JOEEP

e-ISSN: 2651-5318
Journal Homepage: http://dergipark.org.tr/joeep

Araştırma Makalesi ● Research Article

Retail and Finance in the Era of Digital Transformation: Analysis of E-commerce, Exchange Rates, and Interest Rates*

Dijital Dönüşüm Çağında Perakende ve Finans: E-ticaret, Döviz Kurları ve Faiz Oranlarının Analizi

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MAKALE BİLGİSİ

Makale Geçmişi:
Başvuru tarihi: 12 Haziran 2024
Düzeltme tarihi: 4 Temmuz 2024
Kabul tarihi: 30 Kasım 2024

Anahtar Kelimeler:
Makro Ekonomi
E-Ticaret
Ticari Krediler
Döviz Kuru
Faiz

ARTICLE INFO

Article history:
Received: June 12, 2024
Received in revised form: July 4, 2024
Accepted: Nov 30, 2024

Keywords:
Macro Economy
E-Commerce
Commercial Loans
Exchange Rate
Interest Rate

ÖZ

Çalışma, Türkiye'deki perakende sektörü ve ticari/bireysel kredilerin dönüşümünü inceleyerek, e-ticaret (internet üzerinden yapılan kartlı alışverişler), döviz kuru ve mevduat faiz oranlarının bu alanlardaki etkisini değerlendirmeyi amaçlamaktadır. Literatürde, internet tabanlı kart ödemelerinin perakende sektörü üzerindeki etkisini makroekonomik faktörlerle bir arada değerlendiren çalışmalar sınırlıdır. Bu bağlamda, araştırma, hem teorik hem de uygulamalı katkılar sunmayı hedeflemektedir. 2017–2023 dönemine ait verilerle Vektör Ototregresyon (VAR) modeli kullanılarak yapılan analizde, perakende satışlara uygulanan bir şok kendisini iki dönem pozitif etkilediği belirlenmiştir. E-Ticarete uygulanan bir şok, perakende satışlarını ilk üç dönemde pozitif yönde etkilemektedir ancak döviz kuru şokunun etkisiyle bu etki dördüncü döneme kadar negatif yönde değişmektedir. Mevduat faizi şokunun etkisi belirsizdir. Diğer taraftan, ticari ve bireysel kredilere uygulanan bir şok, kendisini üç dönem boyunca pozitif yönde etkilemektedir. E-Ticarete uygulanan bir şok, ticari ve bireysel kredileri ilk üç dönemde pozitif yönde etkilemektedir. Döviz kuru şokunun etkisi de ticari ve bireysel kredileri ilk üç dönemde pozitif yönde etkilemektedir. Mevduat faizi şokunun etkisi belirsizdir. Bu analiz, perakende sektörü ve krediler üzerindeki etkileşimleri araştırarak, e-ticaretteki kartlı işlemlerin önemini vurgulamaktadır. Ayrıca, bulgular, dijitalleşme ve makroekonomik değişkenlerin birleşik etkilerini incelemek isteyen araştırmacılar için kapsamlı bir çerçeve sunmakta ve politika yapıcılar ile işletmelere somut öneriler sağlamaktadır.

ABSTRACT

This study aims to examine the transformation of the retail sector and commercial/individual loans in Turkey, evaluating the impact of e-commerce (card-based online transactions), exchange rates, and deposit interest rates on these areas. The literature reveals a limited number of studies that simultaneously assess the effects of internet-based card payments on the retail sector in conjunction with macroeconomic factors. In this context, the research aims to provide both theoretical and practical contributions. An analysis conducted using the Vector Autoregression (VAR) model with data from 2017 to 2023 indicates that a shock applied to retail sales has a positive effect over two periods. A shock to e-commerce positively affects retail sales for the first three periods, but this effect turns negative by the fourth period due to the exchange rate shock. The impact of the deposit interest rate shock is uncertain. Conversely, a shock to commercial and individual loans has a positive impact for three periods. A shock to e-commerce also positively affects commercial and individual loans for the first three periods, with the exchange rate shock having a similar positive effect. The impact of the deposit interest rate shock remains uncertain. This analysis highlights the interactions between the retail sector and loans, emphasizing the significance of card transactions in e-commerce. Moreover, the findings provide a comprehensive framework for researchers aiming to explore the combined effects of digitalization and macroeconomic variables, while also offering concrete recommendations for policymakers and businesses.

* Bu çalışma Bozüyük/Bilecik'te gerçekleştirilen 4. Uluslararası Bankacılık Kongresi'nde sözlü bilsdiri olarak sunulmuştur.

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Atıf/Cite as: Koç, H. (2024). Retail and Finance in the Era of Digital Transformation: Analysis of E-commerce, Exchange Rates, and Interest Rates. *Journal of Emerging Economies and Policy*, 9(SI), 202-221.

1. Introduction

Today, economic transformation and technological advancements significantly impact financial markets. Understanding these effects can assist businesses and policymakers in making informed decisions. This study provides a framework to comprehend the relationship between the retail sector and financial markets in Turkey, emphasizing the importance of understanding the impacts of financial variables on retail sales and credit demand. Notably, exchange rates, interest rates, and internet-based card payments (e-commerce) are critical variables.

With the development of internet infrastructure and the increasing prominence of e-commerce in the digital transformation process, the effects of these variables are becoming more pronounced. The growing prevalence of online shopping is leading to significant changes in the retail sector. Purchases made through online platforms, in addition to physical stores, are becoming more widespread, altering consumer shopping habits (Park & Lee, 2021:2). This necessitates a closer examination of the factors influencing retail sales.

