crops. In irrigated agricultural areas such as Çukurova and the GAP region, crops like cotton, corn, and sunflower provide higher and more predictable short-term returns. TÜİK data show that the areas sown with these crops are significantly larger than those for soybean, indicating that farmers prefer these alternatives to reduce income risk (TÜİK, 2024). The absence of a stable domestic market structure and widespread purchase guarantee mechanisms for soybean is also an important factor limiting production. Since the oil and feed industries largely operate on imported soybeans and soybean meal, integrating domestic production into the market is challenging, and the development of contract farming models is hindered (T.C. Ministry of Agriculture and Forestry, 2022). This situation reduces producers' willingness to invest in soybean cultivation. From a policy support perspective, it is observed that among oilseeds, crops like sunflower and canola receive priority support, while support for soybean remains limited. Furthermore, the lack of extension and advisory services regarding modern production techniques, appropriate variety selection, and yield-enhancing practices restricts productivity increases in soybean agriculture (OECD, 2022; FAO, 2023).

Turkey's vegetable oil industry has historically and economically been shaped predominantly around sunflower oil. Sunflower oil is dominant both in production and consumption in Turkey, which limits the development and domestic demand for a soybean-based oil industry (FAO, 2023). Soybean oil consumption is largely limited to margarine and industrial use, with direct consumption as table oil remaining at notably low levels. As a result, the investment appeal and scale of soybean crushing facilities are more limited compared to sunflower processing plants (T.C. Ministry of Agriculture and Forestry, 2022). The inadequate capacity for soybean processing in Turkey restricts not only soybean oil production but also the production of soybean meal, which is critically important for the feed industry. Low levels of domestic

soybean meal production make Turkey highly dependent on imports of both raw soybeans and soybean meal. This increases the sensitivity of feed costs to global price movements and exchange rate fluctuations, thereby exerting pressure on the costs of animal production (FAO, 2023; USDA, 2024). Turkey requires approximately 1.5–2 million tons of soybean meal annually, the majority of which is supplied through imports (USDA, 2023; FAO, 2023). Most of these imports come from major producing countries such as Argentina, Brazil, and the United States. This dependency on imports leaves the sector vulnerable to exchange rate fluctuations and volatility in global market prices.

The underdevelopment of the soybean processing industry in Turkey limits value creation in the agricultural sector and contributes to the chronic nature of the foreign trade deficit in soybeans and soybean products. The low level of domestic soybean production and limited crushing capacity have led the oil and feed industries to rely heavily on imported raw materials. Reports from the FAO and the Ministry of Agriculture and Forestry indicate that the oilseed industry in Turkey has historically been shaped around sunflower and cottonseed, and this structure has slowed the development of soybean-focused processing investments (FAO, 2023; T.C. Ministry of Agriculture and Forestry, 2022). In major agricultural economies such as the European Union and the United States, there is strong integration between soybean oil production and the soybean meal and feed industries. In these countries, soybeans are considered a primary input for both the oil industry and livestock feed production, and are processed within a highly value-added supply chain. In contrast, the dominant position of sunflower oil in Turkey's vegetable oil consumption has resulted in limited domestic demand for soybean oil, preventing soybean crushing facilities from reaching economies of scale. The increasing demand in Turkey's feed and oil industries has kept soybean and especially soybean meal imports consistently high. According to data from the Ministry of Trade, Turkey has recently imported an annual average of 1.2–1.5 million tons of soybeans and 1.2–1.4 million tons of soybean meal (Ministry of Trade, 2024). These import volumes are critically important for compound feed production, particularly in poultry and cattle farming, and constitute the main protein source for the feed industry.

Turkey's imports of soybeans and soybean meal largely depend on major global producer countries such as Argentina, Brazil, the United States, and Paraguay. These countries play a decisive role in Turkey's external supply due to their significant shares in global soybean production and exports, as well as their competitive logistical positions. According to FAO and USDA data, Argentina and Brazil in particular stand out in global trade with their high volumes of genetically modified (GM) soybean products and are among the main source countries for Turkey's imports (FAO, 2023; USDA, 2023).

International trade in soybeans and soybean meal is predominantly priced in US dollars, making the domestic prices of imported soybeans and soybean products in Turkey directly dependent on both global price movements and exchange rate fluctuations. During periods when the Turkish Lira depreciates against the US dollar, import costs rise rapidly; this increase is particularly reflected in animal production costs through the feed industry. Indeed, feed costs constitute a significant portion of total production costs in poultry meat and egg production, and cost increases exert direct upward pressure on the prices of meat, milk, and eggs (FAO, 2023; T.C. Ministry of Agriculture and Forestry, 2022).

Turkey's status as a net importer of soybeans and soybean meal negatively affects the agricultural trade balance and renders the livestock sector vulnerable to supply-demand shocks in global markets. This import-dependent structure is highly sensitive not only to exchange rate movements but also to trade policies implemented by exporting countries, periodic export restrictions, climatic conditions, and changes in international logistics costs. Reports from the FAO and USDA indicate that such external shocks undermine food price stability in import-dependent countries and increase uncertainty for both producers and consumers (FAO, 2023; USDA, 2023). In this context, institutional reports and policy analyses highlight the necessity of a holistic approach to reducing Turkey's dependency on imported soybeans and soybean meal. Increasing domestic soybean production, developing soybean processing (crushing) capacity, and evaluating alternative protein sources in the feed industry stand out as key policy areas to mitigate this dependency. Additionally, the utilization of financial instruments to manage exchange rate risk, the expansion of long-term supply agreements, and the promotion of contract farming models are considered important elements that may help reduce cost volatility and strengthen price stability in the feed and livestock sectors (FAO, 2023; OECD, 2022).

5. ECONOMIC IMPACT OF SOYBEAN PRICE CHANGES ON POULTRY FEED COSTS

Broiler feeds are commonly formulated worldwide as "grain–soy" rations, based primarily on cereals such as corn or wheat and soybean meal (SBM). In practice, cereals constitute the largest portion of the ration as the main energy source, while a significant proportion of essential protein and amino acids is supplied by soybean meal; fats may be added to adjust energy density, and synthetic amino acids along with vitamin–mineral premixes are typically included at lower levels (Leeson & Summers, 2005; NRC, 1994; Aviagen, 2025). Among these components, soybean meal is a critical input due to both its high inclusion rate and its significant share in total ration cost. Consequently, any increase in the price of soybean meal, with formulation remaining constant, substantially raises the unit cost of feed. In practice, producers may attempt to re-

optimize ration composition (e.g., utilizing alternative protein sources, amino acid balancing, etc.) to limit cost increases, yet the price of soybean meal remains one of the main determinants of broiler feed cost in most countries (Leeson & Summers, 2005; Rostagno et al., 2017).

Economic Impact of a 10% Price Increase: The effect of increases in soybean meal prices on feed costs—and consequently on poultry production costs—is explained through its inclusion rate in the ration and the share of feed costs in total production costs. In grain–soy-based broiler and layer systems, soybean meal typically constitutes nearly a quarter of the ration, while feed costs represent the largest single component of total production costs (Leeson & Summers, 2005; NRC, 1994; FAO, 2023). Within this framework, a 10% increase in the price of soybean meal, assuming a constant ration composition, can lead to approximately a 2% increase in unit feed costs. International feed cost analyses and FAO assessments indicate that such increases can raise total costs in broiler production by about 1–1.5%, and in egg production by approximately 1–2% (Leeson & Summers, 2005; FAO, 2023; OECD, 2022). Although effective ration optimization and amino acid balancing can partially mitigate this impact, complete substitution is often not possible in the short term due to the high biological value of soybean meal (Rostagno et al., 2017). Because feed costs play a dominant role in poultry production, fluctuations in soybean meal prices are critical for producer profitability and sectoral sustainability. A significant portion of these cost increases, especially for producers operating with competitive margins, must eventually be reflected in broiler meat and egg prices. FAO and OECD reports show that price shocks in feed raw materials rapidly drive up animal protein prices in import-dependent countries, and that this effect becomes even more pronounced during inflationary periods (FAO, 2023; OECD, 2022).

Economic Impact and Practical Example: In broiler feed, the share of soybean meal in the ration is typically around 30% in practice. Thus, a 20% increase in the price of soybean meal, with ration composition held constant, results in an approximate 6% increase in unit feed cost. Since feed costs constitute the majority of total production costs in broiler production, this increase is directly reflected in production costs, leading to an overall rise of about 3–3.5% in total production costs. Reports from the FAO and USDA indicate that such price shocks in feed raw materials have a strong and rapid impact on animal production costs, particularly in import-dependent countries (FAO, 2023; USDA, 2023). These cost increases raise cash flow and financing burdens for large-scale producers, while creating significant pressure for small and medium-sized enterprises with lower cost flexibility, making it more difficult for them to remain in the sector. Rising feed costs also directly influence producers' pricing behavior and make it more challenging to ensure price stability within the sector.

Fluctuations in global soybean markets, exchange rate volatility, and increases in international logistics costs further intensify this cost pressure, adversely affecting the international competitiveness of domestic producers. FAO and OECD assessments emphasize that such external shocks make the agriculture and livestock sectors more vulnerable in countries with import-dependent production structures (FAO, 2023; OECD, 2022).

6. ADVANCED ECONOMIC SCENARIO ANALYSES

Extreme Price Increase Scenario (Effects of Scarcity and Geopolitical Risks): Extraordinary events in the soybean meal and soybean supply chain—such as severe droughts in Brazil or unexpected supply shocks in the United States—can lead to sharp increases in global soybean prices. Given that Brazil and the United States account for a large share of global soybean production, adverse developments in these countries can cause soybean prices to rise by 30–40% on international exchanges such as the Chicago Board of Trade (CBOT) (USDA, 2024; FAO, 2023). Such global supply shocks are directly reflected in the feed sector of import-dependent countries like Turkey. An increase of this magnitude in soybean meal prices results in a 7–10% rise in feed costs. Due to the high share of feed costs in total production expenses, these increases are rapidly passed on to final product prices. In particular, broiler meat production may see total costs rise by 4–6%, while egg production costs may increase by 6–8%. It has been reported that such shocks have been observed in global markets, especially in 2022 and 2024. Global supply chain disruptions in 2022 and climate-related production declines in Brazil in 2024 led to rapid increases in soybean prices on the CBOT (USDA, 2024; FAO, 2023). Producers in Turkey, being dependent on imported soybean products, have had to directly reflect these price increases in their costs. Such sudden spikes in soybean meal prices not only increase production costs but also disrupt the supply-demand balance in the market and negatively affect price stability. This situation results in unpredictable cost increases and market fluctuations for both producers and consumers. Furthermore, the profitability of the sector decreases, and sustainability becomes a concern for small and medium-sized producers. In summary, extreme increases in soybean meal prices significantly raise feed costs, creating cost pressures throughout all stages of animal production—especially in the poultry sector—and increase the prices of animal products. This process can intensify inflationary pressures and undermine food security.

Exchange Rate Shock Scenario (Impacts and Sectoral Outcomes): In countries like Turkey, where a significant portion of agricultural raw material needs are met through imports, exchange rate volatility poses a major risk to cost stability. Particularly in the feed sector, soybean and soybean meal—being key inputs—are priced in US dollars on international markets, so the depreciation of the

Turkish Lira against the dollar is directly reflected in feed costs. For example, if the USD/TRY exchange rate increases by 20% in a short period, the price of imported soybeans and soybean meal in Turkish Lira rises by the same proportion. This increase similarly affects the cost of all imported inputs used in feed production. Since most soybeans, corn, and other protein sources are imported, exchange rate changes create a cascading effect on feed costs (FAO, 2023). The impact of such rapid currency increases on feed costs is quite pronounced. Due to the high inclusion rate of soybean meal in feed formulations, a 20% increase in the exchange rate typically results in a 4–6% increase in total feed costs. The repercussions of this situation are not limited to feed producers; it also raises the costs for final animal product producers such as broiler meat and egg producers. From a broiler production perspective, slaughter costs can increase by approximately 3–4%. Such cost increases constitute one of the most critical vulnerabilities of the livestock sector in Turkey. Volatility in feed costs not only reduces producer profitability but is also directly reflected in animal product prices. The heavy reliance on imported feed raw materials and additives has made exchange rate movements a primary determinant of costs in Turkey's feed and livestock sector. Indeed, data from the Central Bank of the Republic of Turkey (CBRT) and TÜİK show that the rapid depreciation and volatility of the Turkish Lira in 2021 and 2022 led to extraordinary increases in feed prices as well as prices of animal products like meat and eggs (CBRT, 2022; TÜİK, 2023). Reports from the Ministry of Agriculture and Forestry indicate that inputs such as soybean meal, corn, and oilseed derivatives used in compound feed production are largely priced in foreign currency; therefore, exchange rate shocks are quickly and significantly reflected in feed costs (T.C. Ministry of Agriculture and Forestry, 2022). FAO assessments also emphasize that exchange rate volatility is a major factor increasing instability in food and feed prices in import-dependent countries (FAO, 2023). The fact that most agricultural inputs in Turkey's domestic market are priced in US dollars reduces cost predictability for producers and complicates long-term production planning. CBRT analyses indicate that exchange rate pass-through is strong for food and feed prices, and that this effect becomes even more pronounced during periods of high inflation (CBRT, 2022). This structure creates significant uncertainties for both producers and consumers and negatively affects the economic sustainability of the livestock sector.

Substitution Scenario: In Turkey, in response to rising soybean meal prices and the risks associated with import dependency, the use of alternative protein sources in the feed industry is increasingly being considered. In this context, by-products such as sunflower meal, canola meal, cottonseed meal, and distillers dried grains with solubles (DDGS) are evaluated as partial substitutes for soybean meal to help limit ration costs. However, each of these raw materials has significant limitations in terms of nutrient content, amino acid profile, and

digestibility. Sunflower meal is a protein source with relatively high domestic production in Turkey and is widely used in the feed sector. Nevertheless, the high crude fiber and low lysine content of sunflower meal impose limitations on the performance of rapidly growing poultry. High fiber content reduces feed utilization, while deficiencies in essential amino acids necessitate the addition of synthetic amino acids to rations. Therefore, the use of sunflower meal as a substitute for soybean meal is generally limited to certain proportions; higher inclusion levels may negatively affect body weight gain and feed conversion (Ravindran et al., 2017). Canola meal is advantageous in terms of protein content, but due to its glucosinolate content and their breakdown products, it can have adverse effects on animal health and feed intake. Especially at high inclusion rates, it can exert pressure on thyroid function and performance. Although advances in breeding and processing techniques have reduced these risks, the use of canola meal in poultry rations is still recommended in controlled and limited amounts (Woyengo et al., 2014). Cottonseed meal, due to its gossypol content, faces more serious restrictions in poultry nutrition. Gossypol can be toxic, especially for monogastric animals, and may adversely affect egg production and growth performance. For this reason, the inclusion of cottonseed meal in poultry rations is either limited to very low levels or completely avoided (NRC, 1994). DDGS (Distillers Dried Grains with Solubles), a by-product of ethanol production, can be included in rations at certain levels. While DDGS provides energy and protein, its protein quality and amino acid digestibility do not fully match those of soybean meal. Moreover, the nutrient content of DDGS can vary significantly depending on the production process and raw material source, introducing uncertainty into ration formulation (Ravindran et al., 2017). Overall, the use of alternative protein sources can partially reduce ration costs; however, they cannot fully substitute the highly digestible protein and balanced essential amino acid profile provided by soybean meal. The international literature indicates that most of these alternatives serve as complementary ingredients at appropriate levels, rather than being full substitutes for soybean meal (Ravindran et al., 2017; Woyengo et al., 2014).

7. CONCLUSION

The poultry feed and livestock sector in Turkey is under high production pressure due to a growing population and increasing demand for animal protein. In this context, poultry meat and eggs are of strategic importance both as staple food items and for their export potential. Soybean and soybean meal, as the primary protein source in poultry rations, are indispensable inputs in broiler and layer nutrition owing to their high digestibility and balanced essential amino acid profile (Rostagno et al., 2017; Ravindran et al., 2017). However, Turkey meets the vast majority of its soybean and soybean meal requirements through imports,

making the sector vulnerable to both global supply shocks and exchange rate volatility. FAO and USDA data indicate that Turkey remains a net importer of soybeans; production, logistics, or price fluctuations in countries such as Argentina, Brazil, and the US are directly reflected in feed and animal product costs (FAO, 2023; USDA, 2023). Exchange rate volatility, in particular, leads to instability in meat and egg prices via feed costs and stands out as one of the main drivers of food inflation (FAO, 2023).

In this context, increasing domestic soybean production should be considered a strategic priority to reduce import dependency. Improving irrigation infrastructure, expanding contract farming models, and making effective use of regional production potential can make soybean cultivation more attractive in Turkey. Equally important is the development of soybean processing (crushing) capacity. The current oilseed processing industry in Turkey is largely focused on sunflower, which limits the consistent and local supply of soybean meal. Increasing soybean processing capacity represents an important area of structural transformation that can support the production of both soybean meal and oil, thereby reducing external dependency (FAO, 2023; USDA, 2024).

The use of alternative protein sources also emerges as a complementary strategy to limit feed costs. Conventional alternatives such as sunflower meal, canola meal, cottonseed meal, and DDGS can be included in rations at certain levels, but do not fully substitute for soybean meal in terms of amino acid profile and digestibility (Ravindran et al., 2017; Woyengo et al., 2014). Therefore, these sources can only be used to a limited extent, with balanced formulation and amino acid supplementation. In recent years, next-generation alternatives such as insect proteins, microalgae, and single-cell proteins have attracted attention due to their high protein content and environmental advantages. The literature has shown that insect species such as black soldier fly and mealworm can be successfully used in poultry rations at certain inclusion levels without causing performance loss (van Huis et al., 2013; Henry et al., 2015). However, for these sources to become widespread on a commercial scale, it is necessary to develop legislative frameworks, clarify quality and safety standards, and strengthen economic feasibility (EFSA, 2015).

In conclusion, policies to reduce soybean dependency in Turkey's feed and livestock sector should be based on increasing domestic production, transforming the processing industry, managing exchange rate risk, and rationally integrating alternative protein sources. Achieving these goals will require a coordinated and knowledge-based approach among the public sector, private sector, academia, and producer organizations. A holistic and predictable agricultural and feed policy will enable the sector to become more resilient, sustainable, and competitive in the face of global volatility.

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CHAPTER 10

Financial Inclusion in the Turkic World: Common Patterns and Country-Specific Determinants

Nihan Öksüz Narinç[1]

[1] Assoc. Prof. Dr., Akdeniz University, ORCID: 0000-0001-7650-0085

1. INTRODUCTION

Financial inclusion encompasses the availability of financial services to individuals and businesses, the protection of financial service users, the adoption of financial technologies, and the promotion of financial literacy. It aims to facilitate access to banking, credit, and insurance products for individuals and businesses, as these constitute essential components of the financial system. While the World Bank measures financial inclusion primarily through demand-side indicators, the International Monetary Fund (IMF) adopts a supply-side perspective. In its financial inclusion reports, the World Bank focuses on the ownership of bank and financial institution accounts. Recent evidence indicates that account ownership in emerging economies increased by 8 percentage points between 2017 and 2021, reaching 71%. Insufficient income remains one of the main barriers preventing financially excluded individuals from using formal financial services (Demirgüç-Kunt et al., 2022). A growing body of empirical research demonstrates that reducing financial exclusion, or improving access to and use of financial services, contributes to lower wealth inequality and higher economic growth.

Prior to the 2008 global financial crisis, financial inclusion initiatives were often criticized for being narrowly focused on microcredit programs targeting the poor. In the post-crisis period, however, international organizations have promoted a broader approach that incorporates a wider range of financial products and services. Consequently, the role of individuals and households as financial actors should be examined through a multidimensional lens (Gabor and Brooks, 2016). Governments across many countries continue to allocate substantial resources to enhance financial inclusion, and existing evidence suggests an increasing convergence of global financial inclusion practices toward shared norms and standards.

Ozili (2020a) emphasizes that future research should identify the optimal level of financial inclusion by taking into account the specific characteristics of each country. He further highlights the importance of conducting studies at the level of economic blocs to generate more meaningful insights. For instance, while a positive relationship between social inclusion and financial inclusion is not consistently observed in European countries, such a relationship is more evident in countries across Africa, the Middle East, and Asia (Ozili, 2020b).

The Turkic world—spanning from Türkiye to Kazakhstan, Uzbekistan, and Azerbaijan—represents a relatively coherent region with distinct cultural and economic characteristics. In recent years, economic transformations, technological progress, and globalization have significantly reshaped the financial landscape of the Turkic world, thereby influencing regional efforts toward financial inclusion. Governments and financial institutions have

increasingly sought to expand access to financial services for broader segments of society. In particular, technological innovations such as mobile banking and digital payment systems have played a crucial role in improving financial inclusion by enhancing access for rural and marginalized populations.

The primary objective of this study is to examine the current state of financial inclusion in Turkmenistan and the member countries of the Organization of Turkic States, as well as to identify the factors influencing individuals' likelihood of holding a bank account. By analyzing financial inclusion in this regional context, the study aims to provide insights into the effectiveness of policies and initiatives implemented by governments and financial institutions. Moreover, a deeper understanding of financial inclusion in the Turkic world facilitates the identification of future opportunities and challenges in this field.

This study aims to examine the determinants of financial inclusion in the member states of the Organization of Turkic States and Turkmenistan by employing micro-level data from the Global Findex survey, with a particular focus on account ownership as a core indicator of access to formal financial services. While the existing literature largely concentrates on single-country analyses or macro-level indicators, there is limited empirical evidence that systematically compares the micro-level determinants of financial inclusion across the Turkic world as a culturally and historically coherent yet economically heterogeneous regional bloc. By combining pooled and country-specific logit models, this study fills this gap by revealing both common patterns and country-specific differences in the drivers of financial inclusion, including cases where traditional determinants such as income lose statistical significance. The chapter is structured as follows: the first section provides a brief overview of the economic and financial history of the Turkic States, followed by an examination of the current financial landscape and economic relations between Türkiye and the other Turkic States; the subsequent section reviews the relevant literature on the determinants of financial inclusion, after which the data and methodology are presented; the empirical findings are then discussed in detail, and the final section concludes with a summary of the main results and a critical evaluation of the study's implications.

2. A HISTORICAL PERSPECTIVE ON THE ECONOMY AND FINANCE IN THE TURKIC WORLD

The Golden Age of capitalism extended from the end of World War II to the collapse of the Bretton Woods system. This period was characterized by sustained economic growth and productivity gains, resulting in widespread prosperity. During this era, the global economy grew at an average rate of 2.9 percent, leading to increases in real incomes even in the poorest countries (Yeldan, 2007; United Nations, 2017). Throughout the Golden Age, the United Kingdom

emerged as a dominant political and economic power, largely due to the influence of the Bank of England, which played a central role in shaping the global banking system. Over time, this dominance shifted toward the United States and Wall Street, marking a significant transformation in global financial leadership (Kuruç, 2016).

In the 1950s, the Marshall Plan provided substantial economic assistance and reinforced U.S. influence in post-war Europe, thereby consolidating American hegemony. Developed under the guidance of George F. Kennan, the Marshall Plan embodied a comprehensive economic aid strategy for Western Europe. Although initially hesitant, Kennan later supported aid to Greece and Türkiye, recognizing its strategic and economic significance for the region. This development marked an important turning point in the early stages of the Cold War. Although the Soviet Union initially agreed to participate in the Bretton Woods system in July 1944, it withdrew from this commitment in December 1945. Post-war political uncertainty in Eastern Europe, particularly concerning Poland, hindered economic cooperation and dialogue (Pollard, 1985).

Following a period of geopolitical polarization, the Soviet Union secured the resources required for its economic system largely through coercive means, drawing primarily from defeated nations and, to some extent, allied states. In 1949, the Council for Mutual Economic Assistance (CMEA) was established with the aim of coordinating trade through credit and tax agreements among Eastern Bloc countries. Sanchez-Sibony (2014) identifies a parallel expansion of trade volumes in both the liberal world and the Soviet sphere. As global oil prices increased, the Soviet Union emerged as a major oil supplier. However, mounting challenges associated with the overvaluation of the U.S. dollar and its adverse effects on international trade culminated in the Nixon Shock—also referred to as the New Economic Policy—in 1971. In March 1973, six European currencies were allowed to float against the U.S. dollar, signaling the definitive end of the Bretton Woods era (Irwin, 2012).

Despite persistent inequalities in the global political economy following the Golden Age, rising incomes and relatively low inflation became widely observed trends. Nevertheless, a series of economic crises constrained productivity growth and long-term economic progress. In a bipolar world shaped by the Cold War, oil crises emerged as a central economic challenge. The oil shocks of 1971 and 1973 had a limited impact on Soviet output and the centrally planned economy. A noticeable decline in output occurred only in 1984, during the oil crises spanning the periods 1977–1982 and 1982–1988. During this time, the Soviet Union continued to meet the consumption needs of its member states while exporting energy resources to other Eastern Bloc countries. However, oil-related challenges in Western economies in 1989 exerted pressure on the Soviet Union, ultimately

leading to a reduction in oil production (Reynolds, 1998). The policies of *Glasnost* and *Perestroika*, introduced by Mikhail Gorbachev in 1991, accelerated the transition toward a market-oriented system and contributed to the dissolution of the Soviet Union. This transformation—encompassing social, political, and economic restructuring—proved to be complex, constrained, and uneven across regions.

Following the disintegration of the Soviet Union, the Central Asian and Caucasian Turkic republics gained independence and embarked on a transition toward democratic governance and free market economies. This process promoted market-oriented reforms alongside significant social change, positioning these countries as transition economies. The transition was often painful, as it required profound changes in social structures and institutional frameworks, leading to widespread societal disruption (Süleymanov, 2014). In the post-Soviet period, international development organizations played an increasingly prominent role in shaping and reforming public services within newly independent states (Bayramov and Orujova, 2017). However, institutional development, particularly the establishment of robust financial institutions capable of supporting economic growth, required sustained and targeted efforts.

In many transition economies, the banking sector remained underdeveloped due to deficiencies in central banking infrastructure, insurance systems, regulatory frameworks, and supervisory capacity. These structural weaknesses hindered the formation of resilient financial institutions and constrained economic growth (Hermes and Lensink, 2000; Bonin et al., 2014). From the dissolution of the Soviet Union until the early 2000s, the Turkic republics transitioned from centrally planned systems to market-oriented economies, each following a distinct path shaped by national conditions. In many of these countries, policymakers, administrators, and economists lacked experience with market-based economic systems. International institutions such as the International Monetary Fund and the World Bank, along with their technical experts, played a critical role in addressing these challenges (Pomfret, 2021). During the transition process, comprehensive reforms were implemented across social, economic, military, and political domains to mitigate vulnerability to external shocks and global economic volatility (Çetinkaya and Demirel, 2023).

Azerbaijan, Kazakhstan, and Turkmenistan—located in the Caspian Basin—possess substantial oil and natural gas reserves that have served as key drivers of economic growth (Bayramov and Orujova, 2017; Öge, 2015). These resource-rich countries were generally better positioned to implement reforms and manage financial challenges than Kyrgyzstan, which faced more limited economic capacity (Süleymanov, 2014). While privatization was relatively straightforward for small enterprises—often transferred to employees, the privatization of large-

scale firms proved more complex and contentious. In Kazakhstan, for example, favoritism and discrimination were reported during the privatization of state-owned assets, particularly in the mining sector. After 2000, expanding financial resources, foreign trade, and foreign exchange markets increased the demand for financial diversification across these economies (Pomfret, 2021).

Prior to the collapse of the Soviet Union, the financial systems of the Soviet republics consisted primarily of five state-controlled banks with regional branches. The insurance sector was dominated by the state-owned entity Gosstrakh, and pension funds provided only limited services. Moreover, foreign exchange and stock markets were virtually nonexistent. Following independence, state banks and their liabilities were transferred to the newly sovereign states. Although the financial sector has become a key driver of economic development, substantial differences remain across countries in terms of banking systems, capital markets, and regulatory and legal frameworks (Blackmon, 2007). Compared to early-transition European countries that exited the Soviet system, the delayed initiation of reforms in the Turkic republics has resulted in more pronounced structural gaps (Djalilov and Piesse, 2011; Akimov and Dollery, 2009).

3. CURRENT SITUATION OF FINANCE IN THE TURKIC WORLD AND RELATIONS WITH TURKIYE

Following the disintegration of the Soviet Union, Türkiye promptly recognized the sovereignty of the newly independent Turkic states in 1991. Subsequently, a state policy aimed at strengthening diplomatic relations among these countries was adopted. In this context, the Union of Turkic-Speaking Countries was established in 1992 (Çetinkaya and Demirel, 2023). Later, the Cooperation Council of Turkic-Speaking States—commonly known as the Turkic Council—was founded on October 3, 2009, under the Nakhchivan Agreement (Turkic States, 2009). The founding members of the Council were Azerbaijan, Kazakhstan, Kyrgyzstan, and Türkiye.

Formally referred to as the Turkic Council from 2010 onward, the organization convened its first summit in 2011 under the leadership of Kazakhstan, with a primary focus on promoting economic and commercial cooperation. Discussions at this summit covered a wide range of issues, including environmental protection, security, culture, social affairs, and selected economic matters (Turkic States, 2009; Akçapa, 2023; Keser et al., 2021). In 2019, Uzbekistan joined the Council, which was subsequently renamed the Organization of Turkic States at the Istanbul Summit in 2021. Today, the Organization ranks ninth globally in terms of population and seventh in terms of land area. It also plays a significant role in the global economy, with projections indicating that its combined GDP exceeded USD 1.3 trillion in 2023. This

significance stems not only from its economic scale but also from its geopolitical and strategic position (Çetinkaya and Demirel, 2023).

With the rising economic influence of Asian countries such as China, India, and Iran, competition in the global economy and the ability to exert regional influence have gained increasing importance. Türkiye maintains strong cultural, linguistic, social, and religious ties with the Turkic states, many of which can be characterized as late-transition economies (Megoran, 2004). The dissolution of the Soviet Union suggests that the relevance of the Heartland theory has not diminished but has instead re-emerged in a new form. Based on the principle that "whoever controls Eurasia controls the world," assessing the potential of the Organization of Turkic States requires consideration of the members' shared historical background.

As illustrated in Figure 1, Türkiye has recorded the strongest average GDP growth among the member states of the Organization of Turkic States, with an annual average of 4.63 percent since 1991. Azerbaijan experienced exceptionally high growth rates exceeding 25 percent between 2005 and 2007; however, growth declined sharply after 2008 and even turned negative in some years. Over the long term, Azerbaijan's average annual growth rate has been approximately 4 percent. Kazakhstan recorded its highest growth following its dissolution in 2006, while its average growth rate over the past 32 years stands at 2.88 percent. The Kyrgyz Republic experienced rapid growth in 2013 but ranks last among the six countries with an average annual growth rate of 1.69 percent. Turkmenistan, Türkiye, and Uzbekistan recorded average growth rates of 4.39 percent, 4.63 percent, and 4.40 percent, respectively.

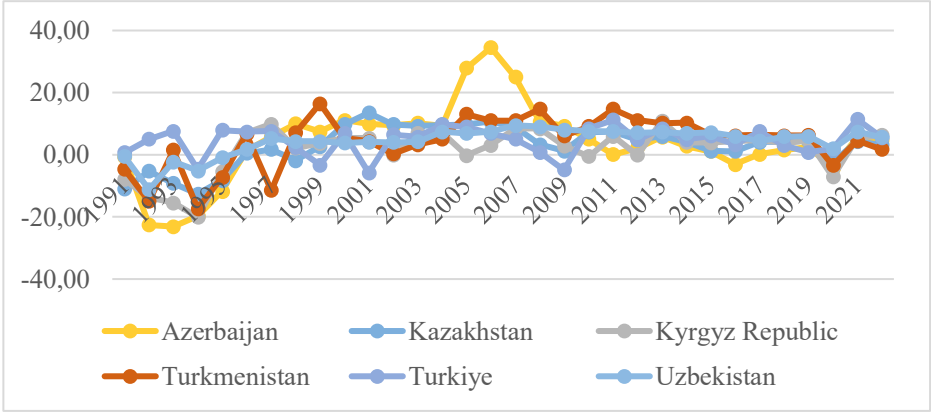

Figure 1. Annual Growth Rate of Organization of Turkic World, Source: Worldbank (2024)

Figure 2 presents the share of Türkiye's imports and exports with the Turkic states as a percentage of its total trade over the past five years. The data indicate that imports from and exports to each of these countries consistently account for approximately 1 percent of Türkiye's total imports and exports. In 2019, Kazakhstan ranked 48th among Türkiye's export destinations and 33rd among import sources. By 2023, Azerbaijan ranked 24th and Kazakhstan 31st among Türkiye's export partners. These figures remain relatively low when compared with Türkiye's trade volumes with European Union countries.

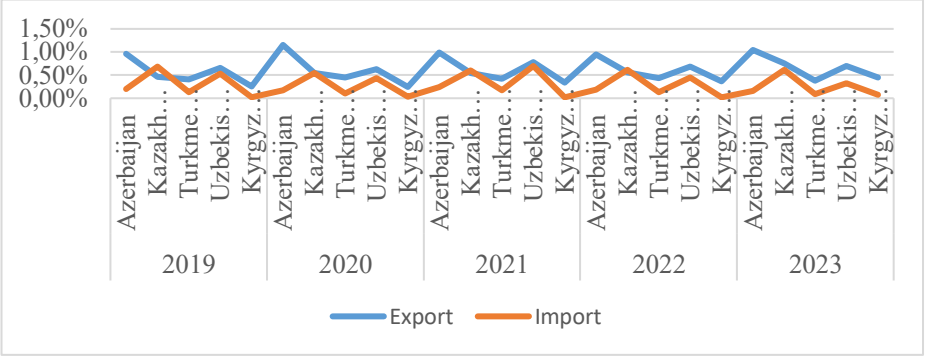

Figure 2. The percentage share of Turkey's imports and exports with the Turkish States
Source: Compiled from TURKSTAT (2024) export and import figures by country.