In addition to the impacts of e-commerce and internet infrastructure, macroeconomic factors such as exchange rates and interest rates play a critical role in shaping retail sales and credit demand. For instance, fluctuations in exchange rates can affect the cost of imported goods, thereby altering retail prices and consumer spending habits (Eryüzlü, 2020:399). Similarly, changes in interest rates can affect borrowing costs for both businesses and consumers, influencing investment and spending decisions (Eryüzlü & Kurtoğlu, 2021:235-236). These financial dynamics underscore the importance of conducting comprehensive analyses to understand how different economic variables are interconnected and their combined effects on the retail sector.

Moreover, businesses need to adapt to these economic and technological changes to maintain competitiveness in the market. Retailers should invest in digital platforms and optimize their supply chains to meet the demand for online shopping. On the other hand, financial institutions should develop innovative credit products and services tailored to evolving needs. This adaptation process will contribute to the sustainable growth of both the retail sector and financial markets.

Exchange rate fluctuations, changes in interest rates, and internet-based card payments are significant factors affecting credit demand. Understanding the interaction between these variables allows for better interpretation of changes in financial markets. In this context, this study aims to examine the relationship between the retail sector and financial markets in Turkey, specifically evaluating the effects of internet-based card payments, exchange rates, and interest rates on retail sales and credit demand. The Vector Autoregression (VAR) model employed in the analysis will facilitate a better understanding of these relationships.

This study addresses a significant gap in the literature by examining how macroeconomic variables and digitalization processes jointly influence retail sales and credit demand in the context of Turkey. Studies that assess the impact of internet-based card payments on the retail sector alongside macroeconomic factors are limited. In this regard, this research offers both theoretical and practical contributions. The findings contribute to a better understanding of the effects of digitalization on the retail sector while providing concrete recommendations for policymakers and businesses. Furthermore, this study offers a comprehensive framework for researchers interested in exploring the impact of macroeconomic variables and digitalization processes on the retail sector. Specifically, its methodological approach, which evaluates the combined effects of internet-based card payments, exchange rate fluctuations, and interest rates, can serve as a reference for similar analyses. This, in turn, enables future studies to conduct more in-depth analyses in terms of both methodology and content.

The subsequent sections of the study will first address the conceptual framework and literature review, followed by a detailed explanation of the econometric method and data. Finally, the study's findings will be presented and the results evaluated

2. Theoretical Framework, And Literature

Unlike traditional industrial economics, the term 'New Economy' refers to an economic model centered on knowledge and technology. This term often highlights the impact of information and communication technologies (ICT), the internet, and digitization on economic activities. The New Economy is characterized by the increasing importance of knowledge-based production and service sectors, with digital and innovative sectors replacing traditional industries. Areas such as E-commerce, digital marketing, software, and technology-based entrepreneurship fall within the concept of the New Economy. This term is used to express changes in economic structure and business models, as well as technology-driven innovations and digital transformation (Chaffey & Smith, 2013:24).

The Digital Economy represents a category of economic activities shaped by the widespread use of information and communication technologies (ICT). In contrast to traditional economic models, the digital economy focuses more on activities based on digital technologies, such as internet-based businesses, digital products and services, and data-driven economic models. In the digital economy, information and technology can fundamentally alter business models, marketing strategies, and consumer behaviors (Warner & Wager, 2019:327-328; Scardovi, 2017:65-84).

E-commerce refers to commercial activities conducted via electronic networks and digital technologies. This trading model provides consumers and businesses with access to product and service exchanges through online platforms. Unlike traditional trading methods, e-commerce enables consumers to shop using

internet-connected devices without needing to visit brick-and-mortar stores physically. This allows consumers to browse products, compare prices, and complete purchases through various digital platforms (Park & Lee, 2021:16). Consequently, e-commerce transactions enhance consumers' access to products and services regardless of geographic location while providing businesses with opportunities to reach a broader market.

Digital transformation involves the optimal utilization and widespread adoption of digital technologies by businesses and society. Today, digital transformation has become a crucial strategic objective for businesses aiming to gain a competitive advantage and develop more effective and efficient business models. Linked with the concepts of the New Economy and Digital Economy, digital transformation is essential for understanding the impact of technology on the economy and society and adapting to these changes (Warner & Wager, 2019:327-328). With the global proliferation of e-commerce, consumer shopping habits and preferences are evolving. Alongside purchases made in physical stores, online shopping is becoming increasingly prevalent. This phenomenon leads to significant changes in the retail sector and supply chains. Keeping pace with global e-commerce trends and adapting to this change is vital for businesses to maintain and enhance their competitiveness (Chaffey & Smith, 2013:24-26).

E-commerce has rapidly emerged as a significant trend worldwide. Turkey, in line with this global trend, has developed a dynamic e-commerce market. The increasing internet usage, widespread adoption of mobile devices, and the development of secure payment systems continuously bolster Turkey's e-commerce volume (Özel, 2013:15-16). Turkey's strategic geographical location, robust logistical infrastructure, and youthful population are key factors contributing to the expansion of the e-commerce sector. The growth of e-commerce in Turkey and globally presents both opportunities and challenges for businesses. Therefore, businesses operating in the e-commerce sector must closely monitor market trends, understand customer expectations, and continually update their strategies to maintain a competitive edge (Demirdöğmez et al., 2018:2229-31). Moreover, it is crucial for authorities and regulatory bodies to implement policies that support the fair and sustainable growth of the e-commerce sector.

The rapid growth of e-commerce, which facilitates and diversifies consumer access to products and services, also impacts credit usage. The increasing trend of online shopping often leads consumers to prefer using credit cards or other online payment methods. This trend significantly influences financial markets by increasing the use of credit cards and consumer loans. Both commercial and individual loans, online card payments, and exchange rate fluctuations can be affected. Specifically, changes in a country's currency value can influence the terms of commercial and consumer loans and the volume of online card payments. The effects on individual loans are more complex. Exchange rate fluctuations typically impact inflation, and high inflation often leads to increased interest rates. Consequently, individual loan interest rates may rise, reducing consumer credit usage or prompting borrowers to reassess loan terms. Additionally, exchange rate fluctuations can affect consumer spending by increasing the prices of imported goods, thereby influencing individual credit demand.