From a financial sector perspective, Figure 3 shows that the number of ATMs per 100,000 people in Kazakhstan has increased steadily since 2004. When considered alongside data from 2019, 2020, and 2021, this trend indicates significant recent developments in Kazakhstan's banking and financial sector. Notably, the number of ATMs per capita in Kazakhstan exceeds the OECD average. This expansion may partly reflect state-led reforms aimed at reducing informality and promoting economic development, as the dominance of the market economy gradually reshaped past practices (Oka, 2015; Kredina, 2021; Kredina et al., 2024). In contrast, ATM penetration remains lower in countries such as Azerbaijan, Kyrgyzstan, and Uzbekistan.

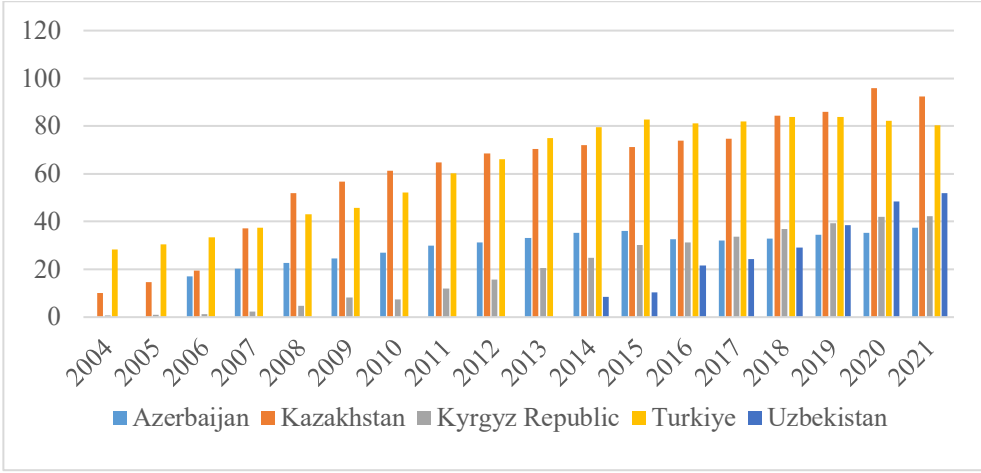

Figure 3. The number of ATMs per 100,000 people Source: Worldbank,2024

A different pattern emerges with respect to the number of commercial banks per 100,000 people. As shown in Figure 4, Uzbekistan leads other member states in this regard. In Uzbekistan, where commercial banks largely operate under state dominance (Babasyan et al., 2023), the Central Bank introduced early reforms in clearing and accounting systems, including the use of international auditing services by commercial banks (Akimov and Dollery, 2009). This relative advantage may be attributed to factors such as the influence of the Eximbank system, the non-convertibility of the national currency (Blackmon, 2007), the use of the banking sector for non-performing loans, and its role in tax collection and the monitoring of business activities (Ruziev et al., 2007).

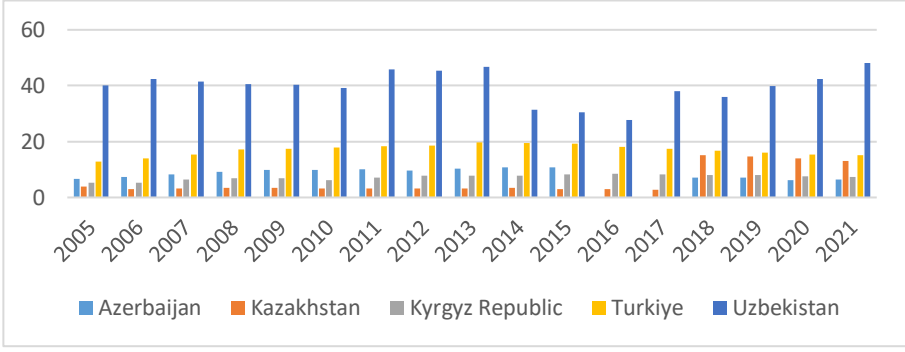

Figure 4. The number of commercial banks per 100,000 people Source: Worldbank,2024

Except for Türkiye, all countries in the region maintain long-standing political, economic, and cultural ties with Russia, reflecting both the legacy of Soviet governance and the presence of significant Russian populations within their borders. The Russia–Ukraine war has had substantial economic and

financial implications for these countries. Türkiye, owing to its strategic geopolitical position and active diplomacy, has emerged as a key stabilizing actor in the region. Nevertheless, significant economic repercussions are expected, particularly for countries such as Kyrgyzstan and Kazakhstan, which are deeply involved in trade in oil and grain with Russia. An examination of the MIR credit card system requires consideration of the historical development of the Central Bank of the Russian Federation under the Soviet system. Prior to the introduction of the MIR card system in 2015, there was no domestic credit card network in Russia. As of September 20, 2022, MIR cards were accepted in eleven countries, including Türkiye, Uzbekistan, Kazakhstan, and Kyrgyzstan. In Türkiye, İşbank was the first financial institution to adopt the MIR system for use at ATMs and affiliated merchants (Başaran, 2022). However, following the announcement by the U.S. Treasury's Office of Foreign Assets Control (OFAC) that sanctions would be imposed on entities facilitating the expansion of the MIR system outside Russia, Turkish banks such as İşbank and Denizbank withdrew from the system (Bloomberght, 2022). As tensions surrounding the MIR payment system intensified, a series of bilateral meetings were held between Türkiye and Russia. During these discussions, President Recep Tayyip Erdoğan emphasized the need to explore alternative payment mechanisms, particularly given the system's importance for the tourism sector (Bloomberg, 2022). The implementation of the MIR system has generated challenges not only in Türkiye but also in other participating countries, including Kyrgyzstan and Kazakhstan (TRT, 2022).

In this context, the significance of the Turkic States Banking Associations Council Agreement lies in its potential to identify alternative policy options and strategic pathways for Türkiye and other member states. Signed as part of a broader economic cooperation framework within the Organization of Turkic States, this agreement represents a recent initiative aimed at strengthening and advancing the banking sector across member countries. Discussions led by the Turkish Banking Association have focused on sectoral development and its broader implications, including experience-sharing to support real-sector production, the creation of shared platforms for banking data, and the expansion of digital banking solutions (TBB, 2022).

4. LITERATURE REVIEW

The literature on financial inclusion is extensive. Gálvez-Sánchez et al. (2021) conducted a comprehensive review of approximately 1,731 academic articles examining financial inclusion from multiple perspectives. Covering a period of nearly 35 years, their analysis reveals a notable increase in scholarly output after 2005. At the macroeconomic level, the implications of financial inclusion are primarily associated with three key dimensions: economic growth, financial stability, and inequality. At the microeconomic level, research commonly focuses

on individuals' participation in the financial system at national or regional scales, emphasizing demand- and supply-side factors related to banking activities. In this context, only selected studies from the existing literature are discussed. Several studies indicate that financial literacy, awareness of banking services, governance, religion, and income level play significant roles as determinants of financial inclusion (Akudugu, 2013; Ozili et al., 2023).

Using Global Findex data and a probit model, Zins and Weill (2016) examined the determinants of financial inclusion in African countries and found that income level, education, age, and gender significantly influence financial inclusion. Similarly, Soumaré et al. (2016) analyzed the characteristics determining financial inclusion in Central and West Africa. Their findings highlight a significant association between gender and marital status in Central Africa, as well as a strong relationship between income and financial inclusion in West Africa. Moreover, the study provides evidence that household size exerts a negative effect on financial inclusion in West Africa.

Recent research by Shabir and Ali (2022) demonstrates that gender inequality has a detrimental impact on financial inclusion in Saudi Arabia. Likewise, Ndoya and Tsala (2021) find that income and educational disparities play a crucial role in shaping gender-based inequalities in financial inclusion in Cameroon. In the context of India, Dar and Ahmed (2020) show that gender, age, education, and income significantly affect various indicators of financial inclusion. In relatively higher-income regions, such as Southern Europe, low levels of financial inclusion have been observed to affect both women and individuals residing in rural areas, with a higher prevalence among these groups (Jahja, 2022).

In a study on Vietnam, Anh and Thuy (2023) conclude that individuals with lower levels of education and income exhibit lower financial inclusion, emphasizing the need for policies aimed at reducing income inequality and poverty in low-income countries. Another study analyzing data from twenty Asian countries between 2011 and 2016 finds that countries with higher economic growth and income levels tend to display greater financial inclusion. Additionally, individuals with higher levels of education and employment are more likely to participate in the formal financial system (Le et al., 2019).

Research focusing on Central Asia and the South Caucasus following the dissolution of the Soviet Union reports relatively low rates of account ownership, particularly in Azerbaijan (28.6%) compared to other countries. In Kazakhstan, account ownership stands at 58.7%, while the rate is 39.9% in the Kyrgyz Republic and 37.1% in Uzbekistan, with even lower levels observed in rural areas. Among these countries, Kazakhstan exhibits a comparatively higher proportion of women holding accounts (60.3%). These outcomes are largely attributed to limited trust in the banking sector and persistent political and

economic instability following the collapse of the Soviet Union. Financial access is further constrained by weak credit assessment systems and stringent collateral requirements. As a result, financial inclusion remains limited, even in countries with relatively higher per capita income, such as Azerbaijan and the Kyrgyz Republic (Morgan et al., 2018).

A study encompassing all transition economies that emerged from the Soviet Union indicates that Uzbekistan possesses a comparatively weaker financial foundation than Azerbaijan and Kazakhstan. Despite recent initiatives aimed at promoting gender inclusion and financial literacy at the national level, most households in Uzbekistan continue to rely on traditional saving and borrowing practices rather than formal financial services (Ahunov, 2018).

Similarly, in Kazakhstan, barriers to financial inclusion stem from the absence of a comprehensive state-level policy framework on financial inclusion and financial education. As a transition economy, Kazakhstan also faces challenges related to limited institutional development, the persistence of usury practices, and the uneven diffusion of infrastructure and telecommunications across the country, all of which hinder financial inclusion (Kapparov, 2018). In the case of Azerbaijan, Ibadoghlu (2018) emphasizes structural weaknesses in the financial system, imbalances in central bank activities, the dominance of oil prices in macroeconomic conditions, and low levels of financial education and inclusion in both quantitative and qualitative terms.

5. METHODOLOGY

The microdata used in this study was obtained from the Global Findex 2017 survey, publicly released by the World Bank. The survey was conducted by Gallup Inc. and covered approximately 140 economies across eight regions, with an average sample size of about 1,000 individuals per country (Global Findex, 2017). Although the analysis initially aimed to utilize the most recent publicly available data from the Global Findex 2021 report, data collection for Azerbaijan was not feasible due to the disruptions caused by the COVID-19 pandemic. Therefore, data from the 2017 survey were employed as a substitute.

Table 1 presents the variables and related indicators used in the analysis. The study includes Azerbaijan, Kazakhstan, the Kyrgyz Republic, Türkiye, and Uzbekistan as member states of the Organization of Turkic States, as well as Turkmenistan, which holds observer status.

Table 1. Descriptive statistics of dependent and independent variables used in the analysis by country.

Possibility of coming up with emergency funds	Not Possible	N	290	407	240	256	223	221	1637
		%	17,7%	24,9%	14,7%	15,6%	13,6%	13,5%	100,0%
	Possible	N	453	402	688	629	616	733	3521
		%	12,9%	11,4%	19,5%	17,9%	17,5%	20,8%	100,0%
Gender	Female	N	367	461	608	433	384	579	2832
		%	13,0%	16,3%	21,5%	15,3%	13,6%	20,4%	100,0%
	Male	N	376	348	320	452	455	375	2326
		%	16,2%	15,0%	13,8%	19,4%	19,6%	16,1%	100,0%
Respondent is in the workforce	out of workforce	N	189	307	465	314	250	350	1875
		%	10,1%	16,4%	24,8%	16,7%	13,3%	18,7%	100,0%
	in workforce	N	554	502	463	571	589	604	3283
		%	16,9%	15,3%	14,1%	17,4%	17,9%	18,4%	100,0%
Age Categories	15-25	N	155	119	161	199	232	192	1058
		%	14,7%	11,2%	15,2%	18,8%	21,9%	18,1%	100,0%
	26-35	N	184	205	197	257	205	237	1285
		%	14,3%	16,0%	15,3%	20,0%	16,0%	18,4%	100,0%
	36-45	N	151	192	154	190	161	151	999
		%	15,1%	19,2%	15,4%	19,0%	16,1%	15,1%	100,0%
	46-55	N	128	115	172	136	129	153	833
		%	15,4%	13,8%	20,6%	16,3%	15,5%	18,4%	100,0%
	56+	N	125	178	244	103	112	221	983
		%	12,7%	18,1%	24,8%	10,5%	11,4%	22,5%	100,0%
Within-economy household income quintile	Poorest 20%	N	114	147	168	121	127	179	856
		%	13,3%	17,2%	19,6%	14,1%	14,8%	20,9%	100,0%
	Second 20%	N	143	144	165	130	168	168	918
		%	15,6%	15,7%	18,0%	14,2%	18,3%	18,3%	100,0%
	Middle 20%	N	136	167	189	165	161	187	1005
		%	13,5%	16,6%	18,8%	16,4%	16,0%	18,6%	100,0%
	Fourth 20%	N	148	174	188	189	173	188	1060
		%	14,0%	16,4%	17,7%	17,8%	16,3%	17,7%	100,0%
	Richest 20%	N	202	177	218	280	210	232	1319
		%	15,3%	13,4%	16,5%	21,2%	15,9%	17,6%	100,0%
Respondent education level	completed primary or less	N	98	67	113	197	26	158	659
		%	14,9%	10,2%	17,1%	29,9%	3,9%	24,0%	100,0%
	Secondary	N	505	505	620	571	711	689	3601
		%	14,0%	14,0%	17,2%	15,9%	19,7%	19,1%	100,0%
	completed tertiary or more	N	140	237	195	117	102	107	898
		%	15,6%	26,4%	21,7%	13,0%	11,4%	11,9%	100,0%
Total		N	743	809	928	885	839	954	5158
		%	14,4%	15,7%	18,0%	17,2%	16,3%	18,5%	100,0%

The sample consists of individuals from multiple countries in the region. Specifically, 14.0% of the sample is drawn from Azerbaijan, 15.7% from Kazakhstan, 18.0% from the Kyrgyz Republic, 17.2% from Türkiye, 16.3% from Turkmenistan, and 18.5% from Uzbekistan.

The Kyrgyz Republic exhibits the highest proportion of individuals without a debit card, accounting for 23.6% of the total sample. Uzbekistan records the highest share of individuals without credit card ownership, at 21.5%, exceeding all other countries in the sample. Kazakhstan shows the highest proportion of individuals unable to meet an immediate financial need, with a rate of 24.9%. In terms of labor market participation, the Kyrgyz Republic has the largest share of individuals outside the workforce, at 24.8%, compared to the other countries included in the analysis.

The logit model was employed to analyze the data. The logit model, also referred to as binomial logistic regression, was initially conceptualized as a population growth model (Cramer, 2002). The term "logit" was first introduced by Berkson in 1944, and the model was later formally developed by Cox in 1958. Logistic regression is a type of generalized linear model that estimates the probability of an event occurring as a function of a set of independent variables. It is particularly suitable when the dependent variable is binary, taking on only two possible outcomes.

The primary objective of the logit model is to transform a binary dependent variable into a continuous probability measure bounded between zero and one. This process begins with estimating the probability of the occurrence of an event at different levels of the independent variables. Subsequently, the probability is transformed using a logarithmic function, following the approach proposed by Long (1997). Equation (1) represents a basic linear model. However, since $Y_i$is a discrete random variable, the use of a linear probability model is not appropriate for prediction purposes. In this case, the probability of $Y_i$must be expressed as a nonlinear function of the regressor X_i. Accordingly, Equation (2) presents the conditional probability of Ytaking the value of 1, as defined by Cramer (2003).

$$Z_i = b_1 + b_2 X_1 \quad (1)$$

$$P_i = E(Y = 1|X) = \frac{1}{1+e^{-(b_1+b_2X_1)}} = 1 - P = 1 - \frac{1}{1+e^{-Z_i}} \quad (2)$$

The logit p ratio, as depicted in Equation 4, is obtained by applying the logarithm function to both sides of the logistic model presented in Equation 3. In this equation, both Xi and the parameters are linear. The variable Q is defined as a continuous random variable that can assume values from positive infinity to

negative infinity. The logarithm of odds, often known as the logistic function of probability, is mathematically defined by the following equation:

$$logit\ p = \ln p \tag{3}$$

$$1-p\ and\ 0 < p < 1 \tag{4}$$

The Hosmer–Lemeshow test is employed to assess the goodness-of-fit of the estimated model. An adequate model fit is indicated when the significance level of the test exceeds 0.05. As an alternative approach to evaluating model adequacy, classification performance is examined through correct classification rates. This involves analyzing the cross-tabulation between individuals' actual observed outcomes and the outcomes predicted by the logistic regression model. In this study, model performance is evaluated using standard classification measures, namely sensitivity, specificity, and overall accuracy (Hosmer and Lemeshow, pp. 143–163).

The initial stage of the empirical analysis employs a logit model to examine the determinants of account ownership. This model is estimated using a pooled dataset that includes all countries in the sample (Model 1, Equation 5). Subsequently, a separate logit model is estimated for each country to identify country-specific factors associated with account ownership (Model 2, Equation 6). In this framework, $Y_i$denotes account ownership, measured by whether an individual holds a debit card, which serves as an indicator of financial inclusion, while $i$represents an individual observation.

$$Y_i = \beta_0 + \beta_1 Creditcard + \beta_2 Emergencyfund + \beta_3 Gender + \beta_4 Workforce + \beta_5 Agecat + \beta_6 Income + \beta_7 Education + \beta_8\ Country + \varepsilon_i \tag{5}$$

$$Y_i = \beta_0 + \beta_1 Creditcard + \beta_2 Emergencyfund + \beta_3 Gender + \beta_4 Workforce + \beta_5 Agecat + \beta_6 Income + \beta_7 Education + \varepsilon_i \tag{6}$$

6. FINDINGS

Table 2 reports the results of the pooled logit model (Model 1) estimating the determinants of account ownership, with Türkiye used as the reference country. The table presents coefficient estimates, odds ratios, average marginal effects, and corresponding significance levels. The results indicate that several individual-level characteristics as well as country-specific factors significantly influence the likelihood of holding an account. Gender does not appear to have a

statistically significant effect on account ownership. The odds ratio associated with gender is 0.986, suggesting that males have nearly the same odds of holding an account as females once other covariates are controlled for. The estimated coefficient is small and statistically insignificant, indicating that gender-based differences in account ownership are not present in the pooled sample.

Employment status emerges as a strong and statistically significant determinant of account ownership. The odds ratio of 2.608 indicates that employed individuals are approximately 2.6 times more likely to hold an account than unemployed individuals. This result highlights the importance of labor market attachment in facilitating access to formal financial services. Credit card ownership is the most influential explanatory variable in the model. With an odds ratio of 6.791, individuals who own a credit card have nearly 6.8 times higher odds of holding an account compared to those without a credit card. This strong association underscores the close link between access to formal credit instruments and broader participation in the financial system. The ability to meet emergency financial needs also has a positive and statistically significant effect on account ownership. An odds ratio of 1.523 indicates that individuals with access to emergency funds are about 1.5 times more likely to have an account than those who lack such financial capacity. This finding suggests that financial resilience and account ownership tend to move together.

Age has a positive and statistically significant, though relatively modest, effect on account ownership. The odds ratio of 1.027 implies that each additional year of age increases the odds of having an account by approximately 2.7 percent, holding other factors constant. This result indicates a gradual increase in financial system participation over the life cycle. Educational attainment is a key determinant of account ownership. Relative to individuals with primary education or less, those with secondary education have an odds ratio of 1.795, indicating that they are about 1.8 times more likely to hold an account. The effect is substantially stronger for individuals with tertiary education or higher, whose odds ratio of 4.694 suggests nearly 4.7 times higher odds of account ownership. These results point to a pronounced positive gradient between education level and financial inclusion.

Income level also affects account ownership, though the relationship is nonlinear. Compared to individuals in the poorest income quintile, those in the second quintile do not exhibit significantly different odds of account ownership. However, individuals in the middle-income quintile have an odds ratio of 1.400, indicating 1.4 times higher odds of holding an account. This effect strengthens further in the fourth quintile, with an odds ratio of 1.533, and in the richest quintile, where the odds ratio reaches 1.684. These findings suggest that

meaningful improvements in account ownership emerge primarily beyond the lowest income groups.

Table 2. Model 1 Logit Analysis

Dependent Variable:Has an Account (Yes =1, No:0)	Coef.	expb	dy/Dx	z	P>|z|
Gender (Female=0, Male=1)	-0,0137	0,986	-0,003	-0,20	0,84
Employment (Yes=1, No=0)	0,9587	2,608	0,234	12,28	0,00*
Credit Card (Yes=1, No=0)	1,9156	6,791	0,467	14,38	0,00*
Emergency Fund (Yes=1, No=0)	0,4209	1,523	0,103	5,44	0,00*
Age	0,0270	1,027	0,007	11,93	0,00*
Education (Base:c primary or less)					
Secondary	0,5849	1,795	0,129	4,98	0,00*
completed tertiary or more	1,5462	4,694	0,364	11,03	0,00*
Income Level (Base: Poorest %20)					
Second %20	0,1374	1,147	0,032	1,18	0,24
Middle %20	0,3368	1,400	0,080	2,97	0,00*
Fourth %20	0,4271	1,533	0,102	3,80	0,00*
Richest % 20	0,5212	1,684	0,125	4,71	0,00*
Country (Base:Turkey)					
Azerbaijan	-1,3802	0,252	-0,330	-10,32	0,00*
Kazakhstan	-1,1129	0,329	-0,266	-8,57	0,00*
Kyrgyz Republic	-1,9728	0,139	-0,455	-14,81	0,00*
Turkmenistan	-0,8520	0,427	-0,201	-6,58	0,00*
Uzbekistan	-1,6545	0,191	-0,391	-12,75	0,00*
Constant	-2,3946	0,091		-12,93	0,00

* p<0,01

Country-specific effects reveal substantial differences in account ownership relative to Türkiye. Individuals in Azerbaijan have an odds ratio of 0.252, indicating approximately 75 percent lower odds of holding an account compared to individuals in Türkiye. In Kazakhstan, the odds ratio of 0.329 implies that individuals are about 67 percent less likely to have an account relative to Türkiye. The Kyrgyz Republic exhibits the lowest odds ratio, at 0.139, corresponding to approximately 86 percent lower odds of account ownership. Turkmenistan shows an odds ratio of 0.427, indicating about 57 percent lower odds relative to Türkiye, while Uzbekistan records an odds ratio of 0.191, corresponding to roughly 81 percent lower odds. All country effects are statistically significant at the 1 percent level. Overall, the results indicate that even after controlling employment status, income, education, age, and access to complementary financial instruments, substantial and statistically significant cross-country differences in account

ownership persist. Türkiye stands out with markedly higher odds of account ownership compared to other Turkic States, suggesting that country-level institutional and financial system characteristics play a decisive role alongside individual socioeconomic factor.

Table 3 presents the results of the country-specific logit analyses examining the determinants of account ownership across the selected Turkic States. The estimations reveal that the factors influencing account ownership vary across countries, although some common patterns emerge. In Azerbaijan, gender, employment status, credit card ownership, age, education, and income distribution all have statistically significant effects on the probability of holding an account ($p < 0.05$).

Table 3. Model 2 Logit Analysis

Country	**Azerbaijan**		**Kazakhstan**		**Kyrgyz Republic**		**Turkiye**		**Turkmenistan**		**Uzbekistan**	
Odds Ratio and Marginal Effects	$\exp(\beta)$	dy/dx	$\exp(\beta)$	dy/dx	$\exp(\beta)$	dy/dx	$\exp(\beta)$	dy/dx	$\exp(\beta)$	dy/dx	$\exp(\beta)$	dy/dx
Gender (Base: Male)	0,668	-0,091*	0,843	-0,043	0,916	-0,015	1,996	0,0883*	1,261	0,056*	1,070	0,013
Employment (Base: Yes)	2,198	0,178*	1,873	0,157*	1,497	0,070*	3,488	0,1597*	7,081	0,471*	1,536	0,081*
Credit Card (Base: Yes)	2,822	0,235*	5,981	0,447*	7,671	0,351*	1,160	0,3133*	***	***	2,088	0,138
Emergency Fund (Base: Yes)	0,991	-0,002	1,516	0,104	2,025	0,122*	1,321	0,0356	2,009	0,168	1,838	0,114*
Age (Base: 15-25)												
Age 26-35	2,185	0,131*	1,161	0,037	2,518	0,131*	2,059	0,1121*	2,436	0,190*	2,373	0,131*
Age 36-45	2,240	0,136*	1,187	0,042	2,464	0,127*	1,542	0,0732	5,353	0,384*	1,997	0,099*
Age 46-55	2,418	0,152*	1,178	0,040	2,177	0,105*	2,623	0,1391*	4,724	0,354*	2,608	0,150*
Age 56+	2,672	0,676*	1,940	0,164*	3,122	0,173*	5,679	0,1974*	1,490	0,077	4,251	0,257*
Education (Base: Primary or less)												
Education: Secondary	1,339	0,058	1,816	0,138	1,402	0,050	2,510	0,1442*	4,499	0,252*	2,048	0,110*
Education: Tertiary or more	4,412	0,344*	4,479	0,358*	2,376	0,151*	3,723	0,1832*	2,449	0,645*	5,841	0,348*
Income quartile (Base: Poorest 20%)												
Income quartile: Second 20%	1,175	0,029	1,189	0,042	1,294	0,042	0,627	-0,0793	1,267	0,055	1,004	0,001
Income quartile: Middle 20%	1,619	0,094	2,052	0,178*	1,243	0,035	1,267	0,0323	1,324	0,065	1,145	0,024
Income quartile: Fourth 20%	2,669	0,210*	1,479	0,096	1,173	0,025	2,170	0,0882*	1,327	0,066	1,376	0,059
Income quartile: Richest 20%	3,064	0,244*	1,799	0,145*	1,583	0,079	1,269	0,0326	1,723	0,130	1,459	0,071
Constant	0,039		0,091		0,031		0,077		0,006		0,028	
Mean VIF	1,12		1,13		1,07		1,25		1,08		1,08	
N	743,000		809,000		928,00		885,00		839,00		954,00	
LR chi2(14)	247,160		198,070		102,27		381,50		327,40		120,23	
Prob>chi2	0,000		0,000		0,00		0,00		0,00		0,00	
Log-Likelihood	-367,639		-461,393		-466,27		-321,48		-412,68		-505,45	
Pseudo R2	0,252		0,177		0,10		0,37		0,28		0,11	
Hosmer-Lemeshow chi2(8)	10,300		8,380		10,04		5,45		16,13		14,27	
Prob>chi2	0,245		0,397		0,262		0,709		0,078		0,075	

*p<0.05

In Azerbaijan, women are more likely to have an account than men, with a marginal effect of 9 percent. Employment significantly increases account ownership, as employed individuals are 17.8 percentage points more likely to hold an account than unemployed individuals. Credit card ownership also plays a substantial role, increasing the probability of account ownership by 23.5 percentage points. Age effects are positive and increasing across cohorts; individuals aged 56 and above have a 67.6 percentage point higher probability of holding an account compared to those aged 15–25. Education is another key determinant, as individuals with tertiary education exhibit a 34.4 percentage point higher probability of account ownership relative to those with primary education or less. Income effects are observed mainly at the upper end of the distribution, with individuals in the fourth and richest income quintiles being 21.0 and 24.4

percentage points more likely, respectively, to hold an account than those in the poorest quintile.

In Kazakhstan, employment status and credit card ownership emerge as the most influential determinants of account ownership. Employed individuals are 15.7 percentage points more likely to have an account than unemployed individuals, while credit card ownership raises this probability by 44.7 percentage points. Among the age variables, only individuals aged 56 and above show a statistically significant difference, with a 16.4 percentage point higher probability of account ownership compared to the 15–25 age group. Education has a strong effect, as individuals with tertiary education or higher are 35.8 percentage points more likely to hold an account. Income effects are significant only for the richest income quintile, where individuals exhibit a 14.5 percentage point higher probability of account ownership relative to the poorest group ($p < 0.05$).

In the Kyrgyz Republic, statistically significant determinants of account ownership include employment status, credit card ownership, access to emergency funds, age, and tertiary education. Employment increases the likelihood of account ownership by 7 percentage points, while credit card ownership raises it by 35.5 percentage points. Individuals who are able to meet urgent financial needs have a 12.2 percentage point higher probability of holding an account. Age effects are statistically significant across all age groups when compared to the 15–25 reference group, indicating a steady increase in account ownership with age. Tertiary education increases the probability of holding an account by 15.1 percentage points relative to primary education or less. A notable result for the Kyrgyz Republic is the absence of statistically significant differences in account ownership across income quartiles, suggesting that income level does not play a decisive role in determining account ownership.

In Türkiye, gender is a statistically significant determinant of account ownership, with men being more likely to hold an account than women. The marginal effect indicates an 8.8 percentage point difference in favor of men. Employment increases the probability of account ownership by 15.9 percentage points, while credit card ownership raises it by 31.3 percentage points. Age effects are mixed; no statistically significant difference is observed between individuals aged 36–45 and those aged 15–25, whereas individuals aged 26–35, 46–55, and 56 and above exhibit higher probabilities of account ownership, with marginal effects of 11.2, 13.9, and 19.7 percentage points, respectively. Education plays a significant role, as individuals with tertiary education or higher are 18.3 percentage points more likely to have an account than those with basic education. An interesting finding for Türkiye is that individuals in the fourth income quintile, rather than the richest quintile, have the highest probability of

account ownership, with an 8.8 percentage point increase relative to the poorest group.

In Turkmenistan, gender differences are statistically significant, with men having a 5.6 percentage point higher probability of holding an account than women. Employment has a particularly strong effect, increasing the probability of account ownership by 47.1 percentage points. Age also plays a significant role; individuals aged 26–35, 36–45, and 46–55 are 19.0, 38.4, and 35.4 percentage points more likely, respectively, to hold an account compared to those aged 15–25. Education is strongly associated with account ownership, as secondary and tertiary education increases the probability of holding an account by 25.2 and 64.5 percentage points, respectively. Similar to the Kyrgyz Republic, income quartiles in Turkmenistan do not show statistically significant effects on account ownership.

In Uzbekistan, employment and access to emergency funds significantly increase the likelihood of account ownership. Employed individuals are 8.1 percentage points more likely to have an account, while those with access to emergency cash exhibit an 11.4 percentage point higher probability. The emergency fund variable is statistically significant only in the contexts of Kyrgyzstan and Uzbekistan. Age effects are statistically significant across all age categories above 25, with individuals aged 56 and above showing a 25.7 percentage point higher probability of account ownership compared to the 15–25 reference group. Education also plays a decisive role, as individuals with secondary education are 11.0 percent more likely to have an account, and those with tertiary education are 34.8 percent more likely, compared to individuals with primary education or less. In contrast, income groups do not exhibit statistically significant effects on account ownership in Uzbekistan ($p > 0.05$).

Diagnostic tests indicate that the estimated logit models satisfy the necessary assumptions. The mean variance inflation factor (VIF) values reported in Table 3 are well below the conventional threshold, indicating no multicollinearity concerns. Likelihood ratio tests confirm that all models are jointly significant (Prob > $chi^2 = 0.000$). Furthermore, the Hosmer–Lemeshow goodness-of-fit tests indicate no specification errors, as the null hypothesis cannot be rejected. Finally, ROC analyses conducted separately for each country show that all models have satisfactory discriminatory power (see Annex 1).

7. DISCUSSION AND CONCLUSION

This study examined the determinants of account ownership as a core indicator of financial inclusion in the countries of the Turkic world. The results obtained from the pooled logit model reveal that employment status, education level, age, and income are statistically significant determinants of account

ownership across the region. These findings indicate that financial inclusion in the Turkic States cannot be understood solely as a financial sector issue but must be evaluated within a broader socio-economic framework. In this context, policies aimed at increasing labor force participation, improving educational attainment, and supporting income-generating opportunities are likely to play a decisive role in expanding access to financial services.

One of the most striking results of the pooled analysis is the comparatively higher level of financial inclusion observed in Türkiye relative to other countries in the sample. This outcome can be attributed to the relatively advanced structure of the banking and financial system in Türkiye, as well as its institutional capacity, regulatory framework, and long-standing experience in financial intermediation. The results suggest that the maturity of financial institutions and the effectiveness of governance mechanisms significantly shape individuals' integration into the financial system.

Country-specific estimations reveal considerable heterogeneity in the determinants of financial inclusion across the Turkic States. Gender emerges as a statistically significant factor only in Türkiye and Turkmenistan, where men are more likely to own bank accounts than women. This pattern reflects persistent gender-based disparities in income, employment, and educational opportunities, indicating the need for gender-sensitive financial inclusion strategies in these countries. In contrast, Azerbaijan presents a distinct case in which women exhibit a higher probability of account ownership than men, suggesting that country-specific social, cultural, and institutional dynamics play an important role in shaping financial behavior.

Another noteworthy finding concerns the role of income. While income level significantly affects account ownership in Türkiye, Azerbaijan, and Kazakhstan, it does not appear to be a statistically significant determinant in Kyrgyzstan, Uzbekistan, and Turkmenistan. This result deviates from much of the existing literature and suggests that in some transition economies, higher income alone is insufficient to ensure financial inclusion. Structural factors such as inadequate financial infrastructure, limited access to banking services, weak institutional capacity, and low levels of trust in financial institutions may prevent income gains from translating into greater participation in the formal financial system.

The analysis further demonstrates that education and age are consistently important determinants of account ownership across all countries examined. Individuals with higher levels of education, particularly tertiary education, are substantially more likely to have bank accounts, underscoring the importance of human capital development in promoting financial inclusion. Similarly, the positive relationship between age and account ownership suggests that experience, financial awareness, and accumulated economic activity contribute

to greater engagement with financial institutions. These findings are largely consistent with previous studies in literature, including Akudugu (2013), Zins and Weill (2016), Dar and Ahmed (2020), and Anh and Thuy (2023).

The significance of variables such as credit card ownership and the ability to meet emergency financial needs highlights the multidimensional nature of financial inclusion. Access to complementary financial instruments enhances individuals' financial resilience and deepens their integration into the financial system. In particular, the significance of emergency fund availability in Kyrgyzstan and Uzbekistan aligns with findings by Ahunov (2018) and suggests that short-term liquidity constraints remain a major barrier to financial inclusion in these economies.

Overall, this study contributes to the literature by providing a comprehensive micro-level analysis of financial inclusion within a culturally and historically coherent economic bloc. By combining pooled and country-specific logit models, the study demonstrates that the determinants of financial inclusion vary significantly across countries, challenging the assumption of uniform drivers across transition economies. The findings emphasize the importance of context-specific policies and caution against one-size-fits-all approaches to financial inclusion.

Future research may build on these results by examining the roles of digital financial technologies, governance quality, religious and cultural norms, and institutional trust in shaping financial inclusion outcomes in the Turkic world. Comparative analysis with other regional organizations could further enrich understanding of how economic blocs influence access to financial services. Such research would contribute to the design of more inclusive, resilient, and sustainable financial systems in the region.

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CHAPTER 11

The Effects of Digitalization on Motor Development in Childhood

Leyla Ulus[1]

[1] Assoc.Prof. İstanbul University-Cerrahpasa, ORCID: 0000-0002-5483-0224

1. Introduction

The rapid technological transformation of the digital age has fundamentally reshaped children's daily practices, habits, and modes of social interaction, as much as those of adults. In recent years, major advances in mobile devices, online media platforms, and gaming technologies have significantly altered children's experiences both at home and in educational settings. Children's engagement with the digital world is no longer limited to television screens; touchscreen tablets, smartphones, sensor-based devices, and applications based on augmented reality (AR) and virtual reality (VR) have become integral components of everyday childhood experiences.

In particular, AR and VR technologies have emerged as innovative tools that offer new opportunities for the development of children's cognitive, social, and motor skills. AR-based applications enable children to interact simultaneously with the physical world and digital content, potentially supporting hand–eye coordination, spatial awareness, and fine motor skills. VR experiences, in turn, may contribute to motor development through fully immersive activities that involve bodily movement, balance, and motor planning. At the same time, the increasing prevalence of these technologies has intensified debates concerning the appropriate age of exposure, duration of use, and nature of digital content for children.

The rapid expansion of digital tool use has introduced children to screen-based technologies at increasingly younger ages, rendering online education, digital games, VR-based movement activities, and AR-supported learning applications inseparable from contemporary childhood. This transformation necessitates an examination of the effects of digitalization on children's motor development not only from a risk-oriented perspective, but also with attention to its potentially supportive aspects. Today, digital games, VR-based movement activities, AR-compatible learning materials, and mobile devices are widely regarded as influential environmental factors shaping children's motor skills, sensorimotor integration, and levels of physical activity. The decreasing age of first exposure to digital content, the steady increase in screen time, and the rapid diffusion of VR–AR applications have made it more important than ever to investigate the impact of screen-based technologies on motor development within an interdisciplinary framework.

In parallel with these developments, motor skill acquisition has re-emerged as a central topic of interest in developmental science. This renewed attention can be explained, at least in part, by the fundamental role of the sensorimotor system in child development: numerous studies have demonstrated that the acquisition of motor skills may influence developmental domains beyond motor functioning itself (Focaroli et al., 2024).

Accordingly, this chapter examines the fundamental mechanisms of motor development, situates digitalization within children's everyday lives, and provides a comparative analysis of both the supportive (e.g., touchscreen interaction, developmental affordances) and potentially adverse (e.g., sedentary lifestyles, postural problems, sensorimotor restriction) effects of digital technologies on motor development. Ultimately, the chapter aims to offer guiding principles for families, teachers, and schools, providing a framework for the responsible and developmentally supportive integration of digital tools into children's motor experiences.

2. Foundations of Motor Development

The foundations of motor development are rooted in a complex maturational process that begins well before birth. During the fetal period, the embryo starts to rely on sensory feedback to adapt to its rapidly changing body. Motor behaviors observed at this stage are not merely simple reflexes; rather, they consist of movement patterns that are sensitive to bodily structure and adaptable to environmental feedback. For example, around the seventh week of gestation, the fetus is able to raise its relatively short arms above shoulder level toward the face, demonstrating early flexibility in motor behavior. As the arms lengthen, the same action is reorganized through shoulder lowering and elbow flexion, revealing that fetal motor behavior is dynamically adjusted in response to structural changes (Adolph & Hoch, 2019).

During the final trimester of pregnancy, the fetal motor repertoire expands substantially. Head turning, leg pushing, arm extension, touching the facial region, and rhythmic, respiration-like chest movements become more regular (Moore, Persaud, & Torchia, 2008). Reflexive responses such as grasping, sucking, and orienting toward stimulation become increasingly evident. Moreover, hand-to-mouth behaviors, including thumb sucking, have been observed even in the prenatal period (Hepper, Shahidullah, & White, 1991). This early motor repertoire provides a foundation for postnatal feeding, environmental exploration, and social interaction.

At birth, infants' body proportions are poorly suited for efficient movement. Their heads are disproportionately large and heavy, making head lifting difficult. Their arms and legs are relatively short in relation to the trunk, further limiting mobility. In addition, infants' bodies consist largely of adipose tissue with relatively little muscle mass, resulting in limited strength (Feldman, 2016).

Primitive reflexes constitute the first stage of postnatal motor development. Early responses such as the Moro reflex, rooting reflex, and sucking reflex regulate infants' automatic reactions to basic stimuli during the first months of life. In addition, the Asymmetrical Tonic Neck Reflex (ATNR) produces

extension of the arm and leg on the side toward which the head is turned, while the opposite limbs flex; this mechanism contributes to the early development of hand–eye coordination. The Symmetrical Tonic Neck Reflex (STNR), by contrast, generates differential muscle tone responses in the upper and lower body depending on head movement and plays a key role in the transition to crawling. As the central nervous system matures, these reflexes are gradually inhibited and give way to controlled, purposeful, and voluntary movements. Age-appropriate inhibition of primitive reflexes is a critical prerequisite for the healthy emergence of postural control, balance reactions, hand–eye coordination, and basic motor competence (Doherty & Hughes, 2014).

In the months following birth, reflexive behaviors are progressively replaced by voluntary, goal-directed actions. Object manipulation represents a major developmental milestone during this period. Reaching and grasping increase infants' capacity to interact with their environment, enabling them to gather information and refine their movements toward greater accuracy and intentionality. This process depends not only on physical contact but also on the integration of visual, tactile, and proprioceptive sensory inputs (Focaroli et al., 2024). Concurrent maturation of the vestibular, somatosensory, and visual systems provides the neural foundation for motor development in early infancy. Head and trunk control, balance reactions, and initial reaching behaviors become possible through the integration of these sensory systems (Doherty & Hughes, 2014).

Interest in object exploration increases rapidly during this period. The acquisition of reaching skills is known to markedly enhance infants' motivation to interact with objects (Fogel, Dedo, & McEwen, 1992). Fogel and colleagues (1992) demonstrated that infants who were able to reach objects spent less time attending to their mothers and more time focusing on objects. Similarly, motor milestones such as sitting, standing, and walking profoundly influence patterns of object exploration and social interaction. The attainment of independent sitting, in particular, facilitates more complex interactions with the environment (Schneider et al., 2023).

Motor and perceptual capacities develop in parallel, enabling increased exploratory behavior. Maturation of gross motor skills especially arm and hand strength allows objects to be grasped for longer periods, extending exploratory cycles (Needham et al., 2002). Advances in fine motor skills and hand-eye coordination further support detailed examination of objects. Developmental science widely acknowledges the reciprocal relationship between motor and cognitive processes. Examples of this interaction include the role of crawling in enhancing spatial cognition, walking in supporting social engagement, and

postural control in relation to language acquisition (Campos et al., 2000; Clearfield, 2011; Walle & Campos, 2014).

In the second half of the first year of life, postural control, locomotor behaviors, and manipulation skills emerge in an organized manner alongside rapid maturation of the central nervous system. Behaviors such as sitting, standing, crawling, and walking are not merely biological milestones; they function as actions that expand the child's capacity to interact with the environment. Crawling typically begins between 6 and 10 months, while most children achieve independent walking between 10 and 18 months. The development of locomotor skills supports manipulation abilities such as holding, pushing, pulling, and carrying objects, thereby enhancing coordination and muscular strength (Adolph & Robinson, 2015; Doherty & Hughes, 2014).

Children may reach stages of motor development at different ages, and such individual variation generally falls within the range of typical development. Genetic factors, environmental affordances, cultural practices, and parental or caregiver attitudes all contribute substantially to this variability. Motor skills are commonly classified into three core categories: stability skills (posture and balance), locomotor skills (movement from one location to another), and manipulative skills (object control). Balanced support across these three domains is essential for building the fundamental motor repertoire children need for daily activities, play, and sport (Doherty & Hughes, 2014).

Historically, motor development has been explained through both the neuromaturational perspective and the modern Dynamic Systems Theory. Esther Thelen was a pioneering figure in the Dynamic Systems Approach, which fundamentally transformed the field from the 1980s onward. Her work revealed the limitations of the long-dominant neuromaturational view that motor behaviors emerge solely as a result of neural maturation in a fixed, universal sequence. Early analyses of repetitive movement patterns in animals and infants, as well as experiments examining muscle-to-fat ratios in the 1980s (Thelen et al., 1982), demonstrated that motor behavior arises not only from neural maturation but from the interaction of body proportions, environmental context, and physical constraints. Dynamic Systems Theory emphasizes that motor competencies are shaped through reciprocal interactions among posture, perception, strength, experience, and environmental conditions. Dynamic Field Theory further proposes that infant behavior cannot be reduced to a single cause; instead, memory, prior movement patterns, bodily control, and environmental cues jointly give rise to action (Savelsbergh, 2005). Together, these perspectives provide a critical framework for understanding the fundamental principles of motor development.

In conclusion, motor development is a multilayered and dynamic process that begins prenatally and is shaped by postnatal experience. Postural control, locomotor abilities, and manipulative skills are constructed upon early movement patterns observed in the fetal period and emerge as products of genetic endowment, body proportions, sensory integration, environmental affordances, and experience. The gradual inhibition of primitive reflexes, maturation of sensory systems, and acquisition of voluntary movements enable children to interact effectively with their environment. As Dynamic Systems Theory illustrates, motor behavior is not the outcome of a fixed, unidirectional biological program, but rather a complex developmental trajectory arising from the continuous interaction of body, mind, and environment. Consequently, understanding the biological and behavioral foundations of motor development is essential for accurately interpreting the effects of contemporary childhood experiences, particularly the increasing presence of digital screens on children's motor trajectories. How children's motor repertoires, shaped through movement, reaching, balance, and physical interaction with the environment, are influenced by screen-based, sedentary, and passive experiences thus constitutes a critical research question. In this sense, a solid understanding of the foundations of motor development is a necessary prerequisite for evaluating the impact of the digital world on children's bodies.

3. The Role of Digitalization in Children's Lives

In comparison with previous generations, digital technologies now enter children's lives at much earlier ages and have become a fundamental component of everyday experience. Smartphones, tablets, computers, televisions, VR and AR technologies, and internet access have become persistent tools encountered in children's home routines as well as in educational, social, and recreational activities. Recent nationally representative data from the United States (Common Sense Media, 2025) indicate that children's contact with digital media begins in the earliest years of life. According to these findings, approximately 40% of children are exposed to a tablet before the age of two, and by age eight, one in four children owns a personal smartphone. The same report shows that children under the age of eight spend an average of 2.5 hours per day in front of screens. These results clearly demonstrate that technology has assumed an increasingly central position within the home environment and plays a prominent role in children's daily routines.

Infants' initial exposure to digital media often occurs not through their own active use, but through passive exposure to their parents' interactions with digital devices. As smartphones have become integral to family communication, work-related tasks, and daily coordination, infants are frequently exposed at an early age to screen light, moving images, and notification sounds. The nature and

intensity of digital practices within the household constitute key determinants of children's frequency of digital media exposure. Parents' patterns of smartphone use, the duration for which televisions remain on in the home, and the purposes and frequency of tablet use directly shape children's habits of media exposure (Chaibal & Chaiyakul, 2022).

In response to the rapid proliferation of digital screens in early childhood, the World Health Organization (WHO, 2019) has articulated basic guidelines aimed at protecting children's health and development. The WHO recommends that children under the age of one should not be exposed to screens at all, and that screen time for children aged two to four should be limited to a maximum of one hour per day. However, observational studies conducted across different countries indicate that families frequently rely on digital media as part of everyday routines and that these recommendations are often difficult to meet. A large-scale global analysis by McArthur et al. (2022), based on data from approximately 90,000 children, revealed that screen exposure in early childhood frequently exceeds recommended limits. The study reported that only one quarter of children under the age of two complied with screen avoidance guidelines, and that only one third of children aged two to five adhered to the one-hour-per-day screen time recommendation. Furthermore, 44% of children in the two-to-five age group were found to use digital media for more than two hours per day. Collectively, these findings demonstrate that digital media exposure in early childhood is both widespread and prolonged.

From the preschool years onward, children encounter digital media in increasingly diverse and complex ways. In addition to television content, digital storybooks, educational applications, online music, and video materials become integral parts of children's daily routines. As digital tools are used for both entertainment and learning, children engage more actively and purposefully with media through touchscreen games, interactive applications, and age-appropriate digital materials. Families may use these tools at times as educational supports and learning opportunities, at other times as means of calming or occupying children, and in some cases as practical solutions that facilitate parents' daily responsibilities (Eichen et al., 2021).

By the time children reach primary school, digitalization assumes an even more multifaceted and visible role in their lives. At this stage, children not only watch television or use tablets, but also rely on digital devices for academic activities such as preparing homework, conducting online research, communicating with teachers and classmates, and participating in video-conferenced lessons. Digital tools thus serve both academic and social functions. Many children develop new social practices, including messaging peers, communicating via online gaming platforms, and sharing content and links

(Özsevgeç et al., 2018). In this context, digitalization extends beyond the mere use of technological devices and becomes a transformative force shaping the nature of children's social relationships, time use, and learning pathways.

Virtual reality (VR) and augmented reality (AR) technologies have also become increasingly visible from the primary school years onward. While these tools offer children three-dimensional and immersive experiences, they simultaneously raise a number of developmental concerns. In general, VR headsets are not considered appropriate for children under the age of 12–13. This position is supported by a combination of physical, emotional, and developmental considerations. Potential short-term effects of VR use include eye and neck strain, headaches, and motion sickness, which may vary in intensity across users. In addition, the limited availability of scientific evidence regarding the long-term effects of VR use in young children reinforces the need for a cautious approach to age-related restrictions. As a result, determining the boundaries and guidance principles for children's use of VR and AR technologies has become a significant subtopic within broader discussions of digitalization.

The increasing use of digital media throughout childhood is closely linked to the rapid digitalization of both home and school environments. In many countries, the expansion of educational Technologies, such as digital homework platforms, interactive whiteboards in classrooms, and online sharing of instructional materials encourages children's regular engagement with technology. Following the COVID-19 pandemic, the acceleration of online education has further intensified children's relationship with digital media. Synchronous and asynchronous online lessons, digital assessment processes, classroom management software, and learning management systems have made technology an integral component of academic processes (Gopika & Rekha, 2025). Consequently, contemporary children grow up in continuous contact with digital tools throughout nearly every stage of their educational trajectories.

Digitalization in children's lives thus represents a phenomenon far broader and more complex than a simple matter of entertainment or "screen habits." It plays a defining role across multiple domains, including family communication patterns, school routines, peer relationships, learning processes, leisure activities, and self-regulation experiences. The steadily increasing exposure to digital media from infancy through the school years indicates that technology has become a natural and in many cases unavoidable component of childhood experience. For this reason, digital media should be understood as a core element of the modern ecology of childhood, to be examined through a holistic perspective that simultaneously considers its supportive, constraining, and transformative dimensions.

4. Positive Effects of Digital Technologies on Motor Development

Although the role of digital technologies in child development is often discussed primarily in terms of potential risks, this section focuses on the structural opportunities through which digital tools may support motor development. Grounded in the view that motor skills are shaped not only by biological maturation but also by social and cultural contexts, the section examines how technology may positively transform these contexts. In particular, it presents scientific evidence showing how goal-directed finger and hand movements experienced at early ages through touchscreens and interactive applications can enhance both the pace and precision of acquiring critical fine motor skills. Rather than framing technology use as a developmental constraint, this section aims to discuss how digital tools can be positioned as powerful supportive resources when used in guided, intentional, and content-focused ways.

4.1. The Social and Cultural Context of Motor Development

Although motor development has traditionally been examined as an individual skill within laboratory-based research paradigms, infants in real-life settings grow up in environments that are continuously shaped by physical and social stimulation. As emphasized by Adolph and Hoch (2018), motor skills are deeply embedded in children's cultural contexts, caregivers' attitudes, and patterns of social interaction. Infants' tendency to take their first steps toward the open arms of a caregiver provides a compelling illustration of how motor behavior is not solely biomechanical in nature, but is also closely intertwined with powerful social motivations. Similarly, many object-directed motor actions are formed within reciprocal interactions with caregivers. Adults' facial expressions, vocal tones, and behavioral cues provide critical information that shapes how children initiate and organize their movements.

The profoundly social nature of motor behavior demonstrates that movement is not governed solely by bodily biomechanics; rather, it is sensitive to the rhythm of human interaction, cultural norms, and environmental conditions (Adolph & Hoch, 2019). The ways in which caregivers organize the physical spaces available for movement, the types of toys they provide, and the strategies they use to encourage or restrict children's engagement with the environment play a decisive role in shaping the trajectory of motor skill development. Moreover, culturally embedded practices related to carrying, sleeping, and play routines, as well as expectations regarding daily physical activity, directly influence both the pace and diversity of motor skill acquisition (van Schaik, Oudgenoeg-Paz, & Atun-Einy, 2018).

4.2. Redefining Developmental Opportunities in the Context of Digitalization

This social and cultural perspective on motor development provides a critical starting point for analyzing the increasingly prominent role of digital technologies in children's lives. When children's movement is conceptualized not as a passive outcome of biological maturation but as a product of the social context in which it occurs, the question of how this context is transformed by digital tools becomes central. The ways in which digital technologies restructure caregiver-child interactions, modify the organization of physical environments, and shape children's everyday opportunities for movement suggest that motor development may be influenced in indirect yet powerful ways.

From this perspective, understanding the social origins of motor skills offers a robust theoretical framework for evaluating how digital tools alter children's movement patterns (Adolph & Hoch, 2019). Children's motor behavior is jointly shaped by caregivers' expectations, household safety arrangements, the quality of play spaces, opportunities for peer interaction, and prevailing cultural norms. When digital technologies become embedded within this system, for example, through the widespread use of tablets and smartphones for play and entertainment they may reduce children's physical movement in domestic settings and promote more sedentary behavioral patterns. At the same time, movement-based and interactive digital applications may generate new opportunities that actively support physical activity.

Accordingly, digitalization should not be approached as a unidirectional threat to motor development, but rather as a contextual shift in which developmental opportunities are redefined. On the one hand, screen-based activities may displace spontaneous outdoor play, free running and climbing experiences, and physically interactive peer play, thereby reducing the frequency and diversity of traditional motor experiences. On the other hand, interactive and movement-oriented digital applications may introduce novel forms of play and learning that support children's physical capacities. In particular, augmented reality (AR), virtual reality (VR), and motion sensor-based gaming systems can create environments that require bodily engagement, provide multisensory feedback, and enhance motivational aspects of play, thereby offering potent stimuli for motor skill learning. In this context, it is essential to evaluate systematically not only the potential risks of digital technologies but also their capacity to support motor development.

4.3. Contributions of Touchscreen Interaction to Motor Skills

During early childhood, the acquisition of motor skills benefits substantially from learning environments that capture children's attention, are relatively easy

to interpret, and provide rapid feedback. The use of augmented reality (AR) in motor learning is particularly notable in this regard. Rich visualizations presented through AR facilitate the comprehension and sequential execution of learned movements, thereby supporting the motor learning process. Chang et al. (2020) demonstrated that AR is especially well suited for teaching more complex motor skills, while Putri et al. (2021) similarly reported that AR-based applications provide powerful learning stimuli for children's motor skill acquisition.

Interactions with touchscreen devices offer distinct developmental opportunities, particularly with respect to fine motor skills. Actions such as swiping, tapping, and dragging on screens engage hand–finger coordination and fine motor control intensively during the early years of life. Empirical evidence suggests that active touchscreen interaction may support earlier attainment of certain fine motor milestones. In a study conducted by Bedford et al. (2016), children who began using touchscreens between 6 and 36 months of age reached specific fine motor milestones earlier, with swiping movements in particular significantly accelerating fine motor performance. Accordingly, children who actively engage with touchscreens may demonstrate faster progress than peers with limited screen exposure in fine motor tasks such as object manipulation, goal-directed touching, and the precision of finger movements.

Research examining the effects of virtual reality (VR) technologies on children's visuomotor functioning and postural control also provides important insights into the relationship between digital environments and motor development. Tychsen and Foeller (2020) conducted a controlled experiment with 50 children aged 4 to 10 years, assessing potential adverse effects of VR use by examining visuomotor function, postural stability, and motion sickness. Each child participated in two consecutive VR gaming sessions lasting approximately 30 minutes using a Sony PlayStation VR headset. The sessions involved a first-person, three-dimensional flight simulation (Eagle Flight) requiring head movements to control flight direction. The findings indicated no significant changes in children's visual functioning following VR exposure, nor were statistically significant associations observed between VR use and eye strain, head or neck discomfort, or motion sickness. Nevertheless, the fact that three participants discontinued the experiment due to motion sickness or boredom underscores the importance of considering individual differences in sensitivity.

In light of such evidence, the American Academy of Pediatrics (AAP) states that mobile device use in children aged two years and younger may be developmentally acceptable only when it is limited in duration, involves educational and interactive content, and occurs under parental supervision. A critical distinction in this context is that between passive screen exposure and active screen interaction. When touchscreen use involves active motor

engagement, such as decision-making, selecting targets, and adapting finger movements to goals rather than passive activities like video viewing, children are afforded greater opportunities to practice, repeat, and refine hand–finger skills (Bedford et al., 2016).

Yadav et al. (2021) demonstrated that children with early touchscreen experience adapt rapidly in terms of motor control. Their findings showed that two-year-old children acquired appropriate device-grasping skills, while four-year-old children were able to perform complex multi-touch gestures successfully. These results suggest that interactive digital applications may support the flexibility, diversity, and speed of fine motor skill development in early childhood. However, the impact of digital interaction appears to vary by age and developmental stage. Moon et al. (2019) found that smart device use was positively associated with fine motor skills in three-year-old children, whereas no significant association was observed in children aged four to five. This finding suggests that the supportive effects of digital interaction on fine motor development may be most pronounced during early critical periods characterized by rapid motor growth.

Similarly, Souto et al. (2020) reported that children aged 24 to 42 months who were accustomed to tablet use achieved higher Bayley-III fine motor scores than children without tablet experience. The study noted that most tablet interactions occurred with parental accompaniment and for short, age-appropriate durations, leading to the conclusion that such structured use modestly supported fine motor development. Importantly, this finding also indicates that the developmental benefits of digital tools are sensitive to contextual factors such as duration of use, content quality, and the level of parental involvement.

4.4. Contributions of Digital Technologies to Motor Development in Children with Special Educational Needs

Physical development in early childhood is shaped not only by biological maturation processes but also by the diversity of movement experiences, the quality of sensory feedback, and the richness of environmental opportunities. Because children with disabilities often show more constrained motor progress compared to their typically developing peers, differentiated and specialized instructional approaches are required to support motor skill development (Lin & Chang, 2015). In this context, the integration of modern digital technologies into special education practices has emerged as an important and innovative tool for supporting physical development (Wang et al., 2024).

Augmented reality (AR) based interactive applications have been shown to increase movement motivation and encourage participation in physical activity among children with disabilities. Gamified AR-supported activities enable

children to experience motor tasks not merely as therapeutic exercises or training drills, but within contexts of play and exploration. This shift facilitates increased movement intensity while simultaneously supporting domains such as self-confidence, motivation, and bodily awareness (Lin & Chang, 2015; Wang et al., 2024).

Studies conducted with children on the autism spectrum indicate that AR-based systems may support not only motor behaviors but also social and cognitive processes, including pretend play. Bai et al. (2015) reported that AR use significantly increased the frequency, duration, and contextual appropriateness of pretend play in children with autism spectrum conditions (ASC). This finding underscores the reciprocal relationship between motor development, social interaction, and cognitive symbolization. Within AR environments, children do not merely learn to move; they also learn to structure play, interact with both virtual and real objects, and make sense of their surroundings (Chang et al., 2020).

In physical education contexts, spatial augmented reality (SAR) applications offer hybrid learning environments in which the physical constraints of the real world are integrated with virtual objects. Dynamically generated running courses, shifting targets, and moving obstacles created through SAR contribute to the development of spatial perception, coordination, and balance skills (Mast et al., 2017). Through these experiences, children acquire abilities to navigate their bodies within real space, adjust weight distribution, and adapt to variable movement demands.

For children with cerebral palsy, the integration of electromyography (EMG) biofeedback systems with VR and AR technologies enables more controlled and effective motor execution. Yoo et al. (2017) demonstrated that feedback derived from muscle activation and range-of-motion data measured in virtual environments provides concrete information to both children and therapists. Compared with EMG use alone, these integrated applications yielded superior outcomes in improving neuromuscular control, increasing elbow extension, and strengthening the biceps muscle.

In addition, the use of AR-based storybooks has been shown to support motor skill development in children aged 4-5 years, with positive effects observed even among children classified as marginally delayed (Putri et al., 2021). AR-supported instructional methods have also been found to be more effective than traditional video-based instruction, particularly in the acquisition of complex motor skills (Chang et al., 2020). Taken together, these findings suggest that digital Technologies especially the integration of AR, SAR, VR, and EMG biofeedback constitute effective and innovative approaches for supporting motor development in children with disabilities (Lin & Chang, 2015; Bai et al., 2015;

Mast et al., 2017; Wang et al., 2024; Yoo et al., 2017; Putri et al., 2021; Chang et al., 2020).

Collectively, research examining the effects of digital technologies on motor development in early childhood highlights the need to conceptualize children's engagement with technology in dual terms. While active interaction opportunities afforded by touchscreen and immersive technologies may support early gains particularly in fine motor development these benefits must be carefully balanced against the opportunity costs associated with excessive exposure and increased sedentary behavior. Accordingly, the role of digitalization in motor development cannot be reduced to a simplistic categorization of "good" or "bad." Instead, it presents a developmental duality that is contingent upon factors such as duration of use, content quality, the child's age and developmental level, parental involvement, and the broader social context in which technology use occurs. The following section addresses the other side of this duality by examining, in detail, the potential adverse effects and underlying mechanisms associated with uncontrolled and intensive digital device use on children's physical and neuromotor maturation.

5. Negative Effects of Digital Technologies on Motor Development

This section addresses the ways in which digital technologies may negatively influence motor development in children. Specifically, it examines how screen-based activities can reduce opportunities for learning through bodily exploration and movement, how excessive exposure may lead to delays in developmental skills, how increased sedentary behavior limits physical activity, and how prolonged screen use may exert disruptive effects on posture and postural control.

5.1. Restriction of Sensorimotor Experience and Opportunity Costs

During early childhood, motor development is shaped by children's active exploration of their environment, movement, object interaction, and engagement in multisensory (sensorimotor) experiences. Activities such as running, climbing, crawling, grasping, dragging, and carrying constitute the foundational building blocks of motor development during this period. Excessive screen exposure, however, may substantially reduce children's opportunities to engage in these critical experiences.

Because digital devices predominantly emphasize visual and auditory stimulation and often position the child in a relatively passive role, attention is redirected from interaction with a three-dimensional physical environment toward a two-dimensional screen. Research indicates that intensive screen use can homogenize children's sensorimotor experiences, reduce time spent physically exploring the environment, and constrain the movement opportunities necessary for acquiring motor skills (Páez-Herrera et al., 2025).

This issue is particularly consequential during the earliest years of life. Developmental science has long established the existence of critical periods during which organisms are especially sensitive to environmental input, and experiences acquired during these periods can exert powerful and lasting effects on developmental outcomes. For example, Needham and colleagues (2002) demonstrated that infants who were provided with early object engagement through the use of "sticky mittens" showed accelerated gains in object interaction and exploratory behaviors. This finding provides compelling evidence that early experience directly shapes motor development. Consequently, when tactile and movement-based experiences during these critical periods are displaced by screen-based passive experiences, adverse developmental consequences may emerge.

Large-scale studies further substantiate these concerns. In a cohort study involving more than 7,000 children, infants who were exposed to screens for more than four hours per day at one year of age exhibited significant delays in communication, fine motor skills, social abilities, and problem-solving skills by the age of two; some of these delays persisted until age four (Takahashi et al., 2023).

5.2. Screen Exposure and Delays in Developmental Skills

Exposure to background television has similarly been shown to exert negative effects on motor and behavioral development. In a study conducted with infants aged 6 to 18 months, Chonchaiya and colleagues (2015) found that exposure to adult-directed television programming was associated with increased behavioral problems. As background television exposure increased, oppositional behaviors and developmental difficulties became more pronounced. The authors emphasized that reducing background television exposure is particularly important for supporting adaptive behavior in 18-month-old children (Chonchaiya et al., 2015).

The state of "passivity" created by excessive screen use may negatively affect motor development through several key mechanisms:

- **Restriction of Gross Motor Activity:** Prolonged time spent in front of screens limits children's movement, resulting in reduced opportunities for gross motor experiences.
- **Opportunity Costs for Fine Motor Development:** Screen interaction may restrict active manipulation of physical objects, thereby reducing natural play opportunities that support fine motor skill development.

- **Disruption of Social Interaction:** Sustained focus on screens can interfere with children's ability to attend to social cues, engage in joint attention, and participate in interactional cycles with caregivers that help regulate and scaffold motor behavior.

Accordingly, although digital tools may offer certain developmental opportunities, excessive and uncontrolled use particularly during critical developmental periods can adversely affect multiple dimensions of development (Lin et al., 2020).

5.3. Sedentary Lifestyle, Physical Activity Levels, and Motor Competence

Excessive screen use indirectly affects motor development by reducing children's levels of physical activity. Children who remain sedentary for extended periods in front of screens tend to spend less time engaging in movement-based activities such as outdoor play, sports, or free play. This pattern may narrow children's daily motor behavior repertoire; instead of experiencing diverse movements,nsuch as running, climbing, and jumping across varied environments screen viewing in a uniform seated posture may become the dominant activity.

Indeed, the literature emphasizes that excessive screen exposure can function as a barrier that constrains motor creativity and movement variability in children. A child absorbed in a screen is less likely to participate in socially interactive, movement-rich games such as tag, hide-and-seek, or ball play with peers. Over time, this reduced participation may diminish overall physical capacity and limit the child's ability to adapt to diverse motor demands. As screen time increases, sedentary behaviors rise accordingly, while time spent in physically active pursuits declines. Global studies involving children and adolescents indicate that a substantial proportion of young people fail to meet recommended minimum levels of physical activity. According to World Health Organization data, nearly 80% of adolescents worldwide do not achieve the daily recommended minimum of physical activity (at least 60 minutes of moderate-to-vigorous activity) (Páez-Herrera et al., 2025).

Extended time spent in front of screens is a key contributor to this sedentary lifestyle. The more time children spend seated and engaged with screens, the lower their likelihood of participating in active play or sports. As a consequence of this imbalance, increased screen use has been associated with heightened risk of childhood overweight and obesity, as prolonged sedentary time reduces energy expenditure and facilitates weight gain. Studies have reported higher prevalence rates of overweight and obesity among children with high screen exposure (Chang et al., 2023; Robinson et al., 2017).

Insufficient physical activity also restricts the practice opportunities necessary for acquiring and refining motor skills. Limited movement and lack of motor experience may significantly impede motor development; moreover, these early effects can leave lasting negative traces that extend into later stages of life. Children with low levels of physical activity have been reported to exhibit weaker motor skills and reduced physical capacity not only during childhood but also in adulthood. Conversely, children with more advanced motor development tend to demonstrate higher levels of physical activity and physical fitness, suggesting a reciprocal relationship in which motor competence and an active lifestyle mutually reinforce one another (Páez-Herrera et al., 2025). For this reason, the risk that children exposed to excessive screen use in early childhood may fail to develop habitual movement patterns should be carefully considered, and deliberate efforts should be made to encourage engagement in active play.

5.4. Postural Disorders: "Tech Neck" and Neuromotor Maturation

Another indirect effect of digital screen use concerns the development of postural control. When using mobile devices such as tablets and smartphones, children commonly maintain a forward-flexed head and neck position for prolonged periods. This posture places greater-than-normal mechanical load on the cervical spine and may lead to a postural disorder commonly referred to as "tech neck" (Cuéllar & Lanman, 2017).