In the context of online card payments, the impact of exchange rate fluctuations may be more indirect. Exchange rate fluctuations often affect import and export activities, thereby influencing payments made by those transacting in foreign currencies. Consequently, consumers' payment methods and spending habits for online purchases may change, affecting the volume of online card payments (Eryüzlü & Kurtoğlu, 2021:235). In conclusion, both commercial and individual loans, as well as online card payments, can be influenced by exchange rate fluctuations. Therefore, financial institutions and consumers should manage credit usage and payment habits with an awareness of exchange rate fluctuations. Additionally, developing risk management and financial planning strategies to mitigate the effects of exchange rate fluctuations is essential.

Studies in national and international literature are listed in the table below.

Table 1: National and International Empirical Studies

Author(s)	Sample	Method	Findings
Aras, Kocakoç & Polat (2017)	2012:01– 2015:05	ARIMA– ARFIMA – Neural Networks – Adaptive Network– Fuzzy Inference System (ANFIS)	It has been found that most predictions made with AI can provide statistically significant increases in prediction accuracy when compared to individual models and predictions generated by the company's existing system.
Aimer, Lusta & Abomahdi, (2017)	1999 – 2015	VAR – Cointegration	The development of e-commerce was found to have a statistically significant and positive impact on Libyan economic growth.
Dumičić et al., (2018)	2013–2018	VARIMAX –Multiple Regression Analysis.	The study examines online purchases by individuals in selected European countries in 2013. In the regression model, Factor 1, which includes seven variables such as Investing in Education and IT Infrastructure, and Awareness, and Factor 2, consisting of two variables called IT Skills, are statistically significant at the 1% significance level. Both factors show a positive correlation with online purchases by individuals.
Ünal & Ocak (2020)	2003: Q1– 2018: Q4	Johansen Cointegration – Granger Causality	It has been determined that interest rates have a negative and significant effect on consumer loans and that interest rates explain 28.7% of the variance of consumer loans.

Eryüzlü & Aşkar (2021)	2009:04 – 2021:09	Toda-Yamamoto Causality	One-way causality has been determined from commercial loans to the real effective exchange rate.
Eryüzlü & Kurtoğlu (2021)	2014:01– 2019:09	Toda-Yamamoto Causality	Increases in e-commerce transaction volume (positive shocks) cause an increase in consumer loans (positive shocks). The hypothesis that there is a relationship between e-commerce use and personal loan use in Turkey has been confirmed.
Park & Lee (2021)	2015–2019	SLM – SEM – OLS	Local geographical factors affecting the spatial distribution characteristics of newly opened and closed fashion and beauty-related stores have been empirically analyzed. It has been revealed that the factors affecting the openings and closings of fashion and beauty retail stores in Seoul are related to local geographical variables such as industrial establishments, food and beverage stores, land prices and active population distribution in the region.
Yelghi, Gürsoy & Yelghi (2021)	2017:09 –2019:12	ARDL	No long-term relationship has been found between interest rates and exchange rates according to loan types.
Qidi, (2021)	2018:12 –2020:09	Engle-Granger Causality – Multiple Linear Regression	A one-unit increase in consumer spending leads to an increase in online retail sales. It was concluded that there is no causal relationship between e-commerce retail sales and consumption expenditures.
Özçelik & Süsay (2022)	2005:01 – 2021:04	ARDL – Toda-Yamamoto Causality	A bidirectional causality relationship has been determined between interest rates and loan volume.
Doğanalp, (2022)	2004: Q1– 2021: Q3	VAR – Granger Causality	It was found that interest rates explained 25.7% of the variance of domestic loans. A bidirectional causality relationship was found between domestic loans and interest rates.
Li et al., (2021)	2011 –2018	POLS	They found that there is an inverted U-shaped relationship between the development of e-commerce and the urban-rural income gap, and they showed that when e-commerce reaches a certain level, it helps narrow this gap.
Bogdan & Kalińska-Kula (2021)	2020	Kruskal-Wallis Test – Independence Analysis	The study surveyed nearly 1,000 respondents from Poland, Ukraine, and Belarus. It found that the country of origin significantly influences e-consumers' behaviors and attitudes towards e-commerce, particularly regarding safety, convenience, time, choice, ease, and shopping economics. However, no clear link was found between the respondents' country of origin and their tendency to use the Internet.
Moerth-Teo et al., (2021)	2021	T-Test – Correlation Analysis.	The study compares the e-commerce environments of Singapore and Austria, analyzing survey results from 206 participants. It found that the country of origin significantly influences e-commerce attitudes, with differences in behaviors regarding security, convenience, time consumption, choices, ease of use, and shopping economics. However, no clear relationship was found between participants' country of origin and their tendency to use the Internet.
Bakkal, (2022)	2010: Q1– 2021: Q2	SVAR	It has been determined that interest rates explain approximately 23% of the variance of bank loans.
Kiselicki et al., (2022)	2022	Likert Scale	Literature review and empirical analysis using a survey with 28 questions (open and closed-ended questions, five-point Likert Scale), followed by quantitative and qualitative analysis. The pandemic significantly increased e-commerce adoption rates. Consumers in developing countries are open to online shopping when trust and security parameters are met.
Parvin et al., (2022)	2022	Difference-in-Differences	The Difference-in-Differences methodology was employed to analyze the effects of e-commerce adoption on customers and service providers. E-commerce improves SME agents' efficiency, accelerates business transactions, and contributes to sustainable economic growth.
Eryüzlü & Sakallı (2023)	2013:01 – 2022:06	VAR – Granger Causality	E-Commerce Volume and Commercial Credits series are divided into positive and negative components. A causality relationship was found between E-commerce and commercial loans in only two out of five causality relationships.
Oğuz et al., (2023)	2007 – 2019	Panal Data Analysis	A 1% increase in GDP per capita in Turkey and EU countries leads to a 7.29% rise in e-commerce. Additionally, a significant and positive relationship has been found between GDP per capita, internet usage rate, employment rate by education level, and e-commerce.
Göçmen-Yağcılar & Altun (2024)	2010: Q1–2022: Q4	Toda-Yamamoto Causality	It has been determined that there is a causal relationship between economic growth and SME loans, commercial loans and consumer loans.

Literature Review Summary and Identified Gap:

Table 1 illustrates the diversity of national and international studies examining economic indicators, financial markets, and their interrelations. Research such as Ünal & Ocak (2020) highlights the significant negative impact of interest rates on consumer loans, explaining a notable portion of their variance. Similarly, Eryüzlü & Aşkar (2021) found a unidirectional causality from commercial loans to the real effective exchange rate, while Özçelik & Süsay (2022) identified a bidirectional relationship between interest rates and loan volumes, shedding light on credit market dynamics. Park & Lee (2021) further broaden the scope by analyzing the influence of geographical factors on the opening and closing patterns of retail stores, emphasizing the spatial determinants of retail activities.

In the context of e-commerce, the reviewed studies reveal its multifaceted role across various domains, employing methodologies such as ARIMA, VAR, regression analysis, and Difference-in-Differences. Findings consistently indicate that e-commerce adoption drives economic growth, enhances SME efficiency, and fosters consumer trust, particularly in developing economies. Studies like Li et al. (2021) highlight complex relationships, such as the inverted U-shaped connection between e-commerce development and the urban-rural income gap, illustrating e-commerce's nuanced societal effects. Moreover, pandemic-era analyses, such as Kiselicki et al. (2022), reveal significant increases in e-commerce adoption and shifting consumer behaviors.

Despite this breadth of research, there are notable gaps. Existing studies often lack an integrated perspective that evaluates the macroeconomic factors influencing e-commerce alongside its impact on retail and credit markets. Additionally, cross-country comparisons remain sparse, and the dynamic interactions between digitalization and traditional economic indicators are underexplored.

Addressing these gaps, this study offers a contribution by examining the transformation of Turkey's retail sector and commercial/consumer loans in the context of e-commerce, exchange rates, and deposit interest rates. Using data from 2017–2023 and a VAR model, it provides a comprehensive analysis of the dynamic interactions among these variables. The findings, such as the short-term positive effects of e-commerce shocks on retail sales and credit markets, as well as the nuanced impacts of exchange rate and interest rate shocks, underscore the importance of digitalization in shaping economic dynamics. This research not only fills a critical gap in the literature but also offers valuable insights for policymakers and businesses navigating the intersection of e-commerce and macroeconomic trends.

3. Econometric Method, and Data Sets

When determining the econometric model, it is important to test the stationarity of the variables. For this purpose, common unit root and stationarity tests such as the Augmented Dickey-Fuller (ADF), Phillips-Perron (PP), and KPSS tests are employed (Makridakis et al., 1998: 329).

The PP test equation form is shown in equation number 1.

The PP test equation form is shown in equation number 1.

$$\Delta y_t = a y_{t-1} + x_t'\delta + u_t \quad (1)$$

PP test hypotheses:

H_0: $a = 0$ There is a unit root
H_1: $a < 0$ There is no unit root

The Phillips-Perron test statistic has a structure very similar to the ADF test statistic. For this reason, test statistic values are generally interpreted by comparing them with the critical values determined by MacKinnon (Phillips and Perron, 1981: 335-346).

Unlike unit root tests, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) test tests the stationarity of the y_t time series. Generally, hypotheses are determined with the KPSS test and the p values of these hypotheses are calculated.

H_0: The series is stationary.
H_1: The series is non-stationary.

The basic equation for the KPSS test is as follows:

$$y_t = r_t + \beta_t + \varepsilon_t \quad (2)$$
t=1,…….,T

The autonomous parameter r_t in the model has the characteristics of a random walk process. y_t is the observed series, β_t is the deterministic trend, ε_t is the stationary error term. According to the basic hypothesis, the stochastic process y_t is stationary or trend stationary around the constant $\beta=0$

The LM statistic is obtained as in equation 3:

$$LM = \sum t\, S(t)^2/(T^2 f_0) \quad (3)$$

In equation 3, f_0 is the residual spectrum at frequency zero estimator and S(t) is the cumulative residue function shown in equation 4.

$$S(t) = \sum_{r=1}^{t} \hat{u}_r \quad (4)$$

The residue estimates in Equation 4 are obtained as $\hat{u}_t = y_t - x_t'\hat{a}(0)$. Critical values for the LM test statistics were produced by KPSS (1992). If the LM test statistic is greater than the relevant critical value, the null hypothesis will be rejected (Mert & Çağlar, 2019: 101-102).

3.1 Vector Autoregressive Model

Sims (1980) highlighted the exogeneity assumptions for certain variables in simultaneous equations and proposed the Vector Autoregression (VAR) model as an alternative. VAR models are linear and assume that all variables are endogenous. These models rely on empirical inferences and are not directly tied to economic theories, making them valuable econometric tools for forecasting, causality, impulse response, and variance decomposition analyses. Furthermore, the time series used in VAR model estimation need to be stationary. It is well known that most time series exhibit stochastic trends and follow a unit root process. In other words, most time series are non-stationary, and these series do not exhibit mean reversion (Lütkepohl, 2005: 13; Hepsağ, 2024:159-171).