In forward head posture, the effective load exerted by the head on the cervical spine increases substantially. According to Hansraj's (2014) biomechanical analysis of the spine, when the head is flexed forward at an angle of 60 degrees, the load imposed on the cervical vertebrae can reach approximately 27 kilograms. Such excessive loading generates uneven mechanical stress on the neck and upper back musculature, leading to overactivation of some muscle groups and weakening of others.

Chronic postural loading of this nature during childhood may disrupt the development of spinal alignment and contribute to neck, back, and shoulder pain in later years (Kamper et al., 2016). Prolonged slouched sitting may also cause the shoulders to round forward and increase thoracic kyphosis, thereby compromising the three-dimensional alignment of the spine. Additionally, prolonged inactivity of core muscle groups, particularly the abdominal and back muscles that are critical for trunk stability may result in muscular weakness and adversely affect postural control (Yaşartürk, Aydın, & Genç, 2025).

When children undergo periods of growth and neuromotor maturation while repeatedly adopting maladaptive postural habits, postural reflexes and balance control may be persistently affected. Clinical observations and ergonomic reports indicate that improper screen-use posture acquired during childhood may be

associated with chronic musculoskeletal complaints during adolescence and adulthood (Nanehkeran & Nourbakhsh, 2025).

5.5. Direct Negative Effects on Motor Development

A growing body of research has documented negative associations between screen time and the development of motor skills in children. For example, a longitudinal study conducted in Canada demonstrated that children who spent more time in front of screens at ages 4, 5, and 7 obtained significantly lower scores on motor skill assessments administered at age 7. This finding suggests that high screen exposure during early childhood may exert lasting effects on motor competence in later years. Importantly, the same study reported that the effect of elevated screen time at age 4 on motor skills at age 7 was partially mediated by continued high screen use at age 7, indicating that the adverse impact of persistent screen exposure may accumulate over time rather than operate as a transient influence (Cadoret et al., 2018).

The influence of screen use on motor development is not limited to overall motor proficiency; several studies have drawn attention to specific vulnerabilities in fine motor skills, such as hand–finger coordination and object manipulation. For instance, school-aged children with higher screen exposure have been shown to perform more poorly on tests assessing object control and manual dexterity (Webster et al., 2019). A plausible explanation for this pattern is that time spent in front of screens reduces engagement in activities that naturally foster fine motor development, such as playing with modeling clay, drawing, cutting, or constructing with blocks.

Gross motor skills, such as walking, running, jumping, and climbing, which rely on large muscle groups represent another critical domain potentially affected by excessive screen exposure. When screen use displaces time otherwise devoted to outdoor play or physically active games, the development of gross motor competence may be negatively affected. A recent study conducted with 8–10-year-old children in Chile reported an inverse correlation between screen time and gross motor development: as weekly screen exposure increased, children's motor development scores decreased (Páez-Herrera et al., 2025). However, not all studies converge on this conclusion. For example, Webster et al. (2019) found no significant association between screen use and gross motor skills, highlighting the heterogeneity of findings in this area and suggesting that contextual factors, such as content type, duration, and opportunities for compensatory physical activity may moderate observed effects.

5.6. Indirect Effects Mediated Through Social Interaction

One of the indirect pathways through which intensive digital device use may affect children's development involves alterations in social interaction dynamics.

During early childhood, social and language development are largely shaped through direct interactions with caregivers and peers, shared play, and communicative exchanges (Vygotsky, 1978). Digital screens, by contrast, often provide unidirectional or minimally reciprocal forms of engagement. Excessive screen use may therefore reduce opportunities for face-to-face interaction with both peers and family members.

Research indicates that young children exposed to high levels of screen time may exhibit delays in language development and social–emotional skills relative to their peers (Madigan et al., 2019). For example, studies have shown that children aged 1-2 years who are frequently exposed to background television or who regularly use tablets or smartphones engage in fewer verbal interactions with their caregivers, which may slow language acquisition and reduce sensitivity to social–emotional cues (Christakis et al., 2009).

These social effects may, in turn, indirectly constrain motor development. Children's play with peers often involves substantial physical activity, such as running, chasing, ball games, and cooperative movement-based play. Such activities simultaneously promote social competence and motor skill development (Akbari et al., 2009). When children spend a disproportionate amount of time engaged in solitary screen-based activities, they may miss out on these rich, socially embedded motor experiences.

Motor and social development are not independent trajectories but are closely intertwined. As children acquire new motor skills, their self-confidence often increases, enabling more active participation in peer play and strengthening social relationships (Samodra et al., 2023). Conversely, socially engaged children gain access to diverse motor learning opportunities through group play and shared physical activities. The literature consistently emphasizes a positive association between motor competence and social-emotional development during childhood (Akbari et al., 2009).

Accordingly, reductions in social interaction associated with excessive digital media use may exert a secondary negative influence on motor development. A child who rarely engages in physical play with peers or interactive family activities not only forfeits social learning opportunities but also loses access to the motor practice that naturally accompanies these interactions. For this reason, experts emphasize the importance of prioritizing social skills training and movement-rich group activities for children with high screen exposure (Akbari et al., 2009; Samodra et al., 2023). Parental involvement, such as playing together in parks, organizing peer playdates, or engaging in family-based physical games represents a critical countermeasure that supports both social and motor development.

Ultimately, no matter how engaging a digital game may be, it cannot fully replace the developmental value of a child running, laughing, and playing with peers. The multidimensional stimulation afforded by real-world social interaction remains indispensable for healthy development across domains.

6. Guiding Principles for Families, Teachers, and Schools

From a motor development perspective, digital technologies can function as developmentally supportive tools when used with intentional guidance; however, uncontrolled and purposeless use may substantially narrow children's motor experiences. For this reason, families, teachers, and the broader school ecosystem play a critical role in ensuring that digital tools are used in pedagogically sound and developmentally balanced ways.

Families should shift children's digital experiences away from passive screen consumption toward content that requires active interaction and bodily movement. Within the home environment, gamified digital experiences that integrate physical activity should be encouraged, while overall screen time should be maintained within age-appropriate limits. In addition, parents should move together with their children and enrich digital activities through social interaction and joint participation. Parental role modeling, such as maintaining an active lifestyle, avoiding prolonged forward-head posture while using devices, and demonstrating postural awareness constitutes a powerful attitudinal factor that indirectly influences children's motor development.

Teachers should position screen-based technologies not as replacements for traditional educational tools but as complementary and supportive resources. AR and VR applications should not be used to substitute for direct motor experiences; rather, they should be employed to enrich children's physical interaction with their environment and to encourage movement. Teachers should also be attentive to the development of poor postural habits acquired at early ages and implement ergonomically appropriate classroom practices, including proper seating arrangements, regular movement breaks, and activities that promote bodily awareness.

Schools should establish institutional frameworks for the mindful, ethical, and healthy use of digital technologies. Programs that integrate physical activity into daily routines, such as active recess, structured periods of physical play following digital activities, and spatial awareness exercises can generate sustainable gains in motor development. Moreover, school infrastructure should be designed to support digital interaction without constraining movement; for example, spacious physical play areas and AR-enhanced movement stations can promote a holistic educational approach. Finally, schools should maintain continuous

communication with families and contribute to the consistent management of children's digital habits across home and school contexts.

7. Conclusion

Motor development is a dynamic developmental domain shaped by the interaction of biological maturation, experiential learning, environmental opportunities, and social engagement. Digital technologies introduce both opportunities and risks for the development of motor skills during early childhood. As demonstrated in this chapter, digitalization through tools such as AR-based games, spatial reality applications, and biofeedback systems can increase children's motivation to move, support both fine and gross motor skills, and provide particularly valuable developmental resources for children with special educational needs.

At the same time, when excessive screen exposure replaces physical movement, when children become passive observers, and when direct interaction with the body, space, and objects is reduced, stagnation or regression in motor development may occur. Consequently, the solution lies not in excluding technology, but in aligning its use with children's developmental needs.

In conclusion, the impact of digital technologies on children's motor development cannot be evaluated through a unidirectional or reductionist perspective. What ultimately matters is the *quality* of child–technology interaction. With appropriate pedagogical guidance, limited and mindful use, social co-engagement, and the integration of digital experiences with physical movement, technology can be transformed from a developmental risk into a powerful developmental opportunity. Therefore, families, teachers, and educational institutions should position technology in ways that do not neglect the child's body, but rather integrate movement, experience, and play at the core of learning.

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CHAPTER 12

Banking-as-a-Service (BaaS): New Infrastructure for the Digital Economy

Yüksel Akay Ünvan[1] & Ismail Hassan Ahmed[2] & Nima Ahmed Mohamud[3]

[1] Prof. Dr, Ankara Yıldırım Beyazıt University / Business Administration, Finance and Banking, Ankara, ORCID: 0000-0002-0983-1455
[2] Student, Ankara Yıldırım Beyazıt University / Business Administration, Finance and Banking, Ankara, ORCID: 0009-0000-0741-3033
[3] Student, Ankara Yıldırım Beyazıt University / Business Administration, Finance and Banking, Ankara, ORCID: 0009-0006-9402-3431

Introduction

Over the past decade, platform-based finance has transformed the provision of financial services significantly. Increasingly, digital platforms and fintech firms embed financial products into non-bank consumer journeys, such as e-commerce, ride-hailing and online marketplaces (Waliszewski, 2023). This provides consumers with access to payments, credit, insurance and investment options without necessarily having to visit a traditional financial institution. In sum, financial services are becoming frictionless, personalized and more data driven. What this means in practice is that these emergent forms are reconstructing customer expectations toward instant, convenient and embedded finance solutions. At the same time, this is pushing traditional banks to reassess their core business and working models in partnership with technology platforms if they want to remain relevant within the new financial landscape that is unfolding (Anagnostopoulos et al., 2025).

BaaS is a new framework in which the core financial capabilities of licensed banks are exposed through standardized APIs. The services range from deposits and payments to regulatory functions such as KYC and AML. BaaS thus enables third-party firms to embed complete banking capabilities into their products without necessarily acquiring a banking license. Essentially, the concept means that fintech companies, e-commerce websites and other non-financial firms can directly sell financial products to customers. In a nutshell, BaaS decouples banking infrastructure from customer-facing services and unleashes unprecedented opportunities for innovation, scalability and lower market entry costs for new entrants (Singh & Michels, 2018).

Unlike open banking, which has focused on the safe sharing of customer financial data and embedded finance, which embeds banking functionality into non-financial platforms, BaaS provides third parties with access to underlying banking infrastructure (including accounts, payments and compliance services) to develop and distribute financial products on their own.

BaaS matters because it lowers the barrier to financial innovation, enabling startups, platforms and even legacy businesses to launch financial services rapidly and at lower cost (Tuoma & Ekegren 2021).

This chapter critically examines the architecture, regulation, market dynamics, use cases and future trajectories of BaaS between 2020 and 2025. It synthesizes academic and industry literature to clarify how BaaS is reshaping banking and what its broader implications are for the digital economy.

Although interest in BaaS has grown, the literature still lacks cohesion and remains fragmentary and one-sided. Most research looks at BaaS from a single perspective: either technological, regulatory, market-based or economic, without

integrating the complex ways in which these interrelated dimensions are affecting BaaS adoption and impact. Very few empirical analyses have been conducted so far and conceptual clarity is rather weak, as often BaaS, embedded finance and open banking are used without distinction. Finally, previous research also barely focuses on cross-regional differences, the strategic role of banks and the long-term structural consequences of platform-based financial models. This evidences the need for an overall, theory-relevant review that puts into order and interconnects major themes defining BaaS between 2020 and 2025.

This chapter adds to the literature by providing a structured and integrated review of BaaS developments between 2020 and 2025. While single studies often adopt isolated perspectives such as technology, regulation, market trends or strategy, this review brings these dimensions together into a single, coherent framework. Through the systematic comparison of definitions, theoretical foundations, market differences and technological drivers, this chapter clarifies the conceptual boundaries between BaaS, embedded finance and open banking, an area where earlier research frequently overlaps or misses precision.

A second contribution lies in underlining the differences in BaaS evolution between developed and emerging markets, showing how regulatory readiness, digital infrastructure and inclusion goals shape different paths of adoption. The chapter also synthesizes insights about how BaaS supports digital transformation within banks by explaining its strategic role beyond technical integration.

Third, the review indicates a number of persistent gaps, particularly the lack of empirical studies, bank-centric research and unclear regulatory responsibility in multi-party ecosystems and hence points out areas where further work by academics is needed. In that respect, the chapter provides a consolidated foundation for future research with a better understanding of BaaS as one of the key transformers of modern financial systems.

Methodology

This is a qualitative, literature-based research design with the objective of synthesizing and critically evaluating academic and industry contributions on BaaS from 2020 to 2025. The research relies on a structured review process since the objective is to map existing knowledge, identify thematic patterns and highlight unresolved issues, with no need for primary data collection or statistical analysis. Three major stages in this methodology are as follows.

1. The sources were collected by following a systematic search strategy in academic databases such as Google Scholar, SSRN and Scopus, as well as reputed industry publications like consultancy reports, regulatory documents and fintech white papers. The inclusion of sources was limited to only the 2020–2025 period, thus ensuring

contemporary relevance, with selectively added earlier foundational works used where necessary to explain conceptual origins.

2. The material was then subjected to thematic categorization. In this regard, each source was assigned to one of the major topics underpinning the study, namely, definitions and frameworks, market comparisons, technology architecture, regulatory environments, strategic implications and literature gaps. The approach also helped to clearly avoid duplication, where each reference contributes to only one subsection.

3. The qualitative content analysis was used to interpret the findings in each theme. In so doing, the arguments were compared, the convergence and divergence across sources were identified and the relevant insights about BaaS as a structural transformation in digital finance were extracted. Since the study does not generate any new empirical data, it makes its contribution by integrating highly fragmented literature, clarifying conceptual boundaries and suggesting avenues for future research.

Literature Review

The emergence of BaaS has reshaped the financial landscape over the past five years, driven by technological innovation, evolving regulatory frameworks and changing customer expectations. Academic and industry research from 2020 to 2025 has explored multiple dimensions of BaaS, including conceptual definitions, fintech theories, adoption patterns across markets, technological architecture, regulatory frameworks and strategic implications for financial institutions. While the literature provides valuable insights, it remains fragmented, with gaps in empirical evidence, regulatory analysis and comparative studies between developed and emerging markets. The following section focuses specifically on these key topics, synthesizing the most important findings to provide a comprehensive overview of BaaS research, identify critical gaps and establish the foundation for subsequent discussion.

Fintech Theory and Conceptual Foundations of BaaS

The theory behind the growth of fintech provides a good base on which to explain the rise of BaaS. They are part of the general movement toward financial ecosystems based on platforms, not just technology (Remolina, 2025). In other words, financial services are increasingly being offered through multisided digital platforms where many market participants offer services together on shared infrastructures rather than in vertically integrated banks. BaaS enables this through exposing banks' core capabilities to Fintech, retailers and other non-bank businesses via APIs, lowering infrastructure barriers and embedding financial

services seamlessly into existing digital customer journeys. A second conceptual framework is that of modular banking, where major banking functions operate separately as API-enabled modules (Tater & John, 2025). Modularity allows firms to bundle financial products flexibly and efficiently for either end customers or business partners. Finally, the framework of ecosystem finance positions BaaS as an infrastructural layer that interlinks financial and nonfinancial services within large digital ecosystems, such as e-commerce or mobility platforms. These frames together show exactly how BaaS is creating the transition away from discrete financial institutions and toward interconnected, platform-driven markets.

The causes of the difference in the adoption of regional BaaS include gaps in regulations, technological readiness and customer preference (Alsalaymeh, 2024). The EU, UK and US have maintained mature open banking policies, appropriate digital infrastructures and developed fintech ecosystems that drive innovation and competition. Banks and FinTech's work jointly on standardized APIs for seamless integration of financial functions, allowing the creation of such embedded financial products, including digital wallets, SME lending platforms and integrated payment services. Correspondingly, consumer demand for frictionless and seamless digital experiences fuels the adoption of BaaS. However, in the case of emerging markets, such as Southeast Asia, Africa and Latin America, use cases of BaaS in driving financial inclusion come to the front. In these cases, telecom operators, mobile money providers and e-commerce platforms are often leading BaaS-driven innovation targeting underbanked and unbanked populations. Besides, regulatory uncertainty and lack of interoperability remain concerns, but BaaS has gone a long way to deeper access to credit, payments and savings, therefore catalysing the growth of broader financial ecosystems (Ke, 2025).

BaaS has now emerged as the important component of the digital transformation strategies of banks (Ozili, 2024). Banks increasingly consider BaaS as a strategic way to modernize their operations, extend their customer reach and unlock new revenue sources. This way, banks can monetize their existing infrastructure at the API level by offering regulated banking capabilities to both fintech and platforms and take part in platform-based business models. Many banks are now adopting the hybrid transformation approach, wherein the legacy core remains intact, but agile collaborations with fintech accelerate the pace of innovation. According to Accenture (2023), such partnerships help banks expand their customer bases to newer segments like SMEs, gig workers and the underbanked without having to extend the physical infrastructure. It also means faster deployment of financial products. However, operational risk, regulatory compliance and partner governance remain issues. All in all, BaaS acts both as a

technological and strategic enabler in facilitating banks to innovate, expand into the market and ensure long-term competitiveness.

BaaS Technology Architecture

BaaS depends on modern digital infrastructures. The central foundation of this model rests on API-driven architectures. In these systems, traditional monolithic legacy software is not used as one big structure, but rather small components called microservices replace such monolithic systems (Katal et al., 2025; Saxena, 2024). Each of these microservices executes one specific financial function. Examples of such functions would include payments, customer verification through KYC checks and lending activities. These operate independently from other functions. This segregation allows each module to be deployed without necessary changes in the whole system. Similarly, updates or revisions to one service do not interrupt other services (Stojaković, 2025). Moreover, each of the constituent parts can be scaled depending on the demand coming from users. Ensuing from this concept are fewer disruptions of core systems at banks. Non-bank partners also benefit by faster integrations of financial tools. The shared benefit translates into improved efficiencies of collaboration in general. Finally, product innovation speeds up for banks and their partners.

Data sharing is one of the core tenets of embedded finance with BaaS (Ismail et al., 2021). In this concept, data flows across various players in the financial space. The players include banks and third-party service providers. The data exchanged is generally customer information. The exchange occurs in a secure manner. At the same time, it happens in real time. This system is based on standardized interfaces. These interfaces create a common expression through which platforms interact with one another. The process is further facilitated through interoperability frameworks. Interoperability frameworks ensure that different technological systems can communicate without any barriers. Therefore, the exchange of data occurs without any form of friction. This ability ushers in different capabilities in the form of embedded finance. It also enhances the customer experience of financial services. This is because users enjoy consistency in data and reliability in information flows. Eventually, frictionless data sharing ensures efficiency and user satisfaction within the BaaS ecosystem.

Scalability in the BaaS systems is strongly enhanced by cloud-native infrastructure (Larcher et al., 2024). Such infrastructure is similarly characterized as serverless. The serverless model diminishes the dependence on physical hardware. It also reduces the scope of manual maintenance of the system. With a reduced number of physical components, an organization does not require large data centers at their site of operation. Cloud computing becomes the main mode of service delivery. Such advantages allow financial providers to rapidly roll out new digital products. This is also extended to launching features without lengthy

technical delays. Another strength of the system is the handling of fluctuating transaction volumes. If the levels of transactions rise, the cloud automatically scales up. If the volume drops, it also scales down to avoid waste. This flexibility eases the operations of the system. It allows for a seamless delivery of services by customers and providers. The application of the cloud-based systems lowers the cost of operations. The reduced costs make the investments in BaaS more feasible. This is particularly helpful to the fintech firms. Smaller financial institutions also benefit from the reduced costs. To such organizations, cloud-based BaaS becomes an attractive and viable option.

Research in the Security Journal emphasizes that the scale and growth of the different BaaS ecosystems are pegged on solid security frameworks. With increased data sharing among parties, new vulnerabilities occur that threaten banks and their partners. To prevent unauthorized access, strong authentication must be in place. Digital identity verification is also important in ensuring the validation of user identities. Continuous monitoring aids in real-time detection of suspicious activities. Security controls ensure that trust is developed on multiple integrated platforms. Ultimately, such measures protect consumers in high-risk digital environments (Ayodeji et al., 2024).

BaaS can be widely adopted depends on core banking system updates. For example, most traditional banks are still using some kind of legacy core system. Those older core systems have many limitations: for one, there is restricted real-time access to data and for another, they are not very supportive of API connectivity. Thus, BaaS implementation becomes difficult and could pose as a potentially impactful activity (Marcelo, 2023). Core modernization will move systems toward modular platforms. Modular platforms are cloud ready. They can enable banks to integrate different services seamlessly. Integration can be smoother because the modules are able to communicate well with each other. Cloud-ready platforms will enhance operational efficiency. Efficiency can be achieved by automating processes and reducing manual intervention. Updating core systems will support long-term digital transformation. Digital transformation is necessary to keep pace with evolving technological trends. Modernized cores make scaling services easier in the long term. They will also help banks meet customer expectations in terms of speed and flexibility. In general, core modernization is a crucial step toward successful BaaS adoption.

Regulatory and Compliance Framework

The global regulatory approach to BaaS is highly heterogeneous across jurisdictions, creating an uneven environment for market development. For example, some countries have developed a consistent regulatory framework, while others have a more fragmented one. For instance, in the European Union, there is a promotion of standardized regulations, such as PSD2, which is among

the most important regulations supporting open banking and open finance initiatives are even promoting coherent practices (Atabey, 2021). On the other hand, other regions depend more on market-driven rules. Differences in the regulatory approach have an influence on how banks work with third-party providers and eventually on the maturity and growth of BaaS ecosystems around the world (Omarini, 2021).

The requirements for licensing providers of BaaS are of particular importance. They are considered the most important elements of regulation, establishing the very legal basis for the conduct of activities; banks remain fully liable for compliance (Lobo, 2025). This means that the bank cannot shift the overall responsibility to the third party. Supervisory authorities are particularly sensitive to this sort of partnership. Regulators increasingly require clear structures of governance. Such structures of governance will help to define roles and responsibilities. They will outline procedures for decision-making. Such may help in managing possible operational and financial risks. Mechanisms enabling auditing will also be indispensable in terms of the transparency of activities and their accountability, including for their compliance with regulations (Trautmann, 2023). Clear oversight reduces the probability of a violation of laws. That is how all these measures taken together will be protecting financial stability and the interests of consumers when banks collaborate with fintech.

According to various policy documents of the EU, PSD2 is a foundational regulatory milestone in 2020. PSD2 laid the bedrock for BaaS and allowed access to bank data in a secure manner that had hitherto been acquired more restrictively (Gimigliano, 2023). This regulation makes it binding upon banks to share customers' account information with authorized third parties. This shall be done under strict security protocols, while customer consent should also be there explicitly. From these premises, the move to Open Finance goes beyond mere payment services. This allows sharing a wide range of additional financial data that would come from other than traditional banking sectors. Open Finance also encourages interoperability across multiple platforms (Wolska, 2024). It encourages an enabling environment for innovation while severe standards for data security are maintained and it ensures customer consent is something always obtained and respected. All policies have achieved a proper balance between growth and protection in the BaaS ecosystem.

One of the most important challenges in 2023 will revolve around the vagueness of defining AML and KYC roles and responsibilities within a BaaS partnership (Geçer& Akgiray, 2025). AML and KYC are extremely intricate pieces of legislation. Although most regulatory demands make banks legally liable, the practical implementation of such activities often depends directly on the fintech partner, especially in the identity check during customer onboarding

and continued transaction monitoring. This sets up a model based on shared responsibility: both banks and Fintech will have to work closely with each other and deploy advanced compliance technologies to handle such responsibilities. Such coordinated processes guarantee that all participants adhere to regulatory provisions. In other words, this methodology helps to maintain regulatory conformity along the entire value chain (Tun et al., 2025).

New regulatory risks come from the increasing growth of the BaaS ecosystems. Most of these risks remain heightened, particularly in multi-party structures. Normally, each embedded finance model will involve several participants. Each participant can undertake various roles and responsibilities. Accountability could become unclear in such arrangements. This problem is made more complicated by cross-border service delivery. Different jurisdictions are subject to different regulations. Another source of risk can be technological concentration (Thompson, 2022). When a few providers are responsible for key systems, vulnerabilities may surge. All these factors widen supervisory blind spots. Regulators might not get the full view of all operations (Deuble et al., 2022). This is what makes oversight so difficult. Therefore, regulators now emphasize the strengthening of oversight frameworks. Stronger frameworks are likely to help address systemic risks before they build up and then escalate. This serves to stop failures that would impact several institutions. Another objective of the regulatory measures is to protect consumers from harm. In summary, the expansion of BaaS calls for careful monitoring and proactive regulation.

Market Structure and Leading Providers

Licensed digital bank is entirely structured around the BaaS model. Being a regulated institution, it provides modular financial services such as account creation, payment processing, lending, digital onboarding and KYC/AML checks via API-based building blocks (Roy, 2024). It is being understood that this allows fintech and digital businesses to assemble their financial offerings without having to handle the regulatory burden themselves. The rapid expansion of Solaris bank in Europe, underpinned by partnerships with neobanks, e-commerce firms and mobility platforms, showcases how infrastructure-focused banks can scale efficiently in service of businesses rather than retail consumers (Sucubaşı, 2025). Its growth has reflected the greater market trend toward specialized "invisible banks" powering embedded finance behind the scenes.

BaaS models adapt to regional needs while large pan-European infrastructure banks supply what is required or desired particularly to SMEs' daily basis, early-stage fintech and niche service providers (El Kassmi & Jarir, 2021). The platform bundles payments, card issuance and compliance tools into pre-configured financial products that can be deployed in weeks rather than months. This removes much of the technical and regulatory complexity for smaller firms that

lack the resources to develop financial services from scratch. Localized BaaS solutions enable tailored financial innovation as regional players align themselves more carefully with regional regulations, customer needs and market infrastructures (Tillery, 2023).

Traditional banks are increasingly venturing into the BaaS space (Hanten et al., 2022). Confronted with competition from fintech and changing customer expectations, banks explore BaaS as a means of revenue diversification and strengthening their relevance within digital ecosystems. banks draw on their regulatory know-how, risk management experience and established trust when offering high-value API services (Bhatia, 2022). These enable them to monetize core infrastructure-previously considered a cost canter. They reposition themselves from pure customer-facing organizations to foundational service providers within broader digital ecosystems, reshaping traditional competitive boundaries in the process.

In contrast, the Synapse Collapse Report of 2024 brought to the forefront the vulnerabilities in the BaaS ecosystem. The collapse of this large intermediary in the United States revealed several critical operational failures, including weak oversight of partners, data systems that were incomplete and fragmented and unclear lines of accountability among banks and fintech partners. These operational failures led to delays in customer withdrawals, supervisory interventions and considerable market disruption. This case underlines that with BaaS growth, there ought to be accompanying robust governance frameworks, transparent responsibilities and strong supervisory oversight, especially in multi-party arrangements where customer funds, data and regulatory obligations are concerned. It therefore proved a cautionary tale that scaling at pace without appropriate controls could threaten both Fintech and their partner banks. similarly, a forward-looking view into strong and sustained global growth for the BaaS sector through the decade (Bansal, 2024). In contrast, this is due to high demand across verticals in embedded finance, including e-commerce, mobility, logistics, creator platforms and digital banking. The competitive intensity will be driven by developments in open API standards, a supportive regulatory framework and increasing digital adoption, as both banks and non-bank platforms go to market. Juniper places BaaS within the context of a foundational layer of the digital economy, underpinning scalable, platform-based financial models across diverse vertical sectors.

Economic and Strategic Implications

BaaS plays a transformative role in widening financial inclusion by allowing non-bank digital platforms such as telecom operators, ride-hailing companies, gig-economy applications and e-commerce marketplaces,to distribute financial services at scale (Ha et al. 2025). it reduces the structural and procedural barriers

that have traditionally limited access to finance, especially in low-income and underserved communities (Niu, 2025). Through simplified onboarding processes, reduced documentation requirements and lower service delivery costs, BaaS helps integrate financial products directly into the daily digital routines of consumers. This is particularly significant in emerging markets where physical banking infrastructure is limited and digital ecosystems have become the primary point of interaction for millions of users. Ultimately, BaaS not only expands access but also supports deeper engagement with formal financial systems (Yu et al., 2025).

The OECD (2024) highlights broader economic consequences by examining how BaaS reshapes competitive dynamics in the financial sector. The organization argues that the boundaries between banks, fintech, payment companies and technology platforms are becoming increasingly blurred. Because BaaS allows third-party firms to launch financial products rapidly,with minimal regulatory friction,it increases market contestability and accelerates the diffusion of financial innovation. However, the OECD cautions that the same mechanisms enabling innovation may also concentrate market power. A small number of major BaaS infrastructure providers could become structurally dominant, controlling critical data flows, compliance functions and API-based financial rails. This duality creates a strategic tension: while BaaS promotes competition at the front end, it may produce oligopolistic structures at the back end of the financial system.

BaaS unlocks new business models for both banks and non-bank digital platforms. Banks can monetize their regulatory licenses by offering modular services such as KYC, payments, credit scoring or card issuance, through APIs (Shaltout, 2023). Meanwhile, digital platforms can embed financial tools that improve customer engagement and reduce friction in user journeys. These partnerships generate strong network effects: as more firms join a BaaS ecosystem, the overall value and functionality of the system expand (Teladia & van der Windt, 2021). This makes BaaS not merely a technical arrangement but a strategic lever for collaborative expansion in digital finance. The ecosystem-based nature of BaaS thus shifts value creation from individual firms to interconnected networks.

The multi-party structure of BaaS ecosystems and API-driven integrations can expose financial systems to new forms of cyber-attacks, data-leakage risks, identity fraud and authentication failures (Mallekoote & Balraadjsing, 2025). This demonstrates that responsibilities for compliance, monitoring and fraud detection are distributed across banks and fintech partners, accountability becomes fragmented. This fragmentation increases the difficulty of maintaining unified security standards and ensuring real-time risk visibility. Emerging risks

require advanced security architectures,such as zero-trust frameworks, real-time anomaly detection and standardized data-governance models,as well as clearer contractual agreements to avoid regulatory blind spots (Putra et al., 2025).

consumer-experience and market-strategy perspective by explaining how BaaS fuels the rise of invisible finance (Abbasi & Ibrahim, 2025). This refers to financial services that operate in the background of non-financial digital journeys,for instance, instant credit at checkout, automated insurance in mobility apps or seamless payment flows in subscription platforms. By embedding such functions invisibly into digital interfaces, BaaS transforms user expectations and shifts financial engagement from deliberate actions to frictionless interactions. It is obviously being comprehended that this seamless integration strengthens customer loyalty for digital platforms, while giving infrastructure providers stable and recurring revenue streams based on transaction volumes. This makes BaaS a strategic engine behind the evolution of interconnected digital ecosystems.

The Future of BaaS

Recent scholarship suggests that a future for Baas will be at least partially determined by an ongoing trend toward AI-driven automation across financial infrastructures. The use of AI to reimagine core banking operations has been found to enhance risk modelling and operational efficiency, simultaneously improving fraud detection. It is expected that algorithmic onboarding, ongoing KYC monitoring and compliance screening will be widely adopted by BaaS providers operating large-scale, multi-party platforms (Gyau et al., 2024). In interconnected BaaS ecosystems, AI will increasingly work as an orchestration layer, managing data flows and decision processes in a multi-directional manner across banks, fintech and digital platforms.

A parallel academic trend is related to how blockchain and tokenization reshape the notion of how financial services are offered. Several studies have underlined that blockchain-based systems significantly enhance the visibility, settlement speed and cost efficiency of banking and fintech environments (Rjoub et al,2023). Other research on tokenized assets has suggested that programmable financial instruments can facilitate cross-border payments, lending and digital identity verification (Ristanović et al., 2025). these insights demonstrate the impression that, in the future, BaaS platforms might be further developed toward hybrid infrastructures in which traditional banking rails coexist with blockchain-based settlement layers, facilitating faster and more automated embedded finance services.

Another dimension emphasized in the academic literature refers to the structural transformation of banking within open banking and embedded finance models. illustrate how banks are increasingly becoming "invisible banking,"

where institutions become mainly regulated infrastructure providers behind digital platforms (Stefanelli & Manta, 2023). This is also in line with the logic of BaaS, where licensed banks provide compliance and account-level infrastructure, while the fintech and non-financial companies own customer interfaces. Their results indicate that further development of BaaS will be characterized by even more direct integrations of banking capabilities into non-bank digital ecosystems, reinforcing the platforms of financial services.

The growth of BaaS is also linked to more general trends in embedded finance, representing financial services that are integrated smoothly into everyday digital life. Academic research on the direction of fintech says that financial products are becoming very modular, API-driven architectures that will be interoperable across a wide range of industries, from retail and mobility to digital commerce (Alt et al., 2024). This aligns with the prediction that BaaS will offer the rails on which multisector financial ecosystems are based and will eventually expand far beyond traditional banking into the full embedding of credit, payment, insurance and investment capabilities across connected platforms. Finally, fintech governance and blockchain-enabled finance studies emphasize that the future of BaaS will be determined by regulatory and institutional structures adapting to it. Research on trust and cross-institutional collaboration in fintech–bank partnerships has already indicated a strong need for governance models that outline ways to negotiate data sharing, interoperability and risk allocation (Kaniadakis & Foster, 2024).). These and other studies, suggest that any rapid global scaling of BaaS will require international harmonization of regulatory standards and more muscular supervisory frameworks that are able to manage increasingly complex multi-party infrastructures. As BaaS scales into a cross-sector digital utility, regulatory clarity and institutional trust will feature among the most decisive factors in how this ecosystem evolves through upcoming years.

Discussion and Results

This study set out to synthesize the rapidly expanding research on BaaS and clarify its conceptual, technological and strategic foundations. The discussion brings together the main findings of the literature review and demonstrates how they contribute to the understanding of BaaS evolution and its implications for modern financial ecosystems.