According to Johansen (1995), the VAR model can be shown as in equation (5):

Let $Y_t = (y_{1t'}\, y_{2t'} \ldots, y_{nt})'$ denote the (n×1) vector of variables. The reduced form of the VAR model of order p (VAR(p)) can be represented as follows (Hepsağ, 2024:159-171):

$$Y_t = c + \prod_1 Y_{t-1} + \prod_2 Y_{t-2} + \cdots + \prod_p Y_{t-p} + \varepsilon_t \qquad (5)$$

Where $\prod_1, \prod_2, \ldots,$ and $\prod_p$ are the coefficients matrices with (n×n) dimension and ε_t is i.id. error term. For simplicity, we consider the first-order two-variable VAR model as in the following equation:

$$\begin{aligned} Y_{1t} &= c_1 + \alpha_{11} y_{1t-1} + \alpha_{12}\, y_{2t-1} + \varepsilon_{1t} \\ Y_{2t} &= c_2 + \alpha_{21} y_{1t-1} + \alpha_{22}\, y_{2t-1} + \varepsilon_{2t'} \end{aligned} \qquad (6)$$

In equation (6), $\alpha_{11}, \alpha_{12}, \alpha_{21},$ and α_{22} are coefficients, and y_{1t-1} and y_{2t-1} are the one lagged values of the variables. We estimate VAR models using the Ordinary Least Squares (OLS) method. The primary objective of VAR analysis is to obtain an adequate model; therefore, practitioners should check the estimated VAR model for adequacy. Various procedures are employed on the estimated residuals to confirm the white noise assumptions. It is essential to apply residual-based tests for autocorrelation, non-normality, and heteroskedasticity to the estimated VAR model. One of the most commonly used tests for detecting autocorrelation is the Breusch-Godfrey LM test. The LM test statistic is derived from the following auxiliary model (Hepsağ, 2024:159-171).:

$$\begin{aligned} &\hat{\varepsilon}_t \\ &= A_1\, y_{t-1} + A_2\, y_{t-1} + ,,,, + A_p\, y_{t-p} + B_1\, \hat{\varepsilon}_{t-1} \\ &+ B_2\, \hat{\varepsilon}_{t-2} + ,,,, + B_{h\hat{\varepsilon}_{t-2}} + ,,,, + B_{h\hat{\varepsilon}_{t-h}} + v_r \end{aligned} \qquad (7)$$

The null hypothesis of $B_1 = B_2 = \ldots. = B_h = 0$ is tested against the alternative hypothesis of $B_1 \neq B_2 \neq \ldots. \neq B_h \neq 0$ using an LM-type test statistic that can be obtained as:

$$Q_{LM} = T(K - tr(\sum\nolimits_{\varepsilon}^{-1} \sum_v)), \qquad (8)$$

In equation (8), $\sum_v = \frac{1}{T} \sum_{t=1}^{T} \hat{v}_t\, \widehat{v'}_t$. The LM test statistic follows X^2 distribution and if the LM test statistics is smaller than the critical value with $X^2(hK^2)$ the null hypothesis of no autocorrelation cannot be rejected. While it is generally expected that the normality assumption is met, it is not a necessary condition for VAR models. It is well known that the normality assumption is fundamental for the application of t-tests and F-tests in econometric models. However, in the context of VAR models, we do not focus on t-tests and F-tests. Instead, VAR models are primarily used for forecasting, causality analysis, impulse response functions, and variance decomposition (Hepsağ, 2024: 161).

Impulse Response Analysis is a crucial component in econometric analysis utilizing vector autoregressive models. It aims to describe the evolution of variables in a model as a response to a shock in one or more variables. Impulse Response Analysis quantifies the impact of shocks at a particular moment on the anticipated future values of variables over a temporal cross-section. Variance decomposition serves as an effective method for evaluating how external shocks transmit to each economic variable (Mert & Çağlar, 2019:216-230).

3.2 Data Sets

The analysis for the period of 2017:M01-2023 in the Turkish economy was conducted through two separate models. Firstly, the data representations, both symbolic and explicit, used in these models are presented in Table 2. Subsequently, under the heading "Findings," the analysis findings of Model 1 and Model 2 are reported in detail. These findings will assist in understanding the results of econometric modeling and the relationships between economic variables.

Table 2: Symbolic and Explicit Representation of Data for the Period 2017–2023

Variable	Data Type	Data Source and Code
$Credit_t$	Commercial/Personal Loans	EVDS, TP.KREDI.L023, Monthly Change
$Retail_t$	Retail Sales Volume Index	TUIK, Seasonal and calendar adjusted, Monthly Change
$Card_t$	ETRADECARD[1] - Online Card Purchases (domestic)	BKM, Domestic use of local cards, Monthly Change
int_t	Total Deposit Interest Rates[2]	EVDS, TP.TRY.MT06, Monthly Change
$\mathrm{usd_t}$	Exchange Rate (Dollar/TL)	EVDS, TP.DK.USD.S.YTL, Monthly Change

**The variables shown in the table were obtained from EVDS, TUIK and BKM.*

1 Card payment transactions made online, Transaction amount: https://bkm.com.tr/internetten-yapilan-kartli-odeme-islemleri/

2 Weighted average interest rates applied to deposits opened in TL by banks (flow %).

The data used in this study was obtained from different sources. Symbolic and explicit representation of key variables is presented in Table 2.

In table 2: $Credit_t$; Commercial/Personal Loans, $\mathrm{Retail_t}$; Retail sales volume index, $\mathrm{Card_t}$; E-commerce (Online Card Purchases (domestic)), $\mathrm{int_t}$; Deposit Interest Rates and $\mathrm{usd_t}$; Dollar/TL represents the rate of change of the monthly exchange rate. A total of 82 observations were obtained. All variables in the table are important indicators to understand Turkey's economic performance and developments in the retail sector. The data collection process ensured that reliable and up-to-date data was included in the analysis process.

The fact that the data used in the study is for the periods 2017:01-2023:12 ensures that the analysis reflects the current dynamics of financial and commercial variables. In particular, Turkey's economic and financial developments from 2017 to the present have played an important role in the transformation of the retail sector and changes in commercial loans. Data collection and analysis in this process increases the reliability of the research and ensures that the analysis results comply with current conditions. Therefore, it provides real-time and effective information to decision makers and researchers while strengthening the analytical framework of the research.

4. Empirical Results

Model-1 2017:1-2023:12

$$Retail_t = \alpha_0 + \beta_0 card_t + \beta_7 usd_t + \beta_3 int_t + \varepsilon_t \quad (9)$$

Model-2 2017:1-2023:12

$$Credit_t = \alpha_0 + \beta_0 card_t + \beta_2 int_t + \beta_3 usd_t + \varepsilon_t \quad (10)$$

$Credit_t$; in the equations above; Commercial/Personal Loans, Retail_t; Retail Sales, $Card_t$; Online Card Purchases (domestic), int_t; Deposit Interest Rates and usd_t; Dollar/TL represents the rate of change of the monthly exchange rate. α_0: refers to the fixed parameter, β parameters refer to the coefficient of the variables, and ε: refers to the error term.

A VAR model was estimated using periodic data on retail sales and commercial/personal loans in Turkey. Additionally, economic indicators such as exchange rates and deposit interest rates were incorporated into the model to evaluate their effects on the retail sector and loan demand. The VAR model is a valuable tool that offers flexibility in econometric analysis and captures the dynamic relationships between variables. This analytical method forms the foundational framework of the study, providing a basis for understanding the factors influencing the retail sector and credit demand.

In the study, two models were developed to investigate the transformation of the retail sector and commercial/personal loans in Turkey. The equations for these models are presented as Equation 9 and Equation 10, respectively.

The unit root test results of both models are stationary at the level and are given in **Table 3** under the heading of appendices. Since no cointegrated relationship was found, the VAR model was preferred for analysis. All diagnostic tests performed on the VAR model provide evidence that the model is significant. In addition, the impulse response analysis results and variance decomposition results for both models are included under the findings heading.

The results of the findings regarding the models are presented below.

4.1 Results of Model 1

All diagnostic tests of the VAR (1) model are included in Attachments 1. Econometric outputs of model 1. Appendix 1. In Table 4, the appropriate lag length for the VAR model was chosen as 1 according to the SC criterion. Appendix 1. Figure 1 shows the unit circle graph for the VAR model stability condition. It is understood from the graph that the stability condition is met. Appendix 1. Table

5 shows the Autocorrelation LM Test results. As can be seen from the table, it is understood that there is no serial autocorrelation in the residuals up to 3 lags (P>0.01). In this context, the null hypothesis cannot be rejected for all three delays. Appendix 1. Table 6 shows the White Heteroscedasticity Test results. According to the results in the table, the constant variance null hypothesis cannot be rejected. P= 0.0343>0.01, so there is no heteroscedasticity problem in the estimated model. Appendix 1. Table 7 includes the Jarque-Bera test. According to the JB test, the residuals (P>0.01) comply with the multivariate normal distribution at the .01 error level.

Below are the impulse response analysis graphics of model 1.