First, the findings pertain to the conceptual structure of BaaS. The review indicates that BaaS is often debated along with open banking and embedded finance, while boundaries among these terms are defined inconsistently. Contributing to resolving this conceptual ambiguity, this research identified their different foci: open banking on regulation, embedded finance on distribution and BaaS on infrastructure. Such clarity is critical because inconsistency in terminology thwarts theoretical advancement and makes cross-study comparison

challenging. Thus, the analysis offers a logical conceptual basis that researchers in the future can use when scrutinizing platform-based financial services.

A second key finding concerns the underpinning technological architecture that makes BaaS possible. Strong consensus exists in the literature that APIs, microservices, cloud infrastructure and modernized core systems are the technological enablers of BaaS. Synthesis demonstrates how these different components collectively reduce integration costs, enhance interoperability and allow for far more efficient joint collaboration between banks and third-party platforms. This technological mapping provides an organized view of BaaS architecture that had previously been scattered within industry reports rather than consolidated in academic research.

Third, the review underscores significant variability in the way BaaS develops across diverging markets. The results indicate that innovation, competition and sound regulatory frameworks are paramount in developed economies, while adoption in emerging markets is mostly driven to achieve financial inclusions, infrastructure gaps and heavy reliance on mobile-led ecosystems. Such comparison of regional dynamics the study provides stands to prove that BaaS is not a homogeneous model; it adapts to the local conditions of regulation, technology and the market. This cross-comparison perspective bears a meaningful contribution to a more nuanced, contextually sensitive understanding of the global evolution of BaaS.

Fourth, the literature indicates that, despite rapid market growth, regulatory frameworks remain under-defined, especially concerning the allocation of liability, oversight of partners and compliance responsibilities in multi-party ecosystems. Synthesizing these concerns, this study reveals the mismatch of regulatory structures with emerging business models. Discussion calls for supervisory clarity if BaaS is to expand safely and in a sustainable manner.

Last but not least, some of the review gaps that were identified include a lack of empirical evidence on the economic consequences of BaaS, limited analysis of bank strategies and internal transformations and not enough consideration of risk concentration in platform-based models. By clearly spelling out these gaps, the study offers guidance for future academic research and has enhanced the theoretical foundations of ongoing research. The findings suggest, overall, that BaaS is altering the nature of financial markets, turning banks from product providers to infrastructure partners, a change that makes possible new varieties of innovation and competition. This development also brings forth some conceptual, regulatory and operational challenges that require further in-depth academic investigation. The contributions made by this study are related to conceptual clarification, systematization of technological and market insights and

mapping the unresolved issues-a structured basis for scholars or practitioners interested in an understanding or further development of BaaS research.

Conclusion

BaaS has become an integral component of today's digital finance ecosystem. In this regard, banks no longer position themselves merely as product providers but, rather, as suppliers of the infrastructure underpinning other firms in dispensing financial services. This development epitomizes the broader shift from vertically integrated financial models to interoperable digital platforms where numerous participants operate with shared functions and competencies. Throughout the literature, what becomes apparent is that the evolution of BaaS is driven not just by technological change but, even more so, by deeper structural alterations in how financial value is created, distributed and accessed within markets at large in different parts of the world.

BaaS adoption also develops at very different speeds across global markets and the literature makes clear this uneven growth is shaped by differing priorities, infrastructures and regulatory capacities. In advanced economies, strong digital ecosystems and clearly defined regulatory frameworks-particularly around data sharing, licensing and API standards-create the conditions for rapid scaling. These markets typically view BaaS as a tool for innovation, competition and product diversification. Established fintech clusters, mature payments infrastructure and consumer expectations for frictionless digital experiences further accelerate adoption. In consequence, BaaS in these regions tends to focus on building sophisticated financial products, enhancing customer experience and developing specialized embedded services for sectors such as e-commerce, mobility or SME finance. But the drivers underlying BaaS adoption differ significantly in emerging markets. There, BaaS often grows out of necessity: hard-to-reach rural or low-income populations that traditional banking systems are unable to reach, with a patchwork of digital platforms such as telecom operators, mobile money providers and large marketplaces stepping in to help fill these gaps. With digital and physical banking infrastructures less developed, BaaS is a practical means of extending basic financial services at scale. Regulatory uncertainty and interoperability issues notwithstanding, BaaS widens access in support of financial inclusion and expands opportunities for underserved communities.

Technology is the vital backbone of the modern BaaS system, defining how financial services are constructed, delivered and scaled. Increasingly, APIs let banks expose specific functions in a structured, reusable manner-one that makes integration with fintech and non-financial platforms much more seamless than it could ever have been before. Meanwhile, cloud computing provides the required elasticity and computing power to support volumes of transactions without

requiring heavy physical infrastructure. Microservices further complement such development by breaking banking processes into smaller, independent components that can be updated or deployed independently without interrupting the entire system. Reliability and reduction of operational bottlenecks are further enhanced with modern core banking platforms, thus enabling faster product development cycles. As these technologies continue to evolve and proliferate, barriers to the creation of new financial solutions are significantly lowered for firms. This sets new standards of efficiency, customization and security at an industry level and shapes the expectations for all future financial services.

Regulation is one of the most complex and unsettled aspects of BaaS and the literature points out time and again that this area requires more clarity. Even though BaaS solutions rely on partnerships between licensed banks, developers of Fintech and various third-party platforms, how the regulatory responsibilities are divided remains undefined across these actors. Moreover, supervisory expectations range greatly between regions, so that what is allowed in one jurisdiction may be banned or closely monitored in another. This lack of harmonization makes it hard for an institution to expand its BaaS operations cross-border or to adopt standardized compliance processes. A recurring theme in research is that regulators are still adapting to the multi-layered structure that comes through BaaS. Unlike traditional banking, where the bank controls the full value chain, BaaS introduces a complex set of outsourcing relationships whereby customer onboarding, data handling, distribution or even product design might happen outside the bank. However, even when those functions are delegated to partners, banks remain legally responsible for AML, KYC, consumer protection and operational risk requirements. This creates tension: for innovation, partners need autonomy; for their protection against breaches, banks must impose strict controls.

To sum up everything that has been stated so far, implication of the literature reviews is that long-term growth, stability and trust in the BaaS industry requires much clearer and consistent regulatory frameworks. As partnerships expand and services become more tightly integrated, a refinement of regulation will determine how confidently firms can scale these models.

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CHAPTER 13

The Irony of Bagehotian Doctrine: Approach to Bagehot Rules During Crisis Periods in Türkiye

Bilge Çipe[1] & Dilek Usanmaz[2]

[1] Dr., Nevsehir Univercity, ORCID: 0000-0001-7598-0291
[2] Dr., Nevsehir Univercity,

1. Introduction

Even before the 21st century has completed its first quarter, the countries of the world are simultaneously experiencing an economic crisis in terms of the global economy. In an environment where the effects of the 2008 Global Financial Crisis are still continuing, the COVID-19 pandemic and the energy dilemmas of the Russia-Ukraine war, the Middle East and the Balkans, which are getting hotter every day, deepen this crisis. As a result, almost all countries are struggling intensely with supply inflation. In today's world, where all kinds of crises, shocks and disasters are experienced, it is necessary to be more resilient both individually and socially. Of course, this resistance slows down the system and even brings it almost to a standstill. According to the IMF's October 2023 report, "The world economy is not accelerating but limping. The global economy, which has been struggling with inflation for a long time due to the food and energy crisis disrupted by the Russia-Ukraine war, has slowed down but not stopped thanks to this resilience" (Gourinchas, 2023). According to the latest IMF forecasts, world economic growth will slow from 3.5 per cent in 2022 to 3 per cent in 2023 and 2.9 per cent in 2024. These figures appear to be far below the historical average. In times of crisis, almost all eyes turn to the decisions to be taken by central banks. This is because the aim of central banks is not to make a profit, but to work for economic stability. Considering the historical process of central banks, the Riksbank, the first central bank established, was established to finance war expenditures and to restructure government debts. The same system continued in the following processes. In this respect, the main role of central banks is to bring the ship safely to port without sinking it.

According to Volcker (1990), central banking is a new phenomenon for the 20th century. Swedish and British central banks should be excluded from this phenomenon. However, they also have to keep up with the process of this new phenomenon. Selgin (2010) underlines that central banks are a factor that disrupts market stability. He attributes this argument to the fact that central banks have the sole authority to print money and the contradiction in their role as the lender of last resort. Tucker (2014), on the other hand, states that after 2007, central banks' actions to ensure financial stability have been condemned and praised in equal measure. While central banks are praised for injecting liquidity into the market and keeping markets open, they are criticised for violating the boundary between central banking and fiscal policy. The most important role of central banks is to ensure price stability. However, being the lender of last resort should be distinguished from all other roles. Starting with Henry Thornton and systematised by William Bagehot, the Lender of Last Resort (LOLR) role may

be the most vital aspect of central banking. According to the IMF e-library, LOLR is a "frequently used but little defined" concept. The reason for the under-definition is the changing function of the LOLR over the last century. Starting with 1873 Lombart Street, the definition of LOLR still contains ambiguities. William Bagehot emphasises that "this concept exists, but now there should be a central bank that can assume this role". In this role, central banks would hold a certain amount of money in their hands and use this money at critical junctures in times of crisis. The LOLR Bagehot describes is in fact a monetary policy. Central banks should take seriously their role as Lender of Last Resort to ensure price stability, which is their first and foremost duty. Nonetheless, the Lender of Last Resort role is not without moral hazard (Calomiris and Meltzer, 2016). According to Callegari et al. (2023), the LOLR is a moral hazard problem with market intervention and a mechanism that favours institutions that distort the economy. The fact that the definition of the lender of last resort is so scarce is due to the flexible use of this role. As a matter of fact, this flexible use was seen in the 2008 Global Financial Crisis by the FED and the European Central Bank. In particular, two LOLR rules were violated. Firstly, high penalty interest rate and secondly, strong collateral. In particular, the FED rescued institutions that were almost impossible to save (e.g. Citigroup) and more than doubled its balance sheet in one year. Moreover, it was Ben Bernanke who said that central banks rigorously applied the Bagehot rules to ensure financial stability during this period. The same violations were committed during the COVID-19 pandemic. The pandemic period put intense pressure on central banks to violate LOLR rules. Of course, this period covers a process different from economic crisis periods. The epidemic, which started in almost all countries of the world at the same time, first affected economic units. The USA had to announce an emergency action plan within 8 days. Both financial institutions, companies and individuals were given access to easy and low-interest loans as well as cash assistance. The same applies to European countries. Immediately after the outbreak of the pandemic, closures came to the agenda and these closures seriously damaged the economy. Perhaps, it would have been tolerable for central banks to violate the LOLR rules during this period. However, although the breach of these rules may help to overcome the crisis in the short term, it is not yet clear what the consequences will be in the long term.

This study focuses on the role of central banks as the lender of last resort and discusses the moral consequences of violations of these rules. Moreover, these rules are examined not only from the perspective of the major central banks of the world but also from the perspective of a developing country like Turkey.

Turkey, just like other central banks, is one of the countries that violate the LOLR rules, which are broad in use but still unclear in definition, in almost every crisis. The 2001 crisis may be an indicator of this situation as it was a crisis caused by the weak banking system infrastructure. The 2001 crisis created an opportunity for Turkey to improve its banking system. Turkey made good use of this opportunity and strengthened its banking system infrastructure. In this respect, the Global Financial Crisis of 2008 did not turn into a shocking crisis for Turkey. During the crisis period, measures were taken for price stabilisation rather than bank rescue packages. The first decision was taken in October 2008 regarding the foreign exchange markets. Having suspended foreign exchange buying auctions, the Central Bank resumed Foreign Exchange Deposit Brokerage Activities to enable banks to make flexible decisions on foreign exchange liquidity. Trading limits were extended and FX borrowing interest rates were lowered. This policy continued until the third quarter of 2009 (Serel and Bayır, 2013). Although not as much as the central banks of other developed countries, Turkey took many decisions contrary to the Bagehot rules during the crisis.

The same process took place during the COVID-19 pandemic. Disruptions in the supply chain with the onset of lockdowns affected economic units in a very short time. Turkey, just like other countries, was one of the countries that took urgent measures. Preferring an aggressive monetary expansion, the central bank first lowered policy interest rates. The fall in the policy rate brought the dollarisation problem to the agenda. The central bank dealt with this problem by selling foreign exchange reserves and trying to keep the exchange rate stable. In addition, many incentive programmes were announced with the onset of the pandemic. Incentives were generally made in the form of loans, capital reinforcement, and loan guarantees. On 18 March 2020, a package of 100 billion TL was announced, and later this package reached 200 billion TL and 240 billion TL (Gür, Tatlıyer & Dilek, 2020). Were these measures necessary for that day? What would the economy be like today if these measures had not been taken? Although the answers to such questions are uncertain today, the violation of the Bagehot rules is very clear. Moreover, it is another irony that central banks insistently declare that they apply these rules.

This research is the first study to investigate the implementation of Bagehot rules in Turkey. Although there are other country studies that reveal the violation of these rules, no such study has been found as of the pandemic period. Therefore, this study will contribute to the literature as it is the first study in the field for Turkey. The study consists of seven chapters. The second chapter provides a brief overview of the history and function of central banks. The third section describes

the history, scope and rules of the lender of last resort role. The fourth chapter focuses on the LOLR role of central banks during crisis periods and identifies the violations. The fifth section analyses the approach of the central bank in Turkey to LOLR rules during crisis periods. In the sixth chapter, Challenges of the LOLR role of Central Banks are explained and final chapter discusses the results of the research and makes recommendations.

2. About the history and function of the Central Bank

The development of central banks is evident in the last four centuries. The first recorded central bank, the Riksbank, established in Sweden in 1668, was tasked with financing government expenditures during wars and structuring government debts. The Bank of England, which was established in England in 1694, also had the function of the Riksbank. In fact, the Bank of England was even established as a joint stock company to purchase government bonds. The Banque de France, established in France, was founded by Napoleon in 1800 to re-stabilise the country's currency as a result of the inflation caused by the paper money printed during the French Revolution (Bordo, 2007). The First Bank of the United States, which was established in 1791 on the model of the Bank of England, was assigned as the collector and custodian of public funds. While the federal government lent money to this joint stock bank formed by private shareholders by issuing promissory notes, it was inactivated at the end of its term of office because its 20-year charter could not be renewed. The Second Bank, established in 1817, continued the duties of the First Bank (Capie et al. 1994:175-176). The Federal Reserve System, now known as the FED, was established in 1913 as twelve Federal Reserve banks under the umbrella of the Federal Reserve. The FED, which was established by the Federal Reserve Act, first started to work in order to supervise the banking system in the USA more effectively, to create a flexible currency and to provide rediscount on commercial bills. The 1907 banking panic reflects the main purpose of the establishment of the Federal Reserve. During the crisis, the FED performed the function of a central bank that controls the money supply, supervises and regulates other banks, and maintains the strength of the financial system, in particular by ensuring that confidence in banking is restored and investors return to banks. Providing financial services to depository institutions, the FED is a government bank (centralbanksguide, e.t. 27.12.2022). It has become the supervisor and protector of the country's gold and foreign exchange reserves and is recognised as the lender of last resort. Established in 1998, the European Central Bank, headquartered in Frankfurt, Germany, is one of the most influential central banks in the world, representing 15 European Union member states. Launched on 1 January 1999 for the member states, the

ECB is a bank responsible for monetary policy in the euro area, independent of the politics of the member states and the European Union. The main purpose of its establishment is to ensure price stability, high employment level, low inflation, economic growth and economic stability (Centralbanksguide, e.t. 27.12.2022).

As can be seen, the first central banks established generally functioned as a kind of lifeline to rescue economically shrinking countries. In addition to financing government debts, central banks, which also carried out banking activities, started to be seen as the financial stability provider of countries over time. Of course, central banks were not referred to by their current name in terms of their functions when they were first established. The term central bank started to be used towards the end of the 19th century. Henry Thornton (1802), who defined the concepts of central banking, was also one of the first to express the autonomy of central banks (Bordo and Siklos, 2017). According to Ugolini (2017:9), since central banks are organisational structures, they are a difficult subject to define. According to Capie et al. (1994), "the definition of a central bank is problematic. It can only be defined when it is seen." With the gradual end of the gold standard from the 1920s onwards, the definition of the role of central banks in financial stability has also changed (Bordo and Siklos, 2017). Early central banks were able to ensure price stability in a more comfortable and disciplined manner due to the gold standard. This was because the money supplied and the reserves held were limited by the value of gold. Therefore, price levels did not move above or below expectations (Bordo, 2007). Capie et al. (1994; 12) argue that 1873 marked a sharp line in central banking for three reasons. Firstly, the official recognition of the gold standard as the main exchange rate for the industrialisation period, secondly, the onset of deflation that lasted until the mid-1890s, and thirdly, the publication of "Lombart Street" by Walter Baqehot.

As the most important player in financial markets, central banks are used to define an authority responsible for a country's monetary policy. More precisely, it is the authority that uses monetary policy tools to influence short-term interest rates and the monetary base. The monetary policies used by the central bank have three main objectives: Firstly, price stability, which is achieved by keeping the general level of prices low and stabilising the value of money. Secondly, to support the real economy for sustainable growth by keeping the level of employment high, and thirdly, to prevent possible financial crises through financial stability and smooth and efficient operation of payment systems (Bordo, 2007).

3. Central banks as lenders of last resort

Since central banks have many privileges granted by the state, in later periods they became a lender of last resort to other banks and financial institutions. In the previous section, it was stated that the year 1873 represents a date that creates a sharp line in terms of central banks. One of the elements forming these sharp lines is the publication of Lombart Street by Walter Bagehot. Bagehot's tragic role in central banking and financial instability started with Lombart Street (Selgin et al. 2018:12). Although the story of the Ultimate Lending seems to have started with Lombart Street in real terms, many crises that preceded it have led to debates about the role of central banks.

The Lender of Last Resort (hereinafter referred to as LOLR) policy was developed in the UK at the end of a process that started with the bankruptcy of Overend & Gurney Co. in 1866. Overend & Gurney had a system that functioned as a secondary market in the UK, providing liquidity to the monetary system. Such companies, which are more prevalent in the UK, are legal companies that carry out transactions such as the purchase or redemption of bills of exchange, securities, specific government bonds and financial products such as bank acceptance letters (Investopedia, et:31.12.2022). The introduction of the study on the history of LLR by Schneider (2021) titled "The politics of last resort lending and the Overend & Gurney crisis of 1866" begins with a sentence criticising the structure of British institutions. "When asked in 1911 to research the history of the Bank of England, the economist HS Foxwell remarked that it "resembles that of the truest British institutions: "its form and functions are not based on systematic planning but on attempts to meet occasional emergencies" (Foxwell, 1911, 6). Under the Charter Act of 1844, the Bank of England was organised into two branches. Since the bank, which was divided into two as the Issuing Department and the Banking Department, had to approach the financial crises of 1847, 1857 and 1866 in line with this law, it is seen as the main cause of instability (Schneider, 2021). In reality, the fact that the bank was both a private enterprise and a state bank gave it many privileges. As the monopoly in the issuance of banknotes in England, the Bank of England was an institution that could solve the liquidity problem of small banks in times of crisis as a mechanism that managed gold reserves. The stabilisation of small banks in times of crisis in this way gave the bank the characteristic of being a central bank (Smith, 1936: 14). This responsibility seems to have developed with the guidance of economists during the crisis periods in 1819, 1825, 1836 and 1839. As a result of this responsibility, the Bank also gained the authority to control the banks to which it provided liquidity (Hogan et al. 2015). The 1844 Peel Laws further reinforced the

privileged status of the bank (White, 1995: 85). These privileges granted by the government to the bank holding the money reserve also included intervention in the market. Bagehot argues that under normal conditions money markets would be better off without any intervention. He stated that banking was a trade and any intervention could harm this trade (Bagehot, 1873: 51). Ironically, one of the most fundamental principles of Peel's law, "exempting the bank from the responsibility to take into account the public interest in formulating policy", caused major problems in the subsequent crises. By relying on this law, the central bank escaped its responsibility for the public interest while at the same time retaining the ability to intervene in the market. Walter Bagehot's main aim was to refute this principle (Smith, 1936:142).

In Lombart Street, written in 1873, Bagehot outlines the tasks of the British banking system and the role of central banks as lenders of last resort. Bagehot was not a central banking advocate, but rather a pragmatist economist (Hogan et al. 2015). Rather, he emphasises the lender of last resort role on the assumption that the central bank will continue to manage the money market. "According to our system, the Bank of England is obliged not only to keep a good reserve against the moment of panic, but also to utilise it effectively when that panic comes" (Bagehot 1873: 102). It is emphasised that reserves are necessary and at the same time that these reserves should be lent quickly and easily to anyone (institutional or individual) who provides solid collateral in times of crisis.

Loans of last resort should be granted under certain conditions. Bagehot (1873) explains these conditions as follows: Since the main purpose of the bank is to protect the money of the country, the loans should be given in large amounts at very high interest rates, not at market interest rates. The purpose of giving high interest rates here is to distinguish between good banks and bad banks. It is necessary to support a bank that is affected by a crisis that is not of its own making, whose collateral is sound, and which only needs liquidity. Lending at high rates to a bank that is insolvent due to bad investments can only mean a loan that cannot be repaid (Hogan et al., 2015). Bagehot (1873) states in Chapter 7 of Lombart Street that there are two general rules: The first is that loans should be granted at a high interest rate, and the second is that the loan to be granted at a high rate should be on good collateral and to the extent demanded. The central bank's information to lend only on good collateral in times of crisis may ensure that banks hold good collateral in times of prosperity.

Briefly, the conditions of the lender of last resort role can be summarised as follows:

- Acting with the awareness of the lender of last resort

- The setting of an interest rate that is much higher than market interest rates and the size of the amount to be lent (Section 12)

- The lending banks or entities have the ability to provide strong collateral (Chapter 7).

- The public has assurance that the central bank is aware of this (Chapter 7).

4. Rules of Last Resort and Crises

Foxwell's (1911) remarks about the history of the central bank of England in the previous chapter may be valid for all situations. When economic history is analysed, the theories and assumptions are generally based on extraordinary circumstances. The role of central banks as the lender of last resort has gained its full framework with Lombart Street. The main purpose of the lender of last resort role is to reinforce the central banks' sense of responsibility for maintaining financial stability in the country. While this responsibility is important for stability, it also has many disadvantages. In the 1866 financial crisis, the role of the central bank as the lender of last resort was an important factor in maintaining financial stability in the UK. However, there have been many violations of the LLR rules in the following periods. The Fed committed its first violation in this regard in 1984 on the Continental Illinois Bank. This breach is known as the first bailout by the Fed to prevent the spread of the crisis in the US financial markets (Hogan et al., 2015). In fact, this rescue was the beginning of the subsequent rescue processes for the Fed. Although there are differences of viewpoints on the role of the Lender of Last Resort among Fed doctrines, the New York doctrine is generally taken as a basis. In fact, former Fed Chairman Ben Bernanke is associated with the New York Fed doctrine (Salter, 2016).

Bernanke published many studies on bank bailouts to restore financial stability with the experience of the Great Depression (Hogan et al., 2015). All Bernanke's statements after the 2008 Financial Crisis are in the direction of having dealt with the crisis with the Baqehot doctrine. The main objective of central banks for financial stability is the status of lender of last resort, providing short-term liquidity to financial institutions (Bernanke, 2012). According to Hogan et al. (2015), although Bernanke seems to have approached the crisis with Baqehot's Lender of Last Resort perspective, the situation completely deviated from the path in practices during the crisis. While LLR rules were applied when the first signals about the crisis came, the rules were violated one by one with the panic caused by the crisis.

After the crisis started, the operations of many facilities established by the FED (The Commercial Paper Funding Facility, The Asset-Backed Commercial Paper Programme, The Money Market Mutual Fund Liquidity Facility and The Term Asset-Backed Securities Loan Facility) increased the FED balance sheet from $850 billion to $2 trillion in one year. In order to protect the integrity of the financial system, the Fed ignored solvent banks in favour of saving a few primary dealers (Selgin, 2012). The Fed's biggest breach of the Baqehotian doctrine was the creation of bailout packages for broadly insolvent banks. For example, $20 billion was injected into Citigroup through the Troubled Asset Relief Programme (TARP) with a loan of $306 billion. In the following months, an additional $25 billion was provided (Hogan et al., 2015). Humphrey (2010) summarises the Fed's deviation from Baqehot rules in the 2008 crisis as follows:

1- Emphasis on credit (lending) in exchange for money

2- Poor collateral acceptance

3- Subsidisation rates (above market or deviation from the application of high penalty interest)

4- Rescuing firms that are too large and interconnected to go bankrupt (such as Citigroup and AIG)

5- Extension of loan repayment periods

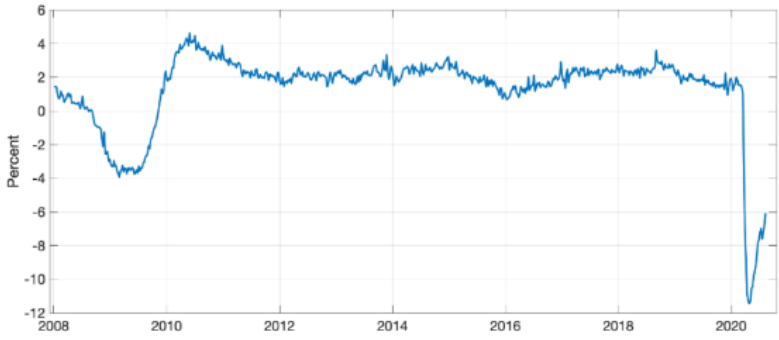
6- Absence of a pre-announced commitment: Lack of a consistent LOLR policy before crises in order for market participants to form balanced expectations

7- Lack of a clear exit strategy: The lack of a robust exit strategy to neutralise or eliminate excess reserves resulting from the Fed's credit easing policies.

Similar interventions in the market were also experienced during the COVID-19 period. In December 2019, the pandemic process that started in China affected all countries in a short time. As of 11 March 2020, this outbreak, which was declared as a pandemic by the World Health Organization, became the first item on the agenda of all countries in a few days. The spread of the epidemic in a short time caused serious and sudden changes in the world economy. The supply and demand chain was disrupted, the supply problem came to the agenda, and employment processes changed dimension. In addition to all these, financial stability deteriorated and the system was heavily damaged by the pandemic. In this process, central banks have undertaken the task of making urgent interventions to save the economies of countries. Although each country's central bank determined different strategies, financial institutions, companies and individuals generally benefited from the support provided. During this period,

significant amounts of liquidity were provided to the market to alleviate the financial tightening associated with COVID-19. The main difference of the pandemic from the 2008 crisis is the unprecedented scale of economic deterioration and the uncertainty of how long the situation will last (IMF Monetary and Capital Markets, Central Bank Support to Financial Markets in the Coronavirus Pandemic, 2020). During the pandemic period, when the stability of national economies deteriorated rapidly, it was seen as the duty of central banks to recover the economy. This critical role undertaken by the central bank can also have problematic consequences in some cases. The FED announced an emergency action plan within eight days (14-23 March 2020). The duration of this plan shows that the crisis was more extraordinary than the 2008 crisis. However, central banks' emergency plans raise two problems: First, the role of central banks in a global pandemic is quite limited. They can mitigate the crisis through lending and easier financial conditions, but this may increase fragility by encouraging more leverage in the future. Second, it may be too early to expect serious consequences, as it takes a long time to see the results of any economic policy (Mosser, 2020). The speed of the pandemic has put pressure on central banks to take quick decisions. While financial crises affect the economy at different times, COVID-19 affected all countries at the same time. The restrictions and bans imposed to prevent the pandemic caused large-scale supply and demand shocks. In addition, as economic activities almost came to an end, employment problems occurred in sectors such as entertainment, travel, services and accommodation. Disconnects in the supply chain disrupted the flow of economy.

Figure 1. Weekly Economic Index (scaled according to 4-quarter GDP growth)



Source: Federal Reserve Bank of New York. Lewis et al. (2020)

Figure 1 shows the weekly economic index chart for the USA. In the graph, the difference between the 2008 financial crisis and the pandemic period is quite

evident. As of March, all indicators moved in the opposite direction. Central banks urgently intervened in this situation to prevent the economy, which seemed quite stable before the pandemic, from collapsing further. The expansionary monetary policy and program implemented by the FED can be examined in three categories: Monetary policy, providing liquidity (the lender of last resort) and supporting non-financial sectors and individuals (Mosser, 2020). The FED used these actions very effectively. Low-cost financing and loosening of credit and lending conditions quickly recovered market activities and ensured financial stability. Baldwin and Mauro (2020:2) drew an interesting conclusion regarding the intervention of central banks in the economic deterioration that started with the pandemic. "On the bright side, a joint crisis response could be something policymakers will manage. "They may even succeed in rebuilding some trust and creating a spirit of cooperation that will help humanity combat other widespread threats, such as climate change." The spread of the epidemic in the G7 countries and China has dragged the economy to the bottom of the cliff, so to speak. At the beginning of the pandemic period, medical data changing hourly caused great confusion. The ten countries most affected by COVID-19 on March 5, 2020 are the countries that direct the world economy. The data refers to the US, China, Japan, Germany, UK, France and Italy, with the following results:

- 60% of world supply and demand (GDP)
- 65% of world production and
- 41% of world manufacturing exports

Baldwin and Mauro (2020:2) explain this issue with a joke: "When these economies sneeze, the rest of the world will catch a cold." According to the above information, the countries of the world are like cogs of an interconnected system in every sense. Economies are also connected to each other by faith. This belief is one of the mechanisms that leads to the spread of economic shocks or economic contagion (Baldwin and Mauro, 2020:17). The COVID-19 pandemic has tested belief systems as well as physical commitment. The belief mentioned here is not a religious basis. Expectations, predictions, and future investment decisions can be stated as factors that trigger each other.

In this process, some economists were concerned that supply-demand shocks would arise when the FED reduced interest rates. In such a wide-ranging crisis, the supply and demand side approach may be wrong. As a result, public health has become more important than any policy. But the real problem was that the payments and debts of the businesses continued even if they were closed. With the closure, supply shocks began and specific demand increases occurred. In such

times, central banks should step in and support both institutions and individuals to prevent the system from closing (Francia and Verdú, 2022). The most defining feature of intervention methods in extraordinary periods is the expansion of central banks' balance sheets. In exchange for less collateral or less liquid assets, large companies, banks, financial institutions and large-cap companies outside the financial sector are supported by the central bank. Other units of the economy indirectly benefit from these supports (Hoffman, 2021).

The European Central Bank, like the FED, has taken special measures for the COVID-19 pandemic. Instead of reducing interest rates like the FED, the Eurosystem expanded Targeted Long-Term Financing Operations (TLTRO), which allows unlimited borrowing for up to three months for banks in March 2020. Other measures began to be announced as of April 2020. Later, long-term loan opportunities were expanded with "Epidemic Emergency Long-Term Refinancing Operations (PELTRO)". PELTRO offered banks loans with a rate of 25 basis points less than the 8-10 month deposit interest rates. Thanks to this opportunity, where the amount is unlimited and the guarantees are less than necessary, banks have become a factor that balances the economic system by borrowing more (Hoffman, 2021). Additionally, on 18 March 2020, the ECB launched a 750 billion Euro purchasing program within the scope of the Pandemic Emergency Purchase Program (PEPP) for private and public sector securities (https://www.ecb.europa.eu, et: 10.10.2023). Purchases under this program reached 1.35 trillion Euros as of June 2021 (Hoffman, 2021). In addition to all these, small and medium-sized businesses' access to suitable loans was facilitated, allowing both households and businesses to survive the epidemic with less damage.

5. Turkey's Response to Crises

Central banks approach both economic crises and global crises such as COVID-19, which develop due to non-economic factors, with different methods. Many studies have been conducted on the decisions taken and programs implemented by central banks, especially during the pandemic period (Kuzucu, 2022; Ozcan, 2021; Adıgüzel, 2020; Arabacı and Yücel, 2020). Turkey and other developing countries, just like the USA and European countries, have approached crises as much as the country's economy can handle. During the 2008 Global Financial Crisis, the Turkish economy was exhibiting positive economic indicators. That's why the central bank has prepared programs to support other economic units as well as price stability. The most important criterion is to maintain price stability and financial stability in balance. Turkey, which implemented an inflation targeting program after the 2001 crisis, first

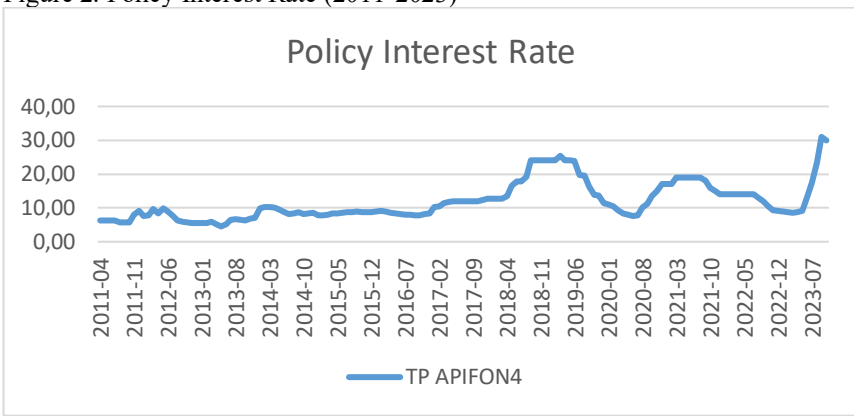
implemented this program as "Implicit inflation targeting". As of 2006, inflation dropped to single digits, establishing confidence in both households and markets. However, during this period, two important developments caused Turkey to deviate from the targeted inflation. The slowdown in foreign capital inflow since May 2006 caused the Turkish currency to lose approximately 30% of its value. In addition, the increase in food prices as a result of various reasons, including this situation, has caused inflation to rise. Although the central bank intervened in this situation, the targeted inflation was 5% at the end of the year, while the actual inflation was 9.6% (Serel and Bayır, 2013). The effects of the crisis that started in the USA towards the end of 2007 began to be felt in the real economy in Turkey in the second half of 2008. Likewise, at the end of 2008, the crisis deeply affected all countries of the world and brought economic activities to a halt (CBRT, 2008: 30). Central banks of developed countries significantly reduced policy interest rates and tried to keep the crisis under control. At the same time, liquid flow was created by providing loans and supports contrary to Bagehot rules to banks and financial institutions affected by the crisis in the market. Developing countries, on the other hand, initially took cautious steps towards the depreciation of the country's currency and financial stability. Thanks to the sharp decreases in demand in the following months of the crisis, inflation decreased and monetary policies were loosened. Many countries in the world, especially the USA and European countries, have made reforms to the banking system. Unlike these countries, cash precaution packages were not needed for the banking system in Turkey. Thanks to Turkey's implementation of many programs to save its banking system after the 2001 crisis, there was no need for rescue packages in the 2008 crisis. In the subsequent period, continuing the regulation and supervision of the banking system without making any concessions increased the resilience of the Turkish banking system against crises (Yılmaz, 2009). Still, many precautions have been taken against the ongoing crisis. First, decisions regarding the foreign exchange market were taken in October 2008. Foreign exchange buying auctions were suspended to ensure that the foreign exchange reserves withdrawn from the foreign exchange market remained within the system. Foreign exchange depository intermediary activities have been restarted in order to encourage policies to eliminate the foreign exchange shortage in the market and to enable banks to make more flexible decisions in terms of foreign exchange liquidity. With this decision, banks' transaction limits in the Foreign Exchange Deposit Markets have been increased. Transaction limits have been extended from 1 week to 1 month, and foreign currency borrowing interest rates have been reduced from 10% to 7% for US Dollars and 9% for Euros. This decision was updated in February 2009 and the transaction limit was extended

from 1 month to 3 months. Likewise, foreign currency borrowing interest rates were reduced from 7% to 5.5% for the US dollar and from 9% to 6.5% for the Euro. A total of 100 million US dollars were sold on 24-27 October 2008 to prevent unhealthy price formations in the market. In December 2008, the Foreign Currency Required Reserve Ratio was reduced from 11% to 9% in order to provide foreign exchange liquidity to the markets. A total of US$ 0.9 billion was sold through foreign exchange sales auctions on 10 March and 3 April 2009. In addition, in order to eliminate the foreign exchange liquidity shortage in foreign trade in December 2008 and between 20 March and 17 April 2009, arrangements were made to expand the use of export rediscount loans in two stages, allowing more companies to benefit from export rediscount loans, and credit limits were increased. . As of August 4, 2009, Foreign Exchange Purchase Auctions were restarted as foreign capital inflows increased with positive expectations for the economy (Serel and Bayır, 2013).

In the 2008 Global Financial Crisis, developed countries such as the USA, European countries and Japan suffered great economic damage. Turkey overcame the crisis in a shorter period of time because it strengthened its banking system during the 2001 crisis. The measures taken were generally aimed at maintaining economic stability for precautionary purposes. However, during the COVID-19 pandemic period, all countries of the world witnessed a huge crisis that developed outside the economy but primarily concerned the economy. CBRT, like other central banks, had to take many measures. With the onset of the epidemic, the closure process caused production and therefore supply to decrease. The decrease in demand accompanying the decrease in supply caused economic units to deviate from balance in a short time. The negative impact on demand generally resulted from the "fear factor" in the new consumption habits of households with limited social interaction. In the ongoing process, disruptions in the supply chain and the decrease in the value of TL have caused an increase in borrowing costs (Çakmakli et al. 2021). The fact that economic stability has deviated from balance on the whole world agenda has made it necessary for the central bank to take urgent measures. Turkey has preferred an aggressive monetary expansion as well as a moderate fiscal expansion (Çakmakli et al. 2021). First, on March 17, 2020, the Money Market Board reduced the policy rate by 100 basis points and determined it as 9.75. By the decision taken on April 22, 2020, the policy rate was determined as 8.75% and on May 21, 2020, as 8.25%. As the real political interest rate decreased, the dollarization problem was triggered. The increase in demand for dollars negatively affected the exchange rate. Although this effect was balanced by the central bank selling its reserves, it was not seen as a sustainable move

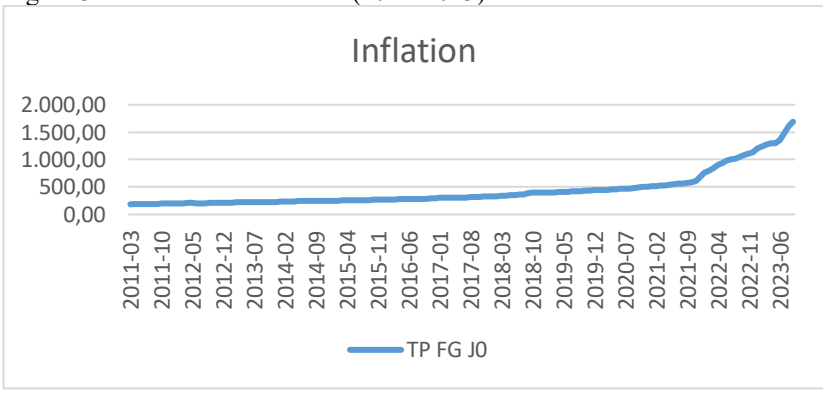
(Çakmakli et al. 2021). As seen in Figure 2, there was a serious decrease during the epidemic period.

Figure 2. Policy Interest Rate (2011-2023)



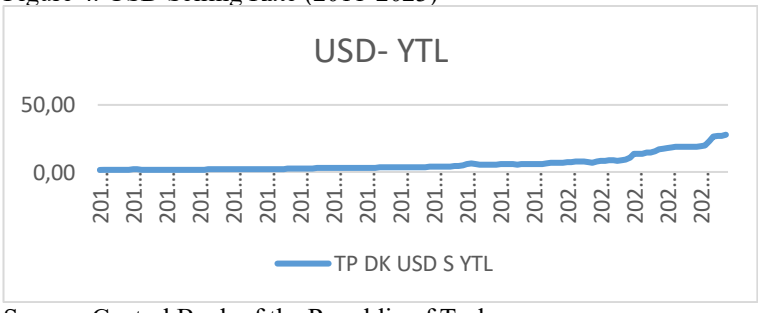
Source: Central Bank of the Republic of Turkey

Figure 3. Consumer Price Index (2011-2023)



Source: Central Bank of the Republic of Turkey

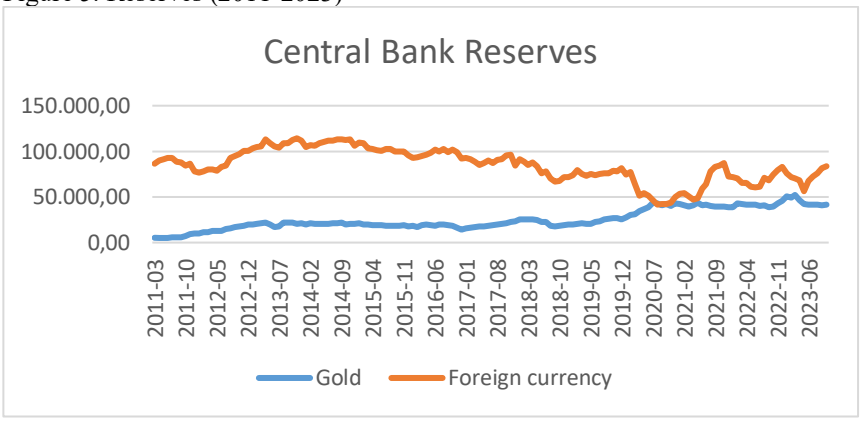
Figure 4. USD Selling Rate (2011-2023)



Source: Central Bank of the Republic of Turkey

The Turkish economy, which survived the 2008 Global Financial Crisis without much damage, has lost its stability due to the economic policies implemented as of 2018. This process was further accelerated by the epidemic that started in the first quarter of 2020. As seen in Figure 3 and Figure 4, inflation and exchange rates have increased gradually and continuously. While the USD exchange rate was between 3-4 TL before the presidential and general elections held on June 24, 2018, it rose above 5 TL after the elections. Two months after the elections, harsh statements about Turkey from the USA regarding the Brunson case increased the exchange rate to 7.20 on the night of August 12, 2018. During this period, exchange rate and inflation continued to rise as a result of the low interest policy implemented by the President and the new government.

Figure 5. Reserves (2011-2023)



Source: Central Bank of the Republic of Turkey

Figure 5 shows the process of CBRT gold and foreign exchange reserves. The most striking date here is the epidemic period. On this date, while the central bank's foreign exchange reserves recorded a serious decrease, gold reserves increased. The bank's moves to ensure economic stability during this period also seem to have affected reserve management. Economies under the influence of dollarization may be forced to sell foreign currency to keep the exchange rate stable as a result of wrong policy and interest rate decisions. In an article published in Independent Turkish on March 1, 2021, “In July 2020, Reuters reported, based on a banking source, that the CBRT reserves, through public banks, amounted to 30 to 32 billion dollars in 2019 and 60 billion dollars in the first six months of 2020.” A statement such as "stated that a sale was made (Tuncer, 2021)" may explain the reason for the decrease in reserves. According to CBRT data in Turkey, the measures taken during the epidemic process can be briefly summarized as follows:

-Providing flexibility and increasing predictability in banks' TL and foreign currency liquidity management

-Ensuring uninterrupted credit flow to the real sector and supporting export companies

-Supporting the cash flow of export companies with rediscount credit arrangements

-Closing the liquidity gap of the Government Domestic Debt Securities market

Governments have taken intensive economic measures since the epidemic started and became serious. Both individual and public support seemed necessary for that period. For example, while the ratio of cash support to national income in the USA was 6.9%, it was 4.4% in Germany (Ülger, 2022). Incentives were generally provided in the form of loans, capital supplements and loan guarantees. Turkey announced an additional package of 100 billion TL on March 18, 2020, and later this package reached 200 billion TL and 240 billion TL in the next stage (Gür, Tatlıyer & Dilek, 2020). Three headings were addressed in the measures announced as the Economic Stability Shield Package. Fiscal measures, financial measures that ease financial access, and social measures to ensure continuity of employment and protect disadvantaged segments (CBRT, Inflation Report, 2020).

6. Challenges of the LOLR role of Central Banks

As can be seen, in times of crisis, countries use all means to restore economic stability. Especially in times of crisis, central banks act as a serious savior for the country's economy. However, the steps taken during these periods may not be the right steps for later processes. As a matter of fact, central banks violate Bagehot's Ultimate Lending Authority rules in almost every crisis. Bagehot especially;

-High interest rate and high amount of loan,

-Low interest and almost collateral-free loans were provided by ignoring the rules of obtaining solid collateral. Calomiris and Meltzer (2016) state that these rules are clear, but their boundaries are not sharp. Although these rules exist to ensure the stability of the financial system, banks' violation of these rules brings to mind three questions: Why do countries avoid setting these rules? Why are Lending Authority structures and actions so diverse? How should financial stability be balanced in the banking system during crises? (Calomiris and Meltzer, 2016). Acharya and Thakor (2016) emphasize that three possible options for LLR should be identified:

1. Comprehensive protection in all conditions,

2. No protection whatsoever

3. Selective protection- used for systemic shocks

Perhaps this approach to rules both overlaps and contradicts the Goodhart Law stated by the British economist Charles Goodhart. This law points out the irony that when criteria or goals for a situation or job are set, those criteria can lead to a focus on the criteria themselves rather than the intended goals. The intervention of central banks in the market during crisis periods can also lead to results such as the Cobra effect. A good thing done to change a bad situation can lead to worse results. While talking about the difficulties of being the final lender, France and Kahn (2016) state that the recovery conditions must be clear in order to overcome this difficulty. Colomiris et al. (2016) mention the political obstacles to establishing lender of last resort rules and state that these rules are evolving. Interventions in crises can increase the risks of financial and moral hazard. Therefore, the support design must be determined well. We see that in crises, central banks provide protection very fearlessly by bending the rules. But nearly a century ago, countries always eschewed comprehensive protection. The approach to LLR rules has undergone radical changes due to changes in economic structures since the 1800s. According to Kaufman (1991), LLR is an ambiguous concept in both economics and banking literature. LLR intervention is an appropriate approach in terms of reducing asset prices, balancing total real income and temporary liquidity pressures. However, such support must be made through open market operations.

George Selgin (2010) may be right that central banks are destabilizing institutions. According to him, the Global Financial Crisis revealed the Jackyll and Hyde nature of modern central banks. The general view argues that central banks have a balancing role. In other words, it is responsible for the management of the national monetary aggregate and the final supply of credit to troubled companies in economic crises. Selgin (2010) emphasizes that central banks are a destabilizing mechanism by focusing on two questions:

-Why do governments turn a blind eye to the establishment of destabilizing institutions?

-Why are central banks seen as stabilizing institutions?

Central banks in the real world actually deviate from the theoretical definition at certain periods. In addition, the lender of last resort role is a responsibility forced upon central banks. The role of lender of last resort to prevent crises and

maintain the gold standard is a failure. Because; Almost no central banks comply with LLR rules. The central bank's sole adaptation to sudden changes in credit conditions disrupted gold payments. As a result, the central bank concept and the gold standard could not be a useful system at the same time (Redish, 1993).

In real terms, Bagehot states that he is not a supporter of central banking in Lombart Street, but if there is a wound, this wound should be closed:

"I can only answer that I propose not to abandon this system (central banking) because I am quite sure that there is no use in proposing to change this system. You too, perhaps better, may try to change the monarchy of England and replace it with a republic (1873, 329)."

7. Conclusion

While George Selgin sees central banks as financially destabilizing institutions, he asks the following question: Why are central banks seen as stabilizing institutions? This question can be answered most simply historically. First of all, if the reasons for the emergence of central banks are taken into consideration, the answer to the question is clear. Central banks were first established to maintain the balance of all types of markets. In fact, war financing may be the first and most important reason for these (see the Riksbank example). In this respect, central banks are an indicator that states have the chance to intervene in the market. Ensuring price stability means intervening to ensure this stability. In this respect, central banks are like scales in the hands of governments.

The concept of the Credit Authority of Last Resort, whose systematic framework was created by William Bagehot, is another important role of central banks. With this role, central banks can solve many problems during crisis periods. While the Credit Authority of Last Resort is actually a key policy tool to stabilize a system in crisis, it can be a potential problem. Vives (2008; 444) notes that a well-intentioned LOLR policy may be inconsistent over time. Financial institutions tend to make suboptimal efforts when they anticipate such aid will be provided. Additionally, this opportunity may lead to distorted policies in financial institutions. A low-interest and easily obtainable LOLR takes over the entire problem of liquidity management in banking. If financial institutions can access easy and cheap help, their efforts to hold cash assets decrease. This moral hazard can have two consequences: First, deposit seigniorage shifts from public to private banks. The second result is that LOLR is also exposed to the credit risk of its collateral (Greenbaum et al.,2019;121-129).

Violation of the LOLR rules, which central banks use as a key policy tool, is not limited to the borrower. Central banks and governments also violate this rule. Violations such as rescuing financial institutions that should not be rescued, providing credit to other sectors outside the financial institution, and adopting a low interest and long term policy are violations of the LOLR role. In this study, violations of central banks are mostly mentioned.

The adoption of the role of central banks as saviors in every crisis is not new. Currently, Bagehot has established the rules of the Credit Authority of Last Resort to delineate the boundaries of this rescue mission. However, it seems that both central banks, governments and the sectors that need this loan are clearly violating the rules. Therefore, central banks must either redefine and clearly define the framework of these rules or remove this rule from being the main policy tool. Otherwise, lines will continue to be erased with each crisis, both economically and morally.

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CHAPTER 14

The Effect of Digital Finance on Financial Stability: Evidence from Türkiye

Yüksel Akay Ünvan[1] & Taha Kürşat Menevşe[2]

[1] Prof. Dr., Ankara Yıldırım Beyazıt Üniversitesi, İşletme Fakültesi, Bankacılık ve Finans Bölümü, ORCIDID: 0000-0002-0983-1455
[2] Phd Student, Ankara Yıldırım Beyazıt Üniversitesi, İşletme Fakültesi, Bankacılık ve Finans Bölümü, ORCIDID: 0009-0007-8094-689X

INTRODUCTION

The Industrial Revolution 4.0 provides to start the digital era. Thus, digital finance has affected the whole financial system. The digital age reshapes the information technology that financial agents can easily reach the financial services (Daud, 2021).

Digital finance can be called as internet based finance, so it consolidates technology to conventional finance. Therefore, the digital finance which is reinforced by information technology is the vital part of financial system. In other words, it can reduce the asymmetry of information, decrease operation costs, develop the capacity of financial services, and improve financial system source distribution.

Digital finance has impact on financial system in many ways: online credit, mobile payment, finance of internet, and insurance of internet. Firstly, online credit provides to meet supply and demand side of the credit easily. Moreover, there is no geographical boundaries for the financial operations. Secondly, finance of internet enlarges the possibilities even for small funds to make investment in financial system. By the way, transaction costs and time are reduced owing to digital payment. That's why, financial services improve their effectiveness with respect to payment and transfer.

Technological improvements are the main factor of increasing yield financial development. Digital finance is so important that play important role in advancing the financial technology innovation (Li, Ye, Zhang, 2023). According to literature, digital finance could reduce financial restrictions and develop technology from the supply side via credit channel. On the other hand, some researchers examined that digital finance can affect the demand side of finance.

Financial inclusion was the main concept of financial sector especially for central bank in the early 2000s. However, financial stability gained importance after 2008 financial crisis. Since, the crisis was threatened the health of financial system and the financial risk was affected financial stability. In general, central banks are the key factor of managing financial stability (Schinasi, 2003). Because the central bank is the last resort of funding for the financial system and by the way it is the only liquidity provider. Moreover, payment system is the main objective for central banks. Finally, transmission mechanism runs with banking system to achieve monetary policy aims.

This paper aims to fill the gap about the relationship between digital finance and financial stability. There are several research on examining the relationship but the method and data which are used are not proper for analysis. Besides, systemic risk is included in our research to emphasize the effect of financial risk on the relationship.

LITERATURE REVIEW

Digital Finance

Scope of Digital Finance

Digital finance is broad term so it contains digitalization whole financial environment. The electronic products which are digital banking, credit cards, automated teller machines are included in finance universe (Gomber, Koch, Siering, 2017). Moreover, mobile phone applications which are related with finance are valid for financial environment. Digital finance gives importance some countries that do not have possibility for infrastructural technology. Since, digital technology leads to develop and improve financial technologies such as internet, ATM, bank. Although digital finance is considered as new thing or something that has not been mentioned before in general idea, new improvements are not limited for digital finance. In other words, digital finance is not restricted by innovation. Providing service and maintenance are important for digital finance.

Digital Finance vs. Conventional Finance

Before digital finance, there is conventional finance. Although digital finance and conventional finance are served for financial environment giving financial businesses to related institutions, there are some different points: operation techniques, communication ways, and business capacity. According to operation techniques, conventional finance deal needs physical attendance like going to financial institutions whereas digital finance make possible to online deal via mobile phones that can be done everywhere. According to communication ways, conventional finance depends on physical report like banknote coins whereas digital finance adopts to consumption and saving via internet. According to business capacity, conventional finance gives importance to traditional banking issues, assets, and finance products whereas digital finance contains online operations peer to peer financial businesses.

After the technological revolution, all over the world's economies has faced economical issues like decreasing profitability, illiquidity, and insufficient sources. Conventional finance is not enough for satisfying recent social requirements (Wenhu, 2025). Conventional finance causes to prevent developing economic growth. In addition, absence of effective abilities are the main issue for financial environment. Digital finance improves recent technological aid and manufacturing based assistance. Thanks to digital finance, big data infrastructures, communication links, and innovation related financial operation can be used. When compare with conventional finance, digital finance is cheaper,

more effective, and more elastic. These properties enhance companies' skills to minimize losses and find a way for issues. Digital finance is useful for making new possibilities.

Technological Improvements of Digital Finance

Digital finance concept is related with improvement and enhancing usage of infrastructures like blockchain, big data. Yet, the description of digital finance is not valid for everyone. By the way, meaning of digital finance is used for close terms like financial technology, net finance, finance intelligence. Conventional finance gives importance to financial technology and financial technology procedure is improved by service of finance which is based on technology information. That's why digital finance is assumed as net finance.

Financial Institutions and Digital Finance

When digital finance is getting improved, conventional banking has changed. Digital finance gives opportunities and leads transaction effectiveness for banks. Digital finance decreases of depending loan finance for enterprises that are small and medium scale. Moreover, upgrading technology link can enlarge transactional effectiveness of banking system. The usage of digital finance makes development in banking system. Digital finance assesses loan risk, displays transactional and financial environment risks, develops transactional effectiveness, decreases risks and raises financial loan. Digital equipments have given hand financial institutions adhere to be more efficient with law necessities and develop exactness for documentation.

Digital finance gives opportunities to banks for decreasing mistakes and employees 'expenditure via transactional mechanization. The acceptance of digital finance is mostly related with consumer according to financial sector. When consumers endorse internet banking duty, the demand for bank divisions are decreased. Digital finance provides consumers to make transaction twenty four hours and seven days. Therefore, consumer pleasant are developed. Digital finance improves new technological products such as digital payment, mobile financing. These products both provide plenty of consumer demands and make new channels for banks. Actually, digital finance develops banks 'transactional effectiveness via amending procedure, decreasing losses, enlarging digital administration abilities, and improving output modernization.

Digital Finance and Innovation

Digital finance improves immediately nowadays. Innovation is the key factor of financial movements, its main parts are the sources of data, the main mechanization of data mining, and source applications, its base is large data,

computing of cloud, things internet, blockchain, and artificial intellegence: these are innovations that give a way to digital turn.

Digital finance has promoted to conventional finance. Recent financial equipments like digital payment, mobile banking changed consumers 'manner and stimulated output and type of finance modernization. Digital finance employs communication technology to give hand modern enterprise, enlarge the flow of economic sources, improve digitalization.

Digital finance has importance for leading financial improvements which are relied on technological modernization. Digital finance has plenty of operation situation and elastic network ways. This situation gives many financial resources and decreases limit for modern enterprises, and enlarging research and development sources. Digital finance decreases economic operation losses and mitigate modern enterprise which is limited by finance. Digital finance promotes source distribution via improving digitalization, decreases communication misleading for operations. By the way, digital finance helps business display and estimation of investment.

Financial Stability

Scope of Financial Stability

According to European Central Bank, financial stability is the concept that all financial systems such as markets, intermediaries, infrastructure could resist the financial impact (Pham, Doan, 2020). In other words, it can diminish the probability intermediaries' interruption procedure that are strictly enough to damage in the financial structures. Financial stability could distribute financial sources properly, control risk issues that are related with finance, and decrease the unwanted price volatility (Ahmad, 2018). That's why, it can protect funding strength which contains assets. Besides, the asymmetry of finance which cause autogenously or unexpected situations can be got rid of in a proper financial structure.

Especially, financial stability is the key subject for accomplishing stable economic growth. Because, plenty of financial operations are related with financial structure.

Main Aims of Financial Stability

Financial stability includes all the financial structure such as markets, agency, and infrastructure. The divisions of financial system are so related that any failure in a division can affect all system's financial stability (Schinasi, 2004).

Financial stability is not only concerned in distributing source and failure, organizing savings, development, and growth but also is concerned in payment systems to run financial structure properly.

Although financial stability term reveals in financial turmoil, it can be capable of inhibiting financial structure, including and negotiating with financial procedure. When financial stability provides for all financial system, market can prevent financial risk autonomously.

Financial stability can be seen as possible results of the real economy. Any failure in financial market is not taken consideration as a risk as long as financial operations are big enough.

The concept of financial stability does not cover all financial structure for maintaining purpose. Managing the whole financial structure does not need every division of financial structure enthusiastically at their best conditions.

Financial Instability Inconsistency

Financial instability inconsistency is the condition that the financial structure seems the most powerful when it is the weakest moment. It is the situation for expanding the financial turmoil.

Financial Stability and Central Banks

Financial stability has so crucial role in the financial structure that central banks have started to follow it to maintain stable of monetary policy. Moreover, some of the central banks take consideration financial stability as a primary duty (Oosterloo, Haan, Pin, 2007). Although monetary policy stability which can be said that balance price general levels is different from financial stability, there is a general acceptance that it is the main part of financial structure.

Generally, central banks have basic objectives on financial stability. Central banks are last resort of lending that fund financial institutions with direct liquidity. Payment systems are under the control of central banks to make sure the functioning of fund flow (Schinasi, 2003). It is crucial for financial system that any malfunction can affect all the system. Monetary policy uses transmission mechanism to direct financial system. Therefore, any defect in transmission mechanism can have adverse effect on the financial system. Consequently, there is definite network between financial stability and monetary policy stability. Crisis terms affect immediately monetary policy by trusting financial system. Then, this situation negates banking system and that's why economic activity gets cooler.

Financial stability report is sort of communication way between public and central banks. Besides communication, the report gives information about recent

economic activities to financial agents in order to eliminate the problems on finance.

The reasons for publishing financial stability report are; rising transparency between public and central bank, devoting financial stability, and increasing bonds between financial institutions and central bank.

In the progress of expected economic event, monetary policy runs appropriately. Yet financial instability condition causes possible tail risks. Tail risk can be defined as occurring when negative shocks are recognized (Adrian, Liang, 2018).

Financial Inclusion

Financial inclusion is a procedure for reaching to financial assistance in exact time and precision where needed people at the lowest cost (Sarma, 2008). The description asserts different aspects of financial inclusion such as; convenience, availability, and conventional finance usage.

There are plenty of index to measure the financial inclusion. The quantity of financial accounts, the quantity of automatic teller machine, and the quantity of credit are the well-known indices. However, the single usage of these indices deceives the concept of financial inclusion.

Accordance with financial literature, increasing financial inclusion can affect financial stability in adverse and affirmative way. Despite this view, raising financial stability can also increase the financial inclusion. There are three approaches for financial inclusion provides the financial stability (Khan, 2011). First of all, distributing of assets could eliminate the risk of portfolio and financial system itself. Secondly, increasing the number of fund holder provides scale and stability and diminish the non-financial assets. Finally, financial inclusion devotes to work well monetary policy transmission and then it provides financial stability.

Systemic risk

Scope of Systemic Risk

Systemic risk affects the whole properties of the financial market. Thus, it is hard to avoid via distributing assets in the portfolio. It can be called as market risk which does not affect only share or division but also affect all over the system (Iqbal, Shah, 2012).

Even though systemic risk is a part of finance, its importance is not restricted with financial concerns. Since, the mortgage crisis affects financial systems. Especially, stock market investments in 2008 collapsed due to market scale situation no matter what sort of shares were invested.

Portfolio diversification can be inquired in crisis term. Then, experts look for solutions to solve systemic risk problem. Conventional finance could answer these questions yet it is not sufficient anymore. Digital finance is the current solution for systemic risk.

Determinants of Systemic Risk

Systemic risk can be considered when financial assets are estimated. It is the well-known aspect for calculating risk related with financial choice. It assesses via beta. Beta is crucial indicator since it connects link between corporation and share market.

There is an assumption on confusing investors 'choice because of financial expert decision about valuation of stock. Alteration of any corporation's price varies systemic risk. That's why, the share value affects investors 'decision contrarily.

Liquidity has positive and negative effect on systemic risk. Increasing cash flows liquidity raises systemic risk (Jensen, 1984). Otherwise, liquidity ratios have a reverse relation among systemic risk. Increasing the liquidity in Corporation lowers the systemic risk.

A Corporation can change capital structure to maximize the profit. Yet, expanding corporation's debts raises systemic risk. Thus, there is a direct relationship between leverage and systemic risk (Milicher, 1974). Besides, beta has direct relations with leverage ratio.

Performance efficiency means that creates more profit when the financial system runs correctly. There is reverse relationship between performance efficiency and systemic risk (Gu, Kim,2002).

Profitability can measure a corporation's financial achievement. It decreases the corporation's systemic risk (Logue, Merville, 1972). It is found that a reverse relation among profitability and systemic risk. On the other hand, this situation is not valid for every corporations. Insurance corporations gain profit from risky events. The greater risk insurance corporations take the more profitability they have.

According to financial literature, because of the economics of scale larger corporations may have lower systemic risk (Olib, 2008). Since, larger corporations have ability to adopt the effect of economics alterations. Moreover, they can easily diversificate and this situtation eliminates the bankruptcy and systemic risk.

Beta is a part of growth function (Hong, Sarkar, 2007). It is found that there are negative and positive relationship among growth and systemic risk. When

growth actualizes rapidly, the reverse relation occurs with systemic risk. Otherwise, Corporation with great growth requires extra resources and this procedure makes positive relationship between growth and systemic risk.

Dividend payment and stock price gain are preferable for investors. Although share gain is correlated with systemic risk, dividend payment has negative relation with it.

Market value is the value of corporation's assets in the market place. There is a negative relationship among market value and systemic risk (Borner, Smidt, 1977).

Systemic Risk and Return

Investors take into consideration risk which is related with investment. It is also called as return and expected return has a direct relation with risk. In other words, investment in an unpredictability raises expected return. Information on systemic risk is useful for investors to examine the investment which contains risk.

Systemic Risk and Decision Making

Corporation's experts use systemic risk to choose the financial instruments that have more value of return. Moreover, decision making process, makig policies and strategies are used systemic risk then it increases investors 'financial assets. By the way, decision making process in financial assets could affect return and uncertainity of invesment.

Systemic Risk and Financial Instruments

Systemic risk has crucial effect on financial instruments. Different sectors have important result determined by financial ratios such as corporation scale, debt ratio, and profitability. Therefore, systemic risk may alter from one sector to another sector. The financial instruments have different effect on risk varying sectors (Lee, Jang, 2006).

DATA AND METHODOLOGY

This section explains the detailed description of the variables. The data contains the time quarterly from 2016 to 2024. The time length is limited because digital payment system has recently integrated to the financial ecosystem. The analyze of the paper includes econometric instruments to specify the selected model.

Data

The research benefits quarterly data from Türkiye to examine the effect of digital finance on financial stability, especially spotting on systemic risk. The model includes financial indicators, containing digital finance and systemic risk. Analysis can explain to determine the relationship among variables.

Banks Association of Türkiye, Banking Regulation and Supervision Agency are the data sources of the paper. Below table reveals an ultimate description of the abbreviations, definitions, frequencies, sources for all variables involved.

Abbreviation	**Definition**	**Frequency**	**Source**
zs	Z Score	Quarterly	Banking Regulation and Supervision Agency
df	Digital Finance	Quarterly	Banks Association of Türkiye
sr	Systemic risk	Quarterly	Banks Association of Türkiye

Z score is a financial tool to examine financial stability. Z score is created by World Bank. Z score reveals that there is an opposite relationship between default risk of a bank and a bank's asset-debt inequality. As long as Z score increases, a bank's default risk decreases. Although Z score measure financial stability, it contains some financial ratios such as profitability, leverage, and volatility of return. Beside measuring default risk, Z score has a positive relationship with profitability and capitalization. Otherwise, Z score has a reverse relationship with standard deviation of return of asset. The formula of Z score:

Z score=(ROA+EAR)/ σ_{ROA}

Z score= Financial stability index

ROA= Return of Asset

EAR= Equity Asset Ratio

σ_{ROA}= ROA volatility

Digital finance index explains that what degree financial transactions are made by digital finance environment. There is no certain formulation for digital finance index because it is almost new for financial industry. Banks Association of Türkiye has data about digital payments. From 2016, there is increasing attention to digital payment tools such as contactless payment, credit and debit card using, and payment from internet. Nowadays, cash payments are rarely used. Although consumers use digital payment methods, business environment still uses conventional finance tools. The data which contain digital finance are restricted. The statistics on digital payments was initiated in 2016. Yet, quarterly data are sufficient to explain the improvements in digital finance. The usage of digital payment system increases accordance with years. Any improvement in digital payment raises the ratio of digital payment system use.

Systemic risk index defines the ratio of risky assets in a bank's balance sheet. Risky assets have high volatility and their prices are not certain in market conditions. To eliminate default risk banks have to spare provisions for risky assets. In inflationist environment, crisis situation, and bad economic conditions increase the value of risky assets. 2019 pandemic term is the most risky time for our data. Since, uncertainty is valid and price perception is precise.

Multicollinearity Test

Multicollinearity is sort of statistical error which among estimator variables have a robust or pure correlation each other. This type of issue fundamentally disrupts all variables of the estimated regression. The model that is ignored the existence of multicollinearity in the studies can cause underestimate the variables and their relations. The skepticism of violation is the source of this statistical problem and then descriptive elements are autonomous. In that case, eliminating the skepticism does not prevent the dependence of descriptive elements, thus it concludes with multicollinearity (Oke&Akinkunmi&Etebefia, 2019).

There are two types of multicollinearity: First of all, perfect multicollinearity occurs in which an independent variable has a clear linear relation with other variables. Finally, extereme multicollinearity can be defined as an estimator is deeply related with the variables.

Although there are plenty of methods to test multicollinearity, the Variance Inflation Factor is used in our analysis. This test can be used as a rate to evaluate the multicollinearity in the regressed model.

The existence of multicollinearity in the variables is determined by the Variance Inflation Factor rate which is above 10. The table shows that there are no multicollinearity among variables since all centered variance inflation factor values are less than 10.