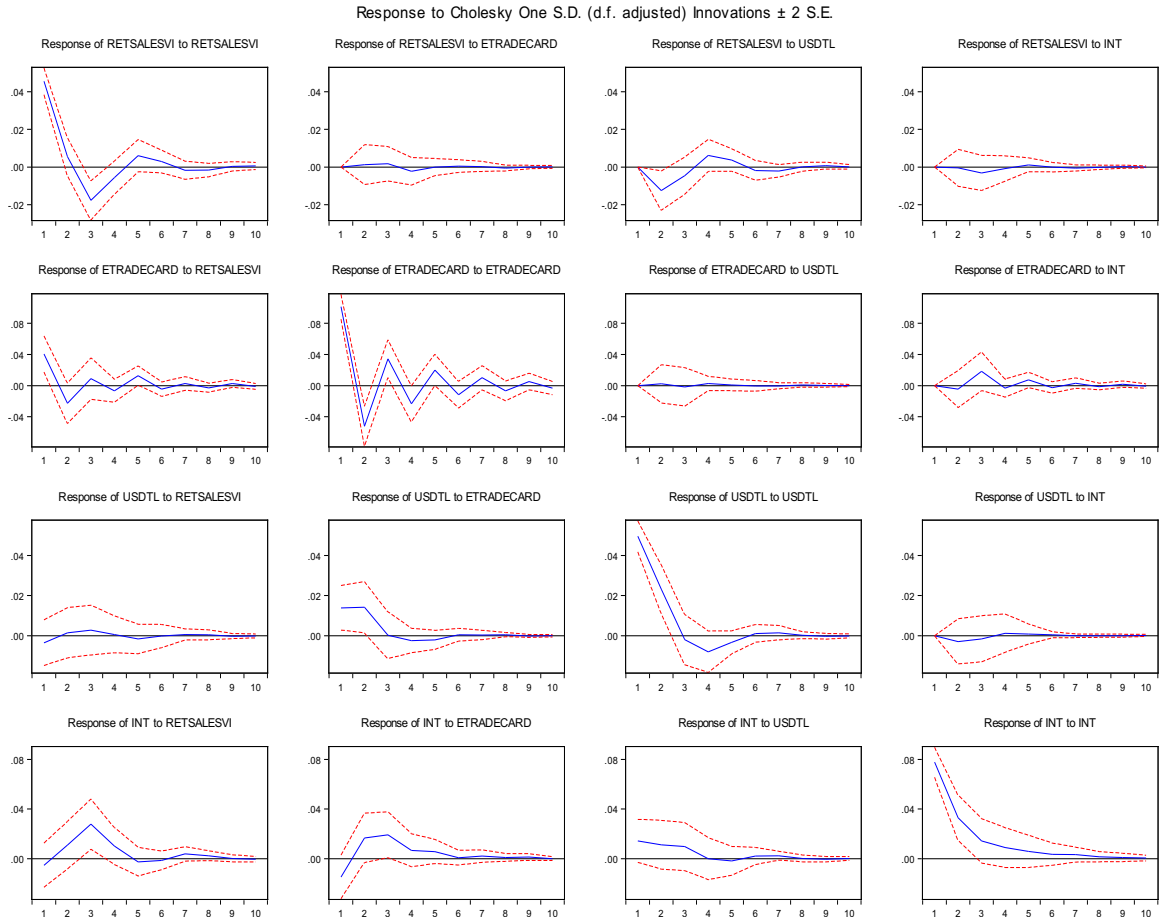

Figure 2. Model 1 Impulse Response Analysis Results

According to the analysis results, a shock applied to retail sales affects itself positively for two periods. Then the impact of shocks is negative until the fifth period. A shock applied to e-commerce affects retail sales positively in the first three periods. The effect of the exchange rate shock also negatively affects retail sales until the fourth period. Although the effect of the deposit interest shock is uncertain in the first two periods, it later affects retail sales negatively until the fourth period. Afterwards, the effect of the shocks disappears.

The reason why a shock to e-commerce has a low but positive impact on retail sales in the first three periods is likely due to changes in the way consumers make payments and shop. In this case, factors such as incentives or discounts that provide consumers with more advantages when purchasing with credit cards or debit cards can increase retail sales. The fact that this effect is positive, especially in the first three periods, may indicate that consumers respond quickly and positively to these incentives or advantages. However, the decrease in this effect or turning negative after the fourth period can be attributed to the fact that these incentives or advantages lose their effect over time or alternative factors become more prominent. In this case, a change in consumers' shopping behavior or the impact of other factors could reduce or reverse the impact of the shock to card transactions on retail sales.

If inflation remains at double-digit levels in Turkey, it may seriously affect the purchasing power of consumers. High inflation rates may require consumers to be more careful to keep their spending under control and balance their budgets. To protect against price increases, consumers often turn to saving and restricting their spending. In this case, a trend can be seen in which consumers may turn more towards online shopping. Online shopping often offers more

competitive prices than traditional stores and provides a variety of benefits. Shopping online not only offers consumers a wider range of products and different price options, but also provides the convenience of doing their shopping in the comfort of their homes. Therefore, in an economic environment with high inflation, consumers' interest and demand for online shopping may increase. This could lead to a shift in retail sales from brick-and-mortar stores to online platforms, with online shopping increasing overall purchase volume.

The negative response of the total retail trade volume index to a shock to the USD/TRY exchange rate may depend on several different factors:

- Increase in Costs: The increase in the Dollar/TL exchange rate may increase imported input costs. The retail industry often uses some or all imported products. Since the exchange rate increase will increase the cost of imported goods, the costs of retail businesses will also increase. Therefore, it may negatively affect profit margins and cause retail prices to increase. Rising prices may reduce consumers' purchasing power and reduce total retail trade volume.
- Consumer Confidence and Expenditures: The increase in the Dollar/TL exchange rate is generally associated with economic uncertainties. This may reduce consumers' confidence in the future and cause them to limit their spending. Consumers may turn to savings or spend more cautiously due to future economic uncertainties. This may reduce the total retail trade volume.
- Impact of Exports: An increase in the Dollar/TL exchange rate may be a positive development for exporters because their dollar-denominated revenues increase. An increase in exchange rate may increase the prices of imported products, leading to an increase in inflation and a decrease in the competitiveness of the local market.
- Investment and General Economic Conditions: An increase in the Dollar/TL exchange rate generally indicates economic uncertainties among investors. This may cause businesses to postpone or reduce their investments. Reduced investments by businesses may also affect employment and consumer incomes. Less employment and income could lead to lower spending in the retail sector. For these reasons, an increase in the Dollar/TL exchange rate can often cause a negative reaction to total retail trade.

Variance decomposition is a method used to analyze how the total variance of a variable can be explained by the variances of other variables affecting this variable. This method reveals a component that represents the effect of each variable on the target variable.

The table below shows the variance decomposition results of the VAR (1) model.

Table 8. Variance Decomposition Results of Retail Sales

Variance Decomposition of RETSALES:

Period	S.E.	RETSALES	ETRADECARD	USDTL	INT
1	0.045523	100.0000	0.000000	0.000000	0.000000
2	0.047554	93.00236	0.070349	6.920302	0.006989
3	0.051065	92.64246	0.176676	6.803549	0.377316
4	0.051804	91.20495	0.358779	8.048285	0.387991
5	0.052306	90.79698	0.352027	8.418436	0.432557
6	0.052420	90.71309	0.359202	8.496983	0.430722
7	0.052490	90.57528	0.361299	8.624647	0.438772
8	0.052518	90.57196	0.372154	8.616516	0.439370
9	0.052526	90.55037	0.372121	8.637016	0.440491
10	0.052530	90.55109	0.372205	8.636248	0.440453

In the variance decomposition results given in Table 8, ten periods were observed for each series. When the variance decomposition results for the retail sales variable are examined, the entire first period total change (100.00) is explained by itself. In the tenth period, approximately 90% of the total change is explained by itself, approximately 8.6% by Dollar/TL, 0.4% by deposit interest and approximately 0.37% by e-commerce.