Variable	Coefficient Variance	Uncentered VIF	Centered VIF
df	407.6887	7.835156	1.015604
sr	1943.530	224.1207	1.015604
c	1061.384	221.2549	NA

Ramsey RESET Test

The common error in Ordinary Least Square is excluded the notable factors. The exclude of these variables causes the wrong acknowledgment of the variables which are in the analysis. This neglect can direct the errors with regressors and then mispresent the coefficients (Volkova&Pankina, 2013).

Ramsey RESET test is used for powerful model in statistical approach. The base duty is observed sequence of variables whether linear or non-linear. Then, it enlarges the description of the variables.

The test considers this type of errors such as; neglecting variables and wrong model form. However, Gaussian distribution assumption is not sufficient for analysis. That's why, bilateral exponential distribution, distribution of maximum and minimum values are used for satisfying the model.

The table reveals our estimation is correctly specified.

	Value	df	Probability
t-statistic	1.779315	26	0.0869
F-statistic	3.165961	(1, 26)	0.0869
Likelihood ratio	3.447173	1	0.0634
F-test summary:			
	Sum of Sq.	df	Mean Squares
Test SSRT	421.7878	1	421.7878

Restricted SSR	3885.659	27	143.9133
Unrestricted SSR	3463.872	26	133.2258
LR test summary:			
	Value		
Restricted LogL	-115.5259		
Unrestricted LogL	-113.8023		

Wald Test

Wald test is sort of statistical approach for examining significant variables in the model. Multiple regression models enhance to be related variables each other in a restricted framework. Thus, the test is used for determining whether the relation among variables is equal to zero.

The Wald test justifies that as long as the relation among variables is not equal to zero, therefore the variables should include in the model. On the other hand, the situation of not getting result from the test explains that a required variable can be neglected. A t-test can be used for a variable to evaluate the importance of it.

The Wald test is evaluated the chi-squared distributions because this distribution could be defined with broader samplings. That's why, the test can be called as Wald Chi-Squared test which is distinguished from Wald Log Linear Chi-Square test that represents a non-parametric difference.

To determine the misspecification in the model p value can be used. Therefore, there is no misspecification in our model.

Null Hypothesis: C(1)=0			
Test Statistic	Value	df	Probability
t-statistic	-3.849196	27	0.0007
F-statistic	14.81631	(1, 27)	0.0007
Chi-square	14.81631	1	0.0001

Null Hypothesis: C(2)=0			
Test Statistic	Value	df	Probability
t-statistic	-3.002822	27	0.0057
F-statistic	9.016941	(1, 27)	0.0057
Chi-square	9.016941	1	0.0027

Unit Root Test

Unit root test is sort of econometrical approach which is used for deciding whether the time series has stationarity or not.The p values of the variables are smaller than % 5 significance level. Therefore, the null hypothesis could be rejected. Moreover, there is no unit root in the variables.

Variable	**Case**	**Statistics**	**Level**	**First Difference**
ZS	Intercept	ADF t-statistic	-2.948404	-2.852315
		P value	0.0074	0.0000
		PP t-statistic	-2.948404	-2.852315
		P value	0.0000	0.00001
	Intercept&Trend	ADF t-statistic	-3.544284	-3.498158
		P value	0.0014	0.0000
		PP t-statistic	-3.553704	-3.498158
		P value	0.0014	0.0001
DF	Intercept	ADF t-statistic	-2.951125	-2.592492
		P value	0.00716	0.0000
		PP t-statistic	-2.948404	-4.393326
		P value	0.0064	0.0001
	Intercept&Trend	ADF t-statistic	-3.544284	-2.178295
		P value	0.00369	0.0000
		PP t-statistic	-2.178295	-1.880909
		P value	0.0061	0.0001
SR	Intercept	ADF t-statistic	-2.971853	-4.781441

		P value	0.0007	0.0000
		PP t-statistic	-2.967767	-4.774638
		P value	0.0006	0.0000
	Intercept&Trend	ADF t-statistic	-12.97660	-29.59214
		P value	0.0000	0.0000
		PP t-statistic	-3.574244	-4.398542
		P value	0.0008	0.000

Robustness Check

Autocorrelation diminishes the explanation power of the model. Durbin-Watson test is used for detecting the autocorrelation. As long as Durbin-Watson statistics is less than 2 there is no autocorrelation in the model. In our model, Durbin-Watson value is equal to 1.13. Therefore, there is no autocorrelation in the model.

Methodology

Linear Regression Model

A diagnostic approach enhances the estimation of variables, defines the main estimator, and examines the effect of the variables to output.

This analysis method is used for examining the cause and impact relations among variables. Although correlation link is highly concerned in the model analysis, the main aim is that determining the stability and the direction of two random variables (Granger&Newbold, 1974).

Multiple linear regression is created on the basis of simple linear regression assumptions. Simple linear regression is not sufficient behalf of the condition that variables can be affected by more than one estimator. Therefore, multiple linear regression is the best option for including plenty of variables in the model. Despite similarities between multiple linear regression and simple linear regression, there is also difference among them. Multicollinearity is the problem which is occurred in multiple linear regression analysis. Correlation among variables causes the issue and affects the model's coefficient and estimator robustness.

To estimate statistical variables there are plenty of specific methodologies in analysis. OLS method runs with minimizing the differences to determine the fit model for analysis. In order to get minimum variance, Gauss-Markov assumptions are used in the method.

There is less research papers about the relation among digital finance and financial stability because digital finance is emerged in the literature recently. Luo, Luo, and Lv (2022) and Beirne and Fernandez (2023) used literature review to explaining the relation among digital finance and financial stability. On the other hand, Valverde (2017), Banna and Alam (2021) used regression analysis to define the relation among digital finance and financial stability. In our research paper, we also use regression analysis to examine the relationship among them. The reason for using Ordinary Least Square Method is that the method is better way to explain the relationship. Moreover, the data we use is more suitable for analyzing the model.

Here is the empirical model which we use in the analysis;

$zs=\beta_0+\beta_1 df+\beta_2 sr+\mu$

zs= Z score

df= Digital finance

sr= Systemic risk

As explained in Methodology, OLS regression analysis is chosen for estimation.

Variable	Coefficient	Std. Error	t-Statistic	Prob.
df	-77.72028	20.19130	-3.849196	0.0007
sr	-132.3809	44.08548	-3.002822	0.0057
C	152.5781	32.57889	4.683342	0.0001
R-squared	0.501064			
Adjusted R-squared	0.464106			
S.E. of regression	11.99639			
Sum squared resid	3885.659			
Log likelihood	-115.5259			
F-statistic	13.55760			
Prob(F-statistic)	0.000084			

Emprical Results

Findings acquired from estimated model which is used the Ordinary Least Square method indicating the effect of digital finance on financial stability. Coefficient of determination (R^2) equals to 0.5 which means roughly % 50 of change in financial stability affects the variables. The F statistics is measured at 13.56 in which % 5 level of significance that determines digital finance has a significant impact on financial stability approximately % 50 effect on it.

The coefficient of digital finance is 77.72, and t value is 3.84 ($p>0.05$). There is a reverse relation among digital finance and financial stability. Specially, % 1 change for digital finance may change % 77 in financial stability. In the order of % 5 significance level, the assumption is that digital finance does not significantly affect financial stability can be rejected. Therefore, digital finance is related with financial stability. According to Liang, Wei, and Duan's research, digital finance has positive and significant effect on financial stability. Their findings reveal that digital finance could affect both profitability and risk management. Therefore, digital finance may increase financial stability. Although Banna and Alam find that digital finance inclusion has a significant direct relationship with financial stability, there is a reverse significant relationship with the volatility of return of asset. The increasing digital finance inclusion provides the better financial stability. Risman reveals that there is positive relationship between digital finance and financial stability The findings develops the research of Ozili, Li, and Juengerkes. On the other hand, Tang, Buchak, and Romanova and Kundishka have the close idea with our research paper. They found to be reverse significant relation among financial stability and digital finance. Differences about the result are based on methodology, data type, and proxies of model. In Risman's research, credit growth was used instead of z-score. Credit growth is insufficient to explain the relation among financial stability and digital finance.

The coefficient of systemic risk is 132.4, and t value is 3.00 ($p>0.05$). There is a reverse relation among systemic risk and financial stability. Especially, % 1 change in systemic risk could change % 132 in financial stability. In the order of % 5 significance level, the assumption is that systemic risk does not significantly affect financial stability could be rejected. Thus, systemic risk can be related with financial stability. In Ellis, Haldane, and Moshirian's research paper, systemic risk has a reverse relation with financial stability. Bank governance can reduce the risk with respect to the paper. Therefore, bank governance and diversity in core financial issues may increase the financial stability. Frait and Komarkova examined the risk and financial stability accordance with macroprudential policy. Their finding is that systemic risk has reverse relation with financial stability. Then, macroprudential policies can prevent risk to distribute to all over the financial system. According to Risman's research paper, systemic risk has a

reverse significant relationship with financial stability. In other words, digital payments could decrease the credit growth since financial institutions can increase the fund carefully. Moreover, systemic risk can affect transmission mechanism which causes the issue in asset health and financial stability. Besides, the studies of Gai and Kapadia, Caballero and Simsek, and Minoiu and Reyes could support our findings. They also revealed negative and significant relation among financial stability and systemic risk.

Conclusion

The relation among digital finance and financial stability prevails important issue thus likely to pursue in the future. There is a reasonable interest for grasping the relation with these two concepts, so the relationship is crucial for many reasons. From the view of financial institutions, evaluating how financial stability could affect to digital finance transactions is important for calculating responsive financial operation strategies. The digital finance transactions enlarge beyond the lead to digital payments of the financial system, it covers all over the financial operations finally interacting with real economy.

For all member of financial markets, the response of financial stability to digital finance is vital. Financial operations affect the whole financial system considerably. Therefore, financial operations based on clear information and risk management policies can change the health of a bank's assets and liabilities.

Financial stability reveal sensitivity to alterations in market situations lead by plenty of financial instruments. This empirical analysis aims to explain the relation among digital finance and financial stability covering period from 2016 to 2024 quarterly. OLS is applied to examine linear relations among all elements of model. dependent and independent variables.

The empirical results indicate that there is no multicollinearity among variables. The VIF is used to detect multicollinearity in the model demonstrating independence and statistical significancy of variables. In econometric methods, some variables or model itself may need to specify in the current situation. To solve this issue, the Ramsey RESET Test could be applied. It evaluates estimation according to omitting variables. Thus, there is no omitted variables in the model. Additionally, importance of all variables should be tested to explain them in the model. Test of Wald explains variables' significance. In our model, all of the variables require for the model meaningfully.

The key point of this research is digital finance operations in banking system should consider the dynamics of financial stability. Systemic risk has negative effect on financial stability. Moreover, financial transactions contain risky situations such as liquidity risk, debt-capital ratio risk, and decision making on financial situations. These risks can affect financial stability of the financial institutions. Although digital finance contributes to financial system convenient opportunities, the whole system may be open for harmful side effect of

technology. Therefore, increasing risks could be reduce financial stability in banking system. That's why, technology based on finance with diminishing the all risk should be used in the financial systems. Besides, there is no regulation on digital finance precisely. To support financial stability, law requirements about digital finance must be fulfill in the regulatory system. Regulatory gap increases risks on the financial system.

Digital finance is in growing stage. There are no plentiful data on digital finance. It takes time to measure certain aspect of the relationship between digital finance and financial stability.

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CHAPTER 15

Organisational Learning: A Conceptual Analysis in Light of Learning Theories

Bahar Yalçın[1]

[1] Doç. Dr., Manisa Celal Bayar Üniversitesi

1. INTRODUCTION

The technological developments, global competition and environmental uncertainties that characterise working life in our era necessitate significant transformations for all organisations. Creative thinking and innovative practices form the most important starting point for transformations appropriate to the era. In this dynamic context, organisational learning has emerged as a central concept in management studies and provides a powerful explanatory framework for understanding how organisations acquire, create, interpret and institutionalise knowledge. Today, organisational learning empowers organisations to create value as a strategic capability that starts at the individual level and spreads to organisational processes.

The concept of organisational learning emerged in the late twentieth century as academics sought to explain why some organisations were better able to respond to change, avoid repeating past mistakes, and translate their experiences into better performance. Early fundamental studies conceptualised organisations as information processing systems capable of identifying and correcting errors, while later approaches expanded this view to include the cultural, cognitive, and political dimensions of learning. Consequently, organisational learning has become a multidisciplinary field intersecting with strategic management, organisational behaviour, knowledge management, and innovation studies.

Despite its widespread use, organisational learning is a concept characterised by theoretical diversity and definitional ambiguity. Different studies emphasise various aspects, such as learning processes, outcomes, levels of analysis, or enabling conditions. Some approaches focus on behavioural change and performance improvement, while others highlight shared mental models, routines, and institutionalised practices. Furthermore, distinctions are often made between organisational learning and related concepts such as learning organisations, knowledge creation, and organisational memory, contributing to the discussions in the literature.

This study, prepared to examine organisational learning at a conceptual level in light of learning theories, first addresses learning theories and then evaluates learning processes at the individual, group, and organisational levels.

2. THE ORGANISATIONAL LEARNING APPROACH

Organisations learn consciously or unconsciously. Learning is a fundamental necessity for organisations to continue their existence. Some organisations consciously encourage learning aimed at achieving their goals and create an

environment that facilitates learning within the organisation. In organisations that do not act consciously, learning occurs in the form of acquiring habits, but this does not occur at the desired level of efficiency (Kim, 1993).

There is a consensus among researchers that organisational learning should be defined as a change in cognition or behaviour (Easterby-Smith et al., 2000). In today's sustainable competition context, 'knowledge-based competencies' constitute an organisation's most important assets in terms of creating uniqueness through different applications. The learning culture that will be created by making the organisation's knowledge and competencies accessible to all employees has a powerful impact on all processes as the organisation's most valuable asset.

From this perspective, the creative and innovative practices realised through the skills possessed by employees, internal knowledge sharing within the organisation, the organisation's adoption of an innovative culture, and the existence of a top management approach focused on 'organisational learning' constitute the most important sources of dynamism for organisations to increase their competitive strength by achieving change and transformation appropriate to the era.

3. LEARNING THEORIES

Moorhead and Griffin (1989) define learning as a permanent change in behaviour or potential behaviour resulting from direct or indirect experience. Another definition states that learning is a process that enables the integration of thinking, feeling, perceiving, and behaving in order to adapt to the world. Here, the interaction between the individual and their environment is important (Vince, 1998).

Looking at studies on learning, it can be seen that learning can occur in three different ways, and learning theories have been developed within the scope of these three learning methods: (Hellriegel et al., 1998; 104-105)

1. Classical Conditioning,
2. Operant (Instrumental) Conditioning,
3. Social-Cognitive Theories.

Ivan Petrovich Pavlov, a scientist trained in physiology and medicine who won the Nobel Prize in 1904 for his research on the activities of the glands, studied physiological conditioning in dogs. While conducting studies on the digestive systems of dogs, Pavlov observed that even when food was not placed in the dog's mouth, the mere sight of food increased saliva secretion.

Pavlov based his work on this observation, teaching dogs to increase their saliva secretion with just the sound of a bell, without tasting the food or even seeing it. This classic experiment was a very important step in understanding the phenomenon of learning. This learning, which occurs in a process called **classical conditioning,** is completed in the following stages: (Kaynak, 1995; 87)

First, meat is shown to the dog as food, and salivation begins. The term *unconditioned stimulus* is used for this natural or unlearned food. The experiment was then continued, and a bell was rung for the dog, but there was no salivation. This is because the bell is a neutral stimulus for the dog.

The experiment continued, and each time the dog was given meat, the bell was also rung. After a while, only the bell was rung without giving the dog meat, and salivation was observed. In this case, the dog learned to associate the bell sound with the sight of food, i.e., it became conditioned. In this case, the salivation is *a conditioned response or reaction*, and the bell ringing is *a conditioned stimulus*.

Bateson also examined learning from a behavioural perspective and, like Argyris, defined learning as "the process of correcting errors through trial and error". According to Bateson, the learning process through trial and error consists of different levels, each differing from the previous one. Bateson defined classical stimulus-response conditioning as "Learning I". Learning I is a step that follows Learning 0. Learning 0 has characteristics that can never be changed, while Learning I has a simple correction process based on trial and error. According to Bateson, "Learning II" is a change experienced in the "Learning I" process, and "Learning III" is an increase experienced in the "Learning II" process. The learning individual comprehends and learns important developments related to what was learned at each lower level at each higher level. In the form of learning defined as "0" ," responses are definitely formed as a result of a certain stimulus, and the response only ends when the stimulus is removed. If Pavlov's dog had been deprived of Learning I, it would never have learned to change its response, i.e., to salivate. In this way, Bateson distinguished between the "learning process" and the "process of learning to learn." According to Bateson's "learning hierarchy theory," individuals can determine and develop appropriate actions by questioning learning itself and the problems in learning (Easterby-Smith, 1997).

Behaviourists argue that whether learning has taken place can only be measured through behaviour. According to this theory, learning occurs through a somewhat random process of trial and error (Robertson and Cooper, 1987). However, it is not possible to explain much more complex events in this way.

Another approach to learning is "**operant conditioning**," proposed by Skinner. In his work at Harvard University, Skinner aimed to prove that the learning process occurs through "operant-instrumental" conditioning. Skinner's "**operant conditioning**" was developed to explain behaviours that classical conditioning cannot account for. Operant behaviour deals with simple, non-automatic responses. In fact, most of the behaviours we perform in daily life, such as going to work, solving maths problems, or playing tennis, are operant. Operant behaviour is generally explained using the stimulus-behaviour-consequence triad. According to this process, there is a stimulus or condition that leads to the behaviour. The behaviour occurs after this stimulus or condition. The likelihood of the behaviour being repeated increases or decreases depending on whether reinforcement or punishment occurs (Tarpy, 1997).

In his experiments, Skinner placed an experimental animal (a bird) in a box that was closed off from the outside world and contained no food. After a while, the bird became hungry. While flying around inside the cage, it suddenly collided with a specially designed lever. This lever activated a system that released food and drink into the box. After this process was repeated several times, the animal learned what to do when it became hungry. It learned that it had to perform a preliminary behaviour in order to obtain food. This behaviour is "operant". Operant conditioning is a phenomenon based on learning and determining behaviour. Here, the bird must create an operant ‘instrumental’ response ‘reaction’ in order to obtain a reward ‘food’ (Kaynak, 1995; 89).

Studies conducted after Skinner's work have developed his theory. However, cognitive learning theories generally do not accept that the learning process consists of a chain of stimulus-response (stimulus-response). According to social-cognitive theory, learning is structured within cognitive processes. In this structure, the organism perceives "expectations" rather than stimulus-response sequences. These expectations consist of connections that carry a specific meaning between the individual's situation and the behavioural goal. In this case, a reward is not present as a reinforcer, but the importance of the aforementioned meaningful connections is understood. In other words, the meaningful connection between the situation and the behavioural goal has been accepted, and the organism has initiated goal-directed behaviour. This event is a cognitive process directed towards the goal, based on the perception of a specific environmental situation (Kaynak, 1995; 90).

Social learning theory combines behavioural and cognitive concepts, complementing each other. It also emphasises the interaction between cognitive, behavioural, and environmental factors (Luthans, 1989).

Albert Bandura developed social learning theory in the 1960s and 1970s based on his observations that people in a social environment can learn new behaviour patterns by observing and imitating the social behaviour of those around them. In this theory, interaction in the learning process has gained importance. According to this theory, people develop various "mental models" by observing the behaviours of people around them and the results they achieve through social interaction. They then try out these behaviours. If they achieve successful results, they repeat the same behaviour; if these behaviours ultimately fail, they do not repeat the same behaviour. According to Bandura, people who observe the behaviour of those around them learn faster than those who do not observe. This is because people who do not observe do not feel the need to change their old behaviours (Hellriegel et al., 1998; 107). The principle that behaviour is influenced by behavioural consequences forms the basis of both operant conditioning and social learning theory (Cherrington, 1983; 472).

There are three factors that influence social-cognitive learning. These are: (Hellriegel et al., 1998; 107)

1. Learning from others,

2. Learning through self-control,

3. Personal competence.

1. Learning from Others: Learning from others occurs when a person (the learner) observes the behaviour and outcomes of another person (the model).

2. Learning through self-control: According to social cognitive theory, people can also learn on their own. In this method, called learning through self-control, the person can learn of their own volition, without any influence from the external environment.

3. Personal Competence: The third important element of social-cognitive theory is personal competence, which refers to an individual's confidence in accomplishing a specific task in a given situation. Individuals with high competence believe that they possess the necessary skills and power and that no external influence can affect their high performance.

4. LEVELS OF LEARNING

When examining learning levels, an inductive approach must be applied. For organisational learning to occur, individual learning must first take place. This is because true learning is achieved through individuals. Organisational learning is significant as an organisational achievement process that can only be attained by

organisations where a successful learning process occurs at the individual level and where group/team-level learning, reflecting group dynamics, is achieved when individuals come together. In line with this approach, individual learning, team learning, and finally organisational learning levels will be evaluated in a hierarchical order as the primary steps towards achieving the level of organisational learning.

4.1. Individual Learning

The human element, which constitutes the greatest source of power for organisations as living social systems, is also the vital source for the organisation's development through learning. Individuals who learn different information and bring it to the organisation form the core element of organisational learning through the sharing of this information with other members of the organisation. The flow of information and shared knowledge among individuals within the organisation paves the way for the formation of new knowledge that will give momentum to the organisation.

With the transition to the information society, the importance given to people has increased. People are seen as key elements in the competitiveness of businesses and are valued as intellectual capital, and the value they carry for the business has also increased. In this context, people's characteristics, such as intelligence, thinking, creativity, learning, and synergy creation abilities, which no other entity possesses, have begun to gain importance. In this context, individual learning creates an environment for the continuous development of the organisation and prepares it for the uncertainties of the future. Therefore, the contribution each individual makes to learning is extremely valuable in the process of creating a learning organisation (Marquardt, 1996).

Individual learning refers to the potential behaviour or changes in behaviour exhibited in response to a specific situation or recurring event.In other words, individual learning occurs as a function of the individual's cognitive structures, intelligence, experiences, and previously developed situation-specific needs and motivations that influence their acquisition of knowledge (Probst and Büchel, 1997). Individuals' learning is particularly dependent on their environment. Individuals' learning abilities are limited by their ability to perceive and explain complex realities.

According to Simon (1991), although learning actually takes place in individuals' brains, what is learned is largely based on what other members of the

organisation know (or believe) or on the information available in the organisation's environment.

Individuals are valued as the main entities that carry out learning and bring about transformation in organisations (Dodgson, 1993). In the information society, changes in all environmental conditions necessitate the change and transformation of organisations. The success of the transformation process that organisations will undergo is related to the individuals that make up the organisation.

The Experiential Learning Model has inspired researchers because it most effectively explains the cognitive and behavioural dimensions of the learning process. According to Kurt Lewin, one of the researchers in this field, people gain different thoughts and experiences by experimenting and observing the results. People form generalisations based on these accumulations and experience different experiences by adapting these generalisations to new events. People continue this behaviour cyclically, in a way that creates continuity (Kim, 1993; 38).

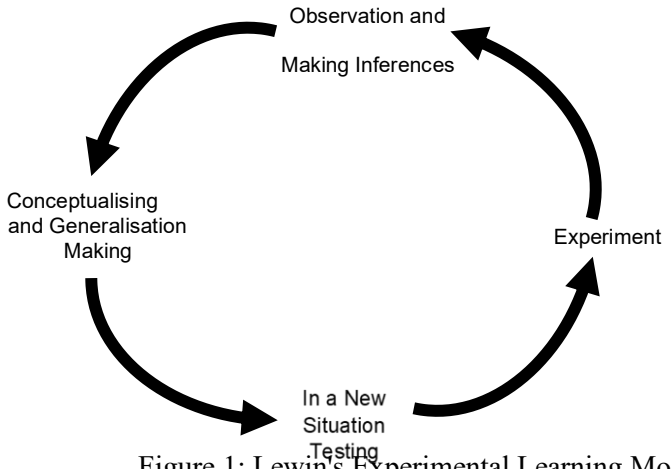

Figure 1: Lewin's Experimental Learning Model

Source: Kim, 1993; p.38

David Kolb also explained the individual learning process using a cyclical approach. Kolb's "individual learning process" addresses the process of learning from experiences in four stages (Boyatzis and Kolb, 1991). The individual learning process begins as a result of people perceiving the world through their intuitions. Kolb et al. (1984) refers to this process as "patterned experience." According to Kolb et al., in order to learn from their experiences, people must

consciously reflect on what they have experienced. This is because people often fail to reflect on a significant portion of what they have experienced. The most important factors in this are sometimes their expectations and sometimes their existing perceptions. Kolb et al. refers to this process as "reflective observation." The third stage of the learning process involves drawing meaning and generalisations from the experiences. In other words, it is the stage of fitting new knowledge into existing patterns of meaning and creating new meanings as a result of the connections made. Kolb also refers to this stage as "abstract conceptualisation." The final stage of the process is described as "active experimentation." At this stage, the structure that has been created begins to be used in daily life, and as a result, new experiences are gained (Kolb et al., 1984; 32).

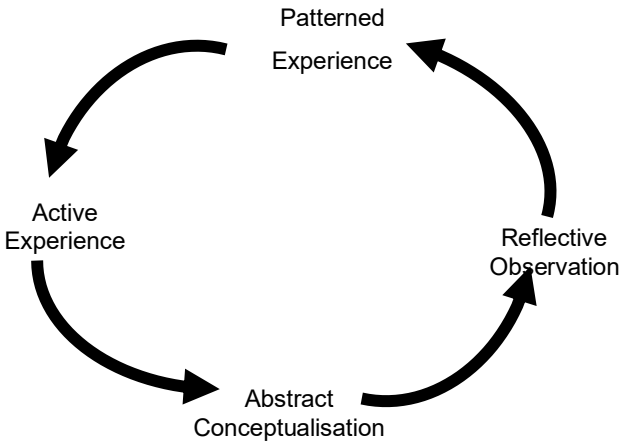

Figure 2: Kolb's Experiential Learning Process

Source: Kolb, Rubin and McIntyre, 1984, p.31.

The basic cycle of experiential learning models can be summarised as follows: in the learning cycle, observations and findings related to the subject are first evaluated (experience). The subject is examined and certain conclusions are reached. Based on these conclusions, a new behaviour and way of thinking is developed. This newly developed form is then reflected in new applications within the lived environment, tested, and observed again (Vince, 1998).

The experimental learning model has been criticised in certain respects by those researching the subject. Kim criticised and described the experimental

learning model as incomplete because it did not take into account the phenomenon of "memory", which is important in relating the individual learning process to organisational learning.

"Cognitive (Mental) Models" which are important in terms of the individual learning process, are significant in terms of influencing individuals' behaviour and reflecting their world views. Although learning models shed light on how people learn, thinking of memory separately from learning leaves the definition incomplete. Learning, as a verb, is more concerned with what is gained (learned). Memory, on the other hand, is concerned with the recall of what has been learned. These two concepts are intertwined. Memory should not be perceived merely as a storage unit. It should be remembered that, in addition to its storage role, memory also plays a role in guiding our behaviour and thoughts. What we have in our memory from the past influences what we learn; what we learn influences our memory (Kim, 1993).

Cognitive models represent an individual's explicit and implicit understanding of their worldview. Cognitive models are the views and interpretations that form in an individual's mind about a situation. They are not only composed of experience, knowledge, and memory; they also involve the understanding, analysis, synthesis, use, and application of experience and knowledge (Kim, 1993). Our memory influences our perceptions and behaviours through the mental models we possess. Mental models influence our worldview and behaviours as well-established, ingrained assumptions and generalisations, even images and pictures, in our minds (Senge, 1993). Within the framework of mental models, the integration of conceptual and operational learning as a process constitutes individual learning (Kim, 1993).

Thought models determine not only how people make sense of their world, but also how they should act, i.e. how they should behave. These can be judgements we form about a person in our minds, or they can be assumptions and theories we hold about any subject. What is important here is the reflection of thought models on our behaviour. For example, if we have formed a prediction that people are untrustworthy, our behaviour in this situation will be different from our behaviour in situations where we believe people are trustworthy. The reason why cognitive models are so powerful in influencing *our actions* is largely because they affect what *we see*. Two people with different mental models may observe the same event but describe it differently if they focus on different details. Psychologists explain this as "selective observation" (Senge, 1993).

We are often unaware of our mental models or their impact on our behaviour. When we interact with someone, the first thing we do is fit them into one of the patterns in our mind. When we cannot do this, the person in front of us is of little importance to us. In this context, insights into new market opportunities often fail to be put into practice because they contradict powerful mental models (Senge, 1993). Yet, when we look at the business world and what is happening in the market, we see constant change. The cost of insisting on our existing patterns in the face of this change may be greater than we can imagine. In the 1970s, Royal Dutch/Shell was seventh among seven oil companies, but it anticipated the 1980 oil crisis by questioning its assumptions about the market and rose to the top. Arie De Geus, Head of Planning at Royal Dutch/Shell, states that adaptation in a changing business world is based on a process of organisational learning that enables company management to change its mental models.

As indicated in the definition of learning, the operational and conceptual dimensions of learning are closely related to two parts of mental models: structures and routines. Operational learning is learning while performing a specific task. In this case, the knowledge of how to do the job (know-how) can be learned by performing various routine tasks. For example, operating a machine or filling out specific forms. Conceptual learning, on the other hand, is concerned with why tasks are performed, seeking new ways of thinking and attempting to develop new structures. It relates to individuals' understanding and application of the knowledge they have acquired. Cognitive models sometimes limit our perceptions because they establish the relationship between what is stored in our minds and the existing situation, and therefore cause us to make biased and wrong decisions (Kim, 1993).

A common view among all managers is that the majority of the best ideas will never be implemented. In this context, brilliant strategies remain untranslated into action, and systemic insights never influence working policies. A pilot trial may prove to everyone that a new approach will yield better results, but widespread implementation of this approach often fails to materialise. The biggest factor here is mental models. The reason new insights fail to translate into practice is that they conflict with our deep-seated mental images (images) of how the world works. These images steer us away from departing from familiar ways of thinking and behaving. The fundamental reason why the discipline of managing mental models (bringing our mental images of how the world works to the surface, testing them, and correcting them) holds the promise of being a significant breakthrough in building learning organisations lies in these details (Senge, 1993).

Research on individual learning, as shown in Table 1, focuses on two different learning models. These are: (Buckler, 1996; 32)

1. Taught model: This model views learning as a phenomenon carried out on people by an external factor. In other words, it is a passive approach.

2. Discovery model: This model, on the other hand, evaluates learning as an event that people do for themselves, by themselves. In other words, it is a process in which people participate actively and willingly.

In this context, the "discovery model" is a model that should be focused on in terms of organisational learning and the resulting transformation into a learning organisation by activating the internal dynamics of employees.

	Teaching Model	**Discovery Model** ⟺
Model	-Learning theory is research-based. -It is tested through applications. -Behavioural change -Taught to others until a better theory is developed.	-Problem identification -Conducting trials to find solutions -Theory development -Behavioural change -Application to similar situations
Focus	-Teacher-centred -Learning is directed by the organisation.	-Learner-centred -Learning is directed by the individual.
Motivation	-External	-Internal
Culture	-Control-based -Bureaucratic	-Empowerment-based -Autonomous
Advantages	-Situational -Suitability -Low risk	-Creativity -Innovation -Customer suitability
Disadvantages	-May suppress internal motivation. -May create barriers to change and learning, leading to situational reactions.	-May focus more on personal goals than organisational objectives. -There is a high risk of failure.

Table 1: Comparison of Learning Models

Source: Buckler, 1996; p.32.

According to Argyris, organisations do not create actions that bring about learning; rather, learning in organisations occurs through individuals (Argyris, 1996; 8). Considering the constantly changing environmental conditions, learning must also be evaluated as a dynamic process. Just as learning is important for the development process of individuals, it is equally important for organisations. It should not be forgotten that in a vital environment where change is inevitable, the path to achieving organisational change passes through individual change. The most fundamental dynamic of individual change is learning.

Individual learning is the change in individual abilities, understandings, knowledge, attitudes and values as a result of personal work, observation and experimentation. Individual learning is necessary for organisational learning to take place. This is because organisations can only learn through individuals who learn (Argyris and Schön, 1978; 20; Kim, 1993; 37). Similarly, Simon states *that "all learning takes place inside the individual's head; an organisation can learn in only two ways: (a) through the learning of its members, or (b) by hiring individuals who possess knowledge that the organisation did not previously have,*" thus placing the individual at the foundation of organisational learning (Simon, 1991; 125). However, while individual learning is necessary for organisational learning, it is not sufficient on its own (Argyris and Schön, 1978; 20).

4.2. Learning as a Team/Group

A community that works together towards a common goal and shares various values, views, and feelings forms a team/group. One of the most important characteristics of groups is the dynamism and creativity that emerge from the synergy they create. Groups have an important role in facilitating the transition between the individual and the organisation. As groups or teams share their experiences within themselves and with other groups within the organisation, new knowledge emerges. This leads to an increase in intellectual capital (Marquardt, 1996).

An organisation is a group of people consisting of various groups and characterised by acting towards a specific goal. For example, a basketball team plays basketball, an orchestra plays symphonies. These activities are activities carried out collectively by teams. It is impossible for individuals to carry them out alone. In other words, it is not possible for a single player to play the game or for a single violinist to perform the entire symphony. These types of activities can only be carried out collectively by a team. Therefore, the activities of these teams

(i.e., playing a match or performing a symphony) depend not on the individuals but on the success of the team that carries them out. The individuals forming the team only fulfil the duties incumbent upon them for the success of that team (Cook and Yanow, 1996).

Therefore, thanks to these dynamic characteristics that teams create within themselves and among themselves, information sharing and the learning environment will develop, and the organisation's holistic learning can be achieved.

4.3. The Organisation's Learning as a Whole: Organisational Learning

The learning of the organisation as a whole can be achieved through individuals and teams sharing their feelings, knowledge and mental models, and by developing the organisation's process of acquiring, using and disseminating knowledge (Stata, 1989). The organisational learning that emerges as a result of this synergy, which will be examined in more detail in the following sections, creates an output that is greater and more valuable than the sum of the results of both individual and group learning.

4.3.1. The Concept and Development of Organisational Learning

Definitions of organisational learning vary greatly depending on the perspectives of those defining it and the disciplines to which they belong. According to psychologists, learning is primarily based on individual processes and is behavioural in nature. Accordingly, learning is primarily a process aimed at behavioural change and increasing the individual's mental (cognitive) capacity (Probst and Büchel, 1997). Psychologists therefore view learning as a high-level adaptation that increases the chances of survival in a changing environment (Dodgson, 1993; 378). Organisational learning manifests itself in various ways, including changes in knowledge, cognition, routines, and behaviour (Argote, 2011).

In business and management literature, learning is evaluated in terms of providing sustainable competitive advantage and innovation. Studies conducted in this context have mostly been carried out within the framework of a systems approach. In the systems perspective, learning is an organisational phenomenon addressed more for its collective dimension than as an individual process. In this approach, attention is directed towards the organisation as the framework or environment in which individual learning occurs. Thus, in approaches that address learning within the systems framework, the interaction between the individual and the organisation is crucial. Organisational learning can only occur

through a bridge between individual learning and organisational learning. There are several crucial building blocks required to establish this bridge. These are: (Probst and Büchel, 1997; 19)

- **Communication:** Achieving collective consensus can only be realised when people understand each other reciprocally and establish multifaceted and robust communication.
- **Transparency:** Multifaceted and robust communication is not sufficient for individuals to transform their individual learning outcomes into collective knowledge. This transformation must be transparent so that it can be understood by other members of the organisation.
- **Integration:** Through transparency, an organisational memory and shared symbolic values will emerge, enabling the consolidation and integration of information. In other words, the transition process necessary for organisational learning will be completed through the integration of information.

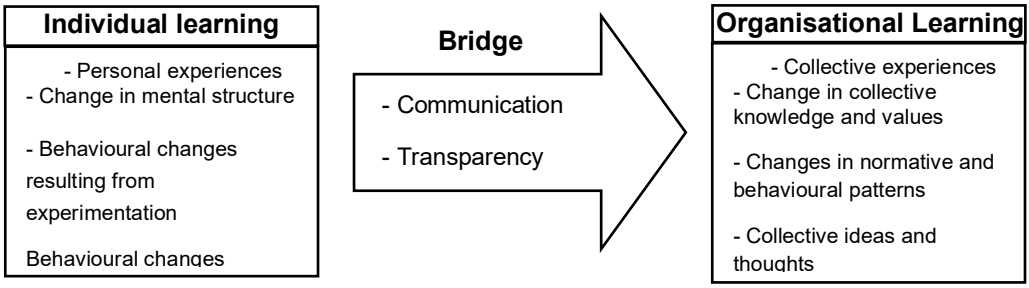

Figure 3: The Bridge Between Individual and Organisational Learning

Source: Probst and Büchel, 1997; p.21.

C. Marlene Fiol and Marjorie A. Lyles defined organisational learning as "the process of developing behaviour through learning and assimilating this knowledge" and divided learning levels into "low and high-level learning" (Fiol and Lyles, 1985; 803). McGill et al. defined organisational learning as "the ability to gain perspective and understanding from the experiences acquired by the organisation through experimentation, observation, and analysis, and the willingness to evaluate its mistakes and successes" (McGill et al.,1992; 6).

Edwin Nevis and colleagues define organisational learning as "the capacity or processes by which an organisation improves its performance based on its experiences." According to them, learning is a phenomenon that must be

considered at the organisational system level. This is because even if the individuals within the organisation change, the learning remains within the organisation. According to Nevis and his colleagues, organisations learn as they produce (Nevis et al., 1995). In this case, production systems are learning systems. Therefore, organisational learning can be examined within the framework of three intertwined main stages in terms of improving organisational performance: (Garvin, 1993)

1. Perception stage: Organisation members are confronted with new ideas, increase their knowledge, and begin to think in different ways.

2. Behavioural stage: Employees internalise new ideas and begin to change their behaviour.

3. Performance improvement: The significant increase in performance observed as a result of the different thinking and behavioural changes that occur in the first and second stages.

Mark Dodgson defines organisational learning as "the ways in which an organisation creates, increases, organises and internalises knowledge for use in its activities and culture, and at the same time develops the skills of its employees to increase organisational effectiveness". According to Dodgson, organisational learning is "the ways in which organisations develop, using the skills and knowledge of their employees, to create, use and distribute knowledge in order to increase their effectiveness," and this definition brings with it certain assumptions: (Dodgson, 1993; 377)

- Although learning generally produces positive results, it may not always be the outcome of positive work (for example, organisations can learn from their mistakes).
- Learning primarily occurs among organisational members. However, learning can occur across the entire organisation as a result of the contributions of its members. Here, organisational culture and group dynamics are the main factors affecting the effectiveness of learning.
- Learning can occur at different levels and at different speeds as a result of all the organisation's activities.

According to Dixon, organisational learning is "the continuous renewal of the organisation through the conscious use of the learning process at the individual, group and organisational system levels to better satisfy the desires and needs of the organisation's stakeholders" (Dixon, 1994; 5). Here, the conscious use of the learning process means that learning is not left to chance or occurs randomly, but

is actively incorporated into the organisation to ensure that it becomes a permanent feature. Therefore, Dixon perceives organisational learning not as an accumulation of knowledge, but as employees gaining new insights and perspectives and correcting old ones (Dixon, 1994; 6).

Organisational learning begins when individuals within the organisation solve problems that arise on behalf of the organisation. When individuals observe a discrepancy between the results they expected and the results they achieved following their actions, they begin to develop different ways of thinking and behaving in order to eliminate this discrepancy. For organisational learning to occur, what individuals learn from their experiences must be incorporated into the organisation (Argyris and Schön, 1996).

Organisational learning ensures the continuous change of the organisation and its environment. However, change is not a single-stage process, such as moving from a bad situation to a good one. Organisational learning has no end. This is because organisational learning is a never-ending process that continuously moves the organisation to better situations. Just as every result gives rise to a new problem, the solutions brought to organisational problems will also cause new problems to arise after a while. The fundamental characteristic of organisational learning is not only its ability to renew or change itself and its environment, but also its ability to ensure the continuity of this change (Dixon, 1994).

4.3.3. Types of Organisational Learning

Learning brings about change in organisational knowledge and behaviour, just as it does in the lives of living beings. This process of change affects different types of knowledge and behaviour in different ways. Therefore, the learning process can be classified in different ways (Probst and Büchel, 1997; 32). The most widely accepted of these is the three-part classification.

These are:

- Single-stage (unidirectional) learning
- Two-stage (two-way) learning
- Three-stage learning (Learning to learn)

Single-stage learning

In single-stage learning, organisational members identify problems arising in their environment, develop the necessary strategies to resolve them, and implement these strategies. In other words, in order to achieve its defined objectives, the organisation adapts to its environment and implements only one

behavioural change. This learning process can be considered a response to the organisation's internal and external environment. This is because the organisation attempts to correct its mistakes and bring its current norms up to the standards it has set. Since this process focuses only on correcting current norms, Argyris and Schön refer to this learning process as single-stage learning (Probst and Büchel, 1997; 33).

The single-stage learning level does not encourage any thinking or questioning. In single-stage learning, the focus is solely on solving existing problems. The behaviours or understandings that produce the problems are left unexamined (Morgan, 1986; 87). For this reason, it is also called "low-level learning" (Fiol and Lyles, 1985; 807) or "adaptive learning" (Senge, 1993; 185).

It is learning that involves changing routine behaviours and correcting mistakes. Mistakes are found and corrected, but no changes are made to the system (Argyris, 1996). The discrepancy between goals and results has led to the emergence of this type of learning process. When deviations from established norms occur, a process of adaptation redirects behaviours towards the established goals. In this case, it can be said that the organisation has adapted to the complexity of its environment by changing its existing norms. While this adaptation takes place, existing norms and values are not questioned; they remain in line with the organisation's established goals (Probst and Büchel, 1997).

Two-Stage Learning

Two-stage learning is a process that goes beyond mere behavioural adaptation, bringing about deeper changes in cognitive structures. Relationships between an organisation and its environment may sometimes require more than simple adaptation. In such cases, seemingly immutable organisational norms and values must be questioned, new priorities established, and new assessments made. The organisation's value systems, existing knowledge structure, and behavioural patterns must be reorganised. Thus, new ways of thinking and behaving will emerge, and existing values and norms will be discussed with a more critical eye (Probst and Büchel, 1997).

High-level two-stage learning involves developing advanced rules and regulations for new actions. In this context, two-stage learning is the correction of errors by examining and questioning the organisation's norms, policies, and objectives. It requires the re-examination and modification of current practices and involves learning that affects the entire organisation. For this reason, it is also referred to as "high-level learning" (Fiol and Lyles, 1985; 808- 810) or "creative learning" (Senge, 1993; 227).

Three-Stage Learning (Learning to Learn)

According to Argyris and Schön, "when an organisation engages in secondary learning, its members reflect on and question examples of organisational learning or learning failures, discover what facilitates or hinders learning, develop new learning strategies, produce these strategies, evaluate what they have produced, and generalise. The results are encoded into individuals' thoughts and mental maps and reflected in organisational learning practices (Argyris and Schön 1978). When this type of learning occurs, organisations can transform and increase their creative capacity. Three-stage learning can, in a sense, also be defined as "learning to learn". The effectiveness of the organisation depends on its ability to learn at appropriate levels under appropriate conditions.

Learning how to learn represents the pinnacle of the learning process. The aim is not only to learn specific things, but to understand the learning process itself. Therefore, only after individuals fully understand single-stage and double-stage learning, grasp their difficulties, and comprehend the learning process as a whole, can we speak of higher-level learning (Probst and Büchel, 1997; 35).

In learning to learn, there is an approach to gathering information about the learning process that aims to question, understand and reach a consensus. Sharing, in this sense, indicates participation. This is because it takes into account the conditions necessary for the survival and development of others in the environment. If organisational members learn how to learn and can pass this on to others, disagreements can be eliminated and opportunities for correction and improvement can be seized. When a system learns how to learn, it begins to see and evaluate its internal relationships more clearly. The models of mutual relationships within the system and between the system and its environment become transparent and easier to understand. This constitutes a very important process in increasing the organisation's capacity for change and transformation (Probst and Büchel, 1997; 37).

CONCLUSION

With the understanding of the importance of learning and developments in organisational theory, it has been accepted that organisations, which are described as living entities, can learn and develop as they learn. As a result of the information society, the success of organisations has become dependent on the success of employees in finding, creating and using knowledge. Continuous learning is necessary to increase productivity. It is not enough to redesign the job and then train the employee according to the newest method of doing that job. This is where learning begins; learning never ends. The greatest benefit of

training is not learning something new. It is doing a job we are already doing well even better.

In management thinking, with the increasing importance of the human factor due to its superior qualities, employees have begun to be regarded as key elements of change. In this context, employees' learning and knowledge creation abilities have come to the fore and have begun to be seen as a prerequisite for organisational change. The creation of knowledge, which is considered the fundamental input of modern businesses, and its use in the formation of more diverse knowledge, is achieved through learning employees. However, the learning used in the creation of knowledge is not only personal in nature; it takes place throughout the organisation, in other words, it gains effectiveness through organisational learning. The strategic importance of organisational learning stems from the sharing of ideas, experiences, results, mistakes and knowledge, and the synergy that these will create collectively. Adopting learning as a strategic tool within a business means embracing it not as a technique but as a philosophy or behavioural approach.

Organisational learning has become an important area of research in business studies since the 1990s (Antunes & Pinheiro, 2020). In today's constantly changing business world, the ability of businesses to learn and adapt to change is seen as a key factor in their survival and competitiveness. Organisational learning gives businesses the ability to think strategically. In a constantly changing, dynamic environment, within the scope of what is learned and the lessons taken, the ability of businesses to create change by developing proactive strategies, predicting future trends and changes in environmental conditions, and continuously innovating will form the basis of their success.

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CHAPTER 16

An Evaluation of Technological Developments in the Field Of Gastronomy: Gastronomy 4.0

Tuncay Çanakçı[1]

[1] Assist. Prof., Erciyes University, Faculty of Tourism, ORCID: 0000-0001-8438-1098

1. Introduction

Today, although we are at the beginning of the concept of industry 4.0 (digital transformation), which has the capacity to radically change social life, working order, and interpersonal relations, we are witnessing a rapidly advancing fourth industrial revolution thanks to developments in science and technology (Atar, 2019). Industry 4.0 applications, based on intensive information and improved technology, aim to reduce the current workforce burden of businesses thanks to technological products (Mutlu Öztürk, 2020, p. 223). The concept of Industry 4.0 is hyper-automation and hyperconnectivity based on artificial intelligence (AI), big data, and robotics that can bridge the gap between physical and cyber systems to increase productivity and intensify industrial production (Korže, 2019, p. 31). Therefore, Industry 4.0 pioneers digitalization and smart working environments in many sectors and contributes to businesses operating both economically and efficiently (Mutlu Öztürk, 2020, p. 224).

This dimension of technology contributes to reflecting the products obtained as a result of production into the digital environment and then maintaining all control with digital elements. For this reason, the industry 4.0 revolution provides benefits in many areas of the industry, especially in the tourism industry, in terms of keeping up with the technological age and ensuring sustainability in the industry (Perakovic, Periša, and Zorić, 2019, p. 259).

In tourism, technological designs such as digital transformation, smart automation, cloud computing, mobile internet, robotics, artificial intelligence, autonomous vehicles, and 3D printing are the developments that create the concept of tourism 4.0. These developments increase the tourism workforce globally (Papathanassis, 2017, p. 212).

Technology, which develops and changes day by day, has brought with it many important innovations, from the cleaning sector to the field of gastronomy, where eating and drinking are transformed into science and art. Developments in both technology and management understanding have changed the way of working and workflows in kitchens, as in other business lines. The use of high-tech equipment in kitchens, with forms and features that were unimaginable in the past, has resulted in time and labor savings, while the food produced has reached the highest level in terms of human health (Akman and Erbil, 2018, p. 286).

Although Industry 4.0 initially focused on factories and industry, it has grown to include many sectors. One of the sectors where Industry 4.0 is rapidly adapting is the tourism sector. Nowadays, the concept of tourism 4.0 is frequently mentioned. However, we can also say that the concept of gastronomy 4.0 has come to the fore, and studies on this subject have started to emerge. In this context, this study aims to make predictions about how restaurants and their management will be shaped in the future through tourism 4.0 and gastronomy 4.0.

2. Literature Review

Industry 4.0 is the ability to manage production processes remotely by replacing human power with machine power. In other words, it is the coordination of machines with the help of the internet and/or computer. The phenomenon called Industry 4.0 has a feature that will completely change consumption and production processes. All elements in the processes (machine, equipment, raw materials, etc.) are constantly coordinated in the context of automation and have the ability to adapt very quickly to the changing needs of consumers (Doğan and Gençer, 2023). The goals of Industry 4.0 are to increase efficiency, productivity, and flexibility in production, reduce costs, and improve product quality. It also allows for the creation of more customized and personalized products, while preserving and even reducing waste and environmental impact. It is crucial to remember that Industry 4.0 is an ongoing process, not a specific set of technologies or a single point in time. Many sectors are gradually adopting these technologies, including the field of tourism and gastronomy.

Since the tourism industry has a dynamic structure that quickly adapts to innovations and technologies, Industry 4.0 technologies have also rapidly found application in the tourism industry. With the use of Industry 4.0 technologies for tourism purposes, the concept of "smart tourism" has emerged (Mutlu Öztürk, 2020, p. 226).

Smart tourism, which emerged with the new generation of technologies developed with Industry 4.0, can be seen as a transition process from traditional tourism to e-tourism logic (Topsakal, Kaptanoğlu, Çelik, and Bahar, 2018, p. 1). Tourism 4.0 (digital transformation in tourism) can be defined as the era of artificial intelligence, the internet of things, destination management systems, central reservation systems, customer relationship management, digital telephone networks, smart hotel management systems, smart ticket (card) systems that make the lives of both tourists and tourism personnel easier, smart tour guide systems, smart travel agencies, virtual reality systems that allow tourists to see the destination center in advance, and mobile applications that allow last-minute room reservations and check-in (Atar, 2019).

According to Verevka (2018), tourism 4.0 is "smart tourism." According to Pencarelli (2019, p. 455), it includes the management of goods and services in the tourism industry with automatically developed methods (Ivanov, 2020). According to Peraković et al. (2019), the use of 4.0 applications on communication devices is effective in causing changes in touristic activities and touristic mobilities. Thus, although 4.0 applications have the power to affect tourists and tourism operations, they are seen as valuable by businesses for the sustainability of tourism (Stankov and Gretzel, 2020, p. 481). According to Peceny, Urbanicic, Mokorel, Kuralt, and Ilijaš (2019, p. 40), smart systems provided by tourism 4.0 increase the interaction between people and technology. The use of 4.0 applications in the tourism industry provides confidence for tourist groups. Therefore, tourism 4.0 is seen as important in terms of the quality of the

tourist experience. Peceny et al. (2019) asserted that through the creation of a collaborative ecosystem involving local people, local authorities, tourists, service providers, and government, an enriched tourism experience can be created in both the physical and digital worlds.

The main purpose of using Industry 4.0 in the tourism sector is to create an interactive platform based on the latest technological infrastructure. One of the main goals of Industry 4.0 for the tourism sector is to provide services and products in a sustainable way, making them accessible to everyone at all times.

Gastronomy 4.0 is a term that extends the principles of Industry 4.0 seen in industrial production to the food and beverage sector. The concepts of gastronomy 4.0 and industry 4.0 are based on similar principles and aim to apply the digitalization and automation principles that industry 4.0 applies to production and industrial processes to the food and gastronomy sectors.

This term is a phenomenon that expresses the gastronomy world's adoption of contemporary technological developments such as technology, data analysis, automation, and digitalization and transforms traditional culinary arts with the influence of technology and digitalization. In addition to providing nutrition, which is the basic need of society, Gastronomy 4.0 also uses high-tech methods such as 3D printing, big data, automation, smart robots, and cyber security, which are the arguments of Industry 4.0 to meet the requirements of visuality, flavor, consistency, taste, smell, healthy nutrition, hygiene, etc. It represents the integration of cutting-edge technologies, data-driven insights, and innovation into various aspects of food and beverage preparation, presentation, and dining experiences. It aims to revolutionize the way food and beverages are prepared, served, and enjoyed while increasing quality, sustainability, and efficiency (Doğan and Gençer, 2023, p. 19).

Some digital applications that will be used in the field of Gastronomy 4.0 include (Luque, Peralta, De Las Heras, and Córdoba, 2017):

- Internet of things
- Cloud systems
- Additive Manufacturing and 3D printing
- Industrial Big Data
- Cache memory technologies (Augmented Reality / Virtual reality / Computer vision)
- Automation and Smart Robots
- Cyber security

There are many studies on digital gastronomy. Rahman et al. (2020, p. 1) conducted a study to determine the rheological and mechanical properties of edible gel materials for three-dimensional food printer technology. Another study on three-dimensional food printers was conducted by Mantihal, Kobun, and Lee (2020, p. 2). The researchers examined the three-dimensional food printer

technique with a general-view approach. Many companies started to produce ready-to-eat foods such as bread, pizza, cakes, cookies, and hamburgers cooked in three dimensions using 3-D printers. In their study, Aytaç and Korçak (2021, p. 4) discussed internet of things-based intelligence applications for proactive waste management in fast food restaurants. In their study, Jang and Lee (2020) concluded that customers showed a positive attitude towards service robots. Seyitoğlu and Ivanov (2020) investigated the effects of Covid-19 on tourism in their study and stated that robots reduced the physical contact of people with each other, and customers were satisfied with this situation. The topic of animation application on tables, also called interactive dining tables, was examined in detail in the study conducted by Echtler and Wimmer (2013) and Margetis, Grammenos, Zabulis, and Stephanidis (2013, p. 668). Animations, or visuals, are projected with the help of several projections placed on the table. Studies have emphasized that using these tables enhances customer satisfaction. In their study on the telematic banquet application, Barden et al. (2012) concluded that customers who are not in the same environment are provided with an environment where they will feel like they are sharing the same atmosphere through communication technology. Spence and Piqueras-Fiszman (2013) argued in their study that digital technologies will become an increasingly common feature of dining tables of the future. According to the study of Ivanov, Webster, and Berezina (2017), in the near future, artificial intelligence robots will work in areas that require human labor services, such as service, kitchens, restaurants, and entertainment in the tourism industry.

3. The New Technological Equipments Used in Food And Beverage Industry

Certain products have been developed in food and beverage businesses to provide different experiences to guests by taking advantage of technological developments. Some of these are described in the following section.

3.1. E-Menu

An e-menu is a device that includes a menu, food content, various games, and the ability to order without a waiter, as well as monitoring the preparation of meals in the kitchen (Margetis et al., 2013, p. 670).

Figure 1. Electronic Menu Example
Source: Hashmicro, 2024

Food and beverage businesses can communicate their production processes to their customers through e-menus and add real-time images of menu items (Narimawati and Pangestu, 2020, p. 2). E-menus help reduce restaurant workload, wait times for orders and checks, and possible errors because orders can be sent directly to chefs. Orders can be placed via menus or tablets, usually without the need for a wait staff, and the use of electronic menus allows customers not only to order food but also to listen to music and play games while waiting for their orders (Pyanikova et al., 2020, p. 549).

3.2. AUSCA

In November 2017, the M Social Singapore Hotel introduced guests to the world's first exemplary robot chef, AUSCA (Autonomous Service Chef Associate), demonstrating its ability to prepare eggs for breakfast in approximately 2.5 minutes.

Figure 2. First Robotic Chef AUSCA
Source: Hi Life, 2024

By the end of 2018, five other hotel establishments in Singapore, including Orchard Hotel Singapore, Grand Copthorne Waterfront Hotel Singapore, M Hotel Singapore, Studio M Hotel Singapore, and Copthorne King's Hotel Singapore, started to use robot chefs in their kitchens (Fah Thai, 2024).

3.3. ROBOTIC BAR

The world's first robotic bartender was designed by the Italian robot company Makr Shakr and was first used in Royal Caribbean. Robots named “Shaken” and “Stirred” have the ability to mix, shake, and strain all kinds of drinks.

Figure 3. Robotic Bartenders Shaken and Stirred
Source: Royal Caribbean, 2024

Customers can place their orders on the digital screen at the bar, and when the orders are ready, the robotic bartenders serve them with a touch on a SeaPass card or WowBand. “Shaken” and “Stirred,” which can prepare two drinks per minute, have the capacity to make approximately one thousand drinks per day (Imbardelli, 2019; Silverstein, 2020).

3.4. FLIPPY

In 2017, John Milner, the owner and operator of Caliburger chains, which provide international service with 36 branches, started automation work in cooperation with Buck Jordan, the investor and founder of Miso Robotics, to keep his employees safer and increase their productivity, and robotic arms called Flippy were produced with the support of an engineering team. Flippy, the artificial intelligence kitchen assistant that can work in both the grill and the fryer, can monitor the cooking process in real time in both units.

Figure 4. Burger chef Flippy
Source: BBC News, 2018

Robots, which can flip hamburgers on the grill and follow the entire cooking and resting process of the products in the fryer, can also clean the relevant areas after the process (CaliBurger, 2024; Heater, 2018; Meisenzahl, 2020; Uzan and Sevimli, 2020, p.51).

3.5. MOLEY

Moley, the world's first robotic chef, was designed in 2015 as a result of 18 years of work. To use Moley, which behaves close to human hands in the kitchen, a smartphone or a touch screen placed in the kitchen is required. In this way, after customers choose the desired meal, they can watch the preparation of the meal behind the glass partition (Erkılıç, 2016).

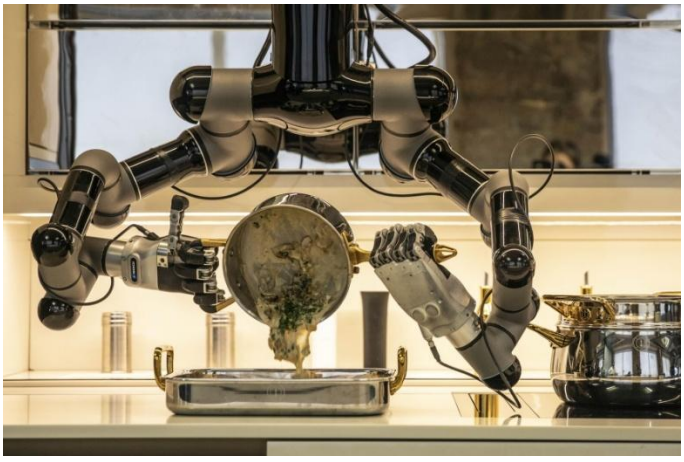

Figure 5. World's First Robotic Chef Moley
Source: Neate, 2020

3.6. PAZZI

Working with Thierry Graffagnino of the French company EKIM, who has won the world pizza championship title three times, the robot named Pazzi can perform the functions of rolling out the pizza dough, spreading the tomato sauce, baking it, and slicing the pizzas by putting them in a box after they are cooked (Uzan and Sevimli, 2020, p.51).

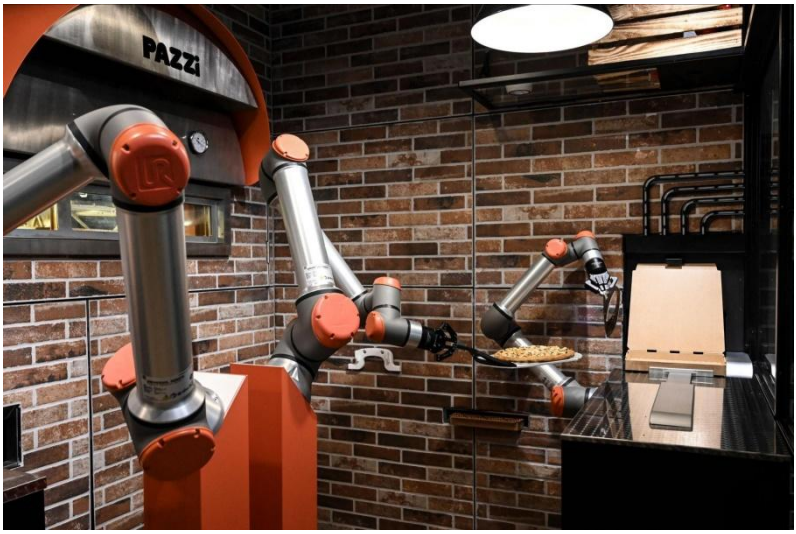

Figure 6. Robotic Pizza Chef Pazzi
Source: Wissman and Fresia, 2022

While a human can make 40 pizzas per hour, robot Pazzi can produce one pizza in 30 seconds and 120 pizzas per hour (Armstrong, 2024).

3.7. BRAT WURST BOT

This is a robotic chef developed by Forschungszentrum Informatik (FZI), based in Karlsruhe, Germany. The federal government of the state of Baden-Württemberg first introduced it at the 53rd Stallwächter party event in Berlin on July 7, 2016. This party was first organized in 1965 and is an event where businesspeople, politicians, and international celebrities gather. Brat Wurst Bot is produced from ready-made parts to show how easy it is to create practical robots. The robotic chef is designed using a set of common parts operated by a flexible and adaptable software package that can interact with humans (Uzan and Sevimli, 2020, p. 54). This single-arm robot can successfully perform the task of cooking sausages. It can take the sausages from the tray and cook them on the gas grill. The robotic chef has a tablet built on top of a ROS (Robot Operating System)-based web front end so that customers can place orders.

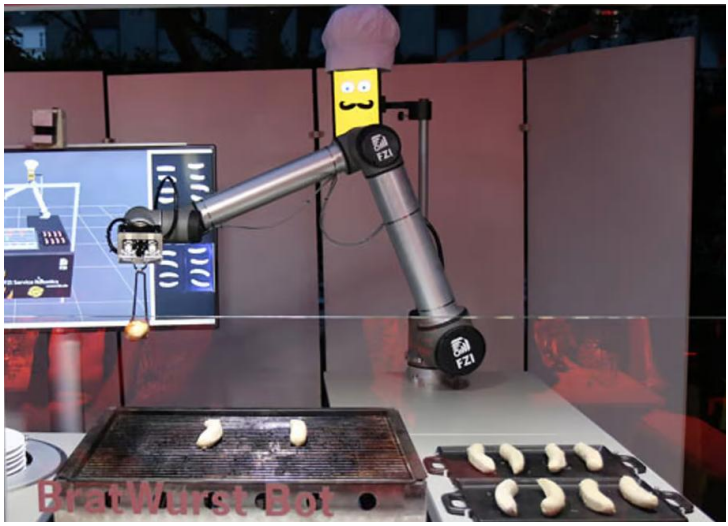

Figure 7. Robot Brat Wurst Bot
Source: Szondy, 2020

Additionally, two RGB cameras and a segmentation algorithm with background subtraction were used to enable the robot to find the sausages on the tray or on the grill and to determine when to flip the sausages. Brat Wurst Bot cooked and served more than 200 sausages during the party (Mauch, Roennau, Heppner, Buettner, and Dillmann, 2017; Szondy, 2020).

3.8. KOYA and KONA

Koya and Kona, which were manufactured in Japan and started working in a ramen restaurant in Shanghai, China, in 2015, prepare ramen (a Far Eastern cuisine dish) for their customers.


Figure 8. Robotic Chefs Koya and Kona

Source: Ningning, 2015

Koya and Kona know how to boil ramen and serve it in the right amount. Moreover, they can perform this entire process in ninety seconds (Ningning, 2015).

4. Discussion And Conclusion

Rapidly developing technologies with the Industry 4.0 revolution are being integrated more and more into many areas of the tourism industry every day. The recent use of robots in the field of gastronomy has an impact on service delivery processes and puts the needs and desires of guests into a new form, taking their touristic experiences to a whole new level (Ivkov, Bleši´c, Dudi´c, Pajtinková Bartáková, and Dudi´c, 2020, p.1). In crises related to the Covid-19 pandemic and similar diseases, robots that are not affected by microbial viruses have the potential to serve infected or quarantined guests effectively and efficiently (Seyitoğlu and Ivanov, 2020, p.2). This study presented studies on e-menu, robotic chefs, and waiters in the tourism sector and provided application examples in the sector.

Digital menus also increase guest satisfaction because they increase the speed of service and provide detailed information about the contents of the foods on the menus (Yepes, 2015). Albayrak (2015) stated that guests enjoy using digital menus and evaluate these menus as having a higher level of knowledge when compared to traditional menus. In their study on menu certification, Ekincek, Yayla, and Göde (2021) emphasized that with the development of technology in the certification process, businesses should reflect the effects of digitalization on their menus. Ercan and Yılmaz (2022) stated that QR menu applications are easy to use, make customers feel special, and provide them with an interesting experience. Yim and Yoo (2020) similarly revealed in their studies that digital menus accelerate the ordering process and give pleasure to consumers. In their study, where consumers were asked about the innovative applications they expect from businesses, Cankül (2019) concluded that digital menu applications such as QR code applications and e-tablet menus are more desired. When the relevant literature is examined (Avşar and Tandoğan, 2022; Hazarhun and Yılmaz, 2020), it is found that digital menus have some disadvantages. As a result of their study, Avşar and Tandoğan (2022) identified disadvantages such as customers not wanting to apply QR codes due to their habits, older age groups not adapting to technology, and phones being insufficient to read QR codes.

Tussyadiah, Zach, and Wang (2020) conducted a study that included two studies involving autonomous transfer and robotic bartenders to measure trust in smart autonomous technologies. In their study investigating the antecedents and consequences of trust in smart robots, researchers reached the conclusion that trust in smart machines is affected by the negative attitude towards technology and the tendency to trust technology, and that the physical form of robots does

not affect trust. The study also concluded that, according to the results of both studies, trust leads to adoption intentions. On the other hand, Flippy, which is the world's first autonomous robotic kitchen assistant, has advantages for businesses such as ensuring product quality and standardization, reducing waiting time, increasing food safety, and providing employees with more time to serve guests. However, the entry-level price of Flippy, at $60,000, significantly exceeds the annual salary of an average burger chef. There is also a 20% annual recurring expense for the maintenance of the robot. However, Caliburger states that it is confident in its return on investment thanks to reduced wait times, consistency, and reduced food waste (CaliBurger, 2024; Heater, 2018).

Technological innovations are very important for the food and beverage industry, as in other areas. Although the technology on which Gastronomy 4.0 is based has a certain cost, it also ensures that it remains competitive. A food and beverage business should calculate costs and benefits when adopting Gastronomy 4.0 applications. The first gastronomy 4.0 applications in the food and beverage industry started with digitalization, and great benefits were achieved. The most important of these benefits is ensuring food sustainability by protecting natural resources. It is possible to achieve food sustainability through digital transformations. Thanks to digitalization, food systems and production processes will be able to play a more integrated role. Gastronomy 4.0 aims to be more sustainable, efficient, and innovative in the food and beverage industry. However, this transformation has also brought about concerns that it could replace traditional culinary arts and craftsmanship. Therefore, it is very important that changes, transformations, and technology-based developments in the food and beverage industry are balanced. It is evident that the use of robots in the tourism sector is increasing. In this context, the prejudices of employees can be eliminated by providing training on the importance and benefits of the presence of robots in tourism enterprises. Offering similar training in tourism faculties would benefit future tourism industry employees by giving them the skills to follow and implement developments in the world more easily.

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