Graphs of variance decompositions are presented below.

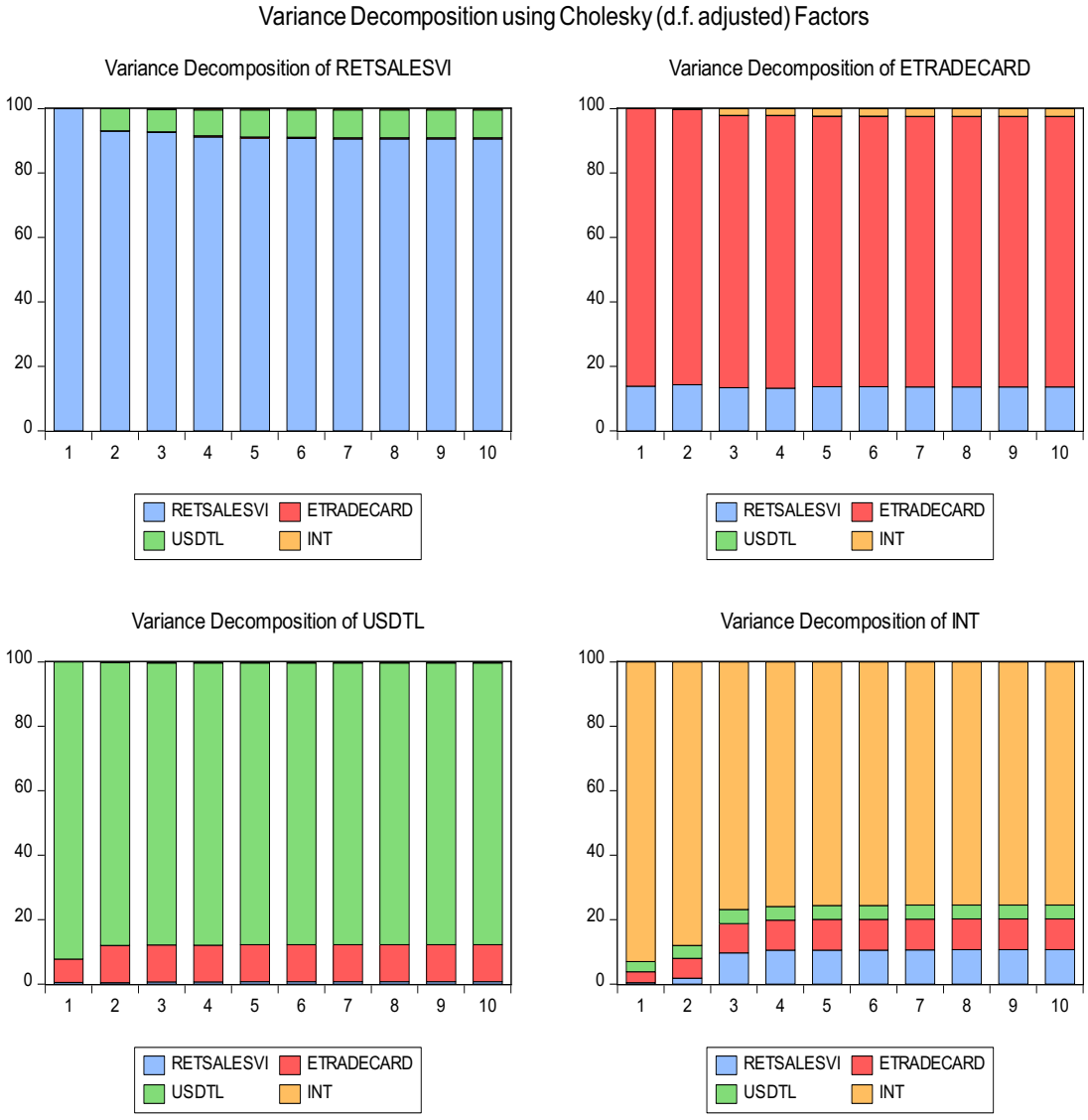

Figure 3. Variance Decomposition Graphs

Blue bars in the charts represent the retail sales variable, red bars represent online card transactions, green bars represent Dollar/TL and yellow bars represent deposit interest. When we look at the first chart, we see that the dollar exchange rate has a significant share in the Retail sales variable. When we look at the second chart, it is understood that retail sales have a significant share in online card transactions.

4.2 Results of Model 2

All diagnostic tests of the VAR (1) model are included in Appendix 2. Econometric outputs of model 2.

Appendix 2. In Table 9, the appropriate lag length for the VAR model is chosen as 1 according to the SC criterion. Appendix 2. Figure 4 shows the unit circle graph for the VAR model stability condition. It is understood from the graph that the stability condition is met. Appendix 2. Table 10 shows the Autocorrelation LM Test result. As can be seen from the table, it is understood that there is no serial autocorrelation in the residuals up to 3 lags (P>0.01). In this context, the null hypothesis cannot be rejected for all three delays. Appendix 2. Table 11 shows the White Heteroscedasticity Test results. According to the results in the table, the constant variance null hypothesis cannot be rejected. P= 0.0126>0.01, so there is no heteroscedasticity problem in the estimated model. Appendix 2. Table 12 includes the Jarque-Bera test. According to the JB test, the residuals (P>0.01) comply with the multivariate normal distribution at the .01 error level.

Below are the impulse response analysis graphics of model 2.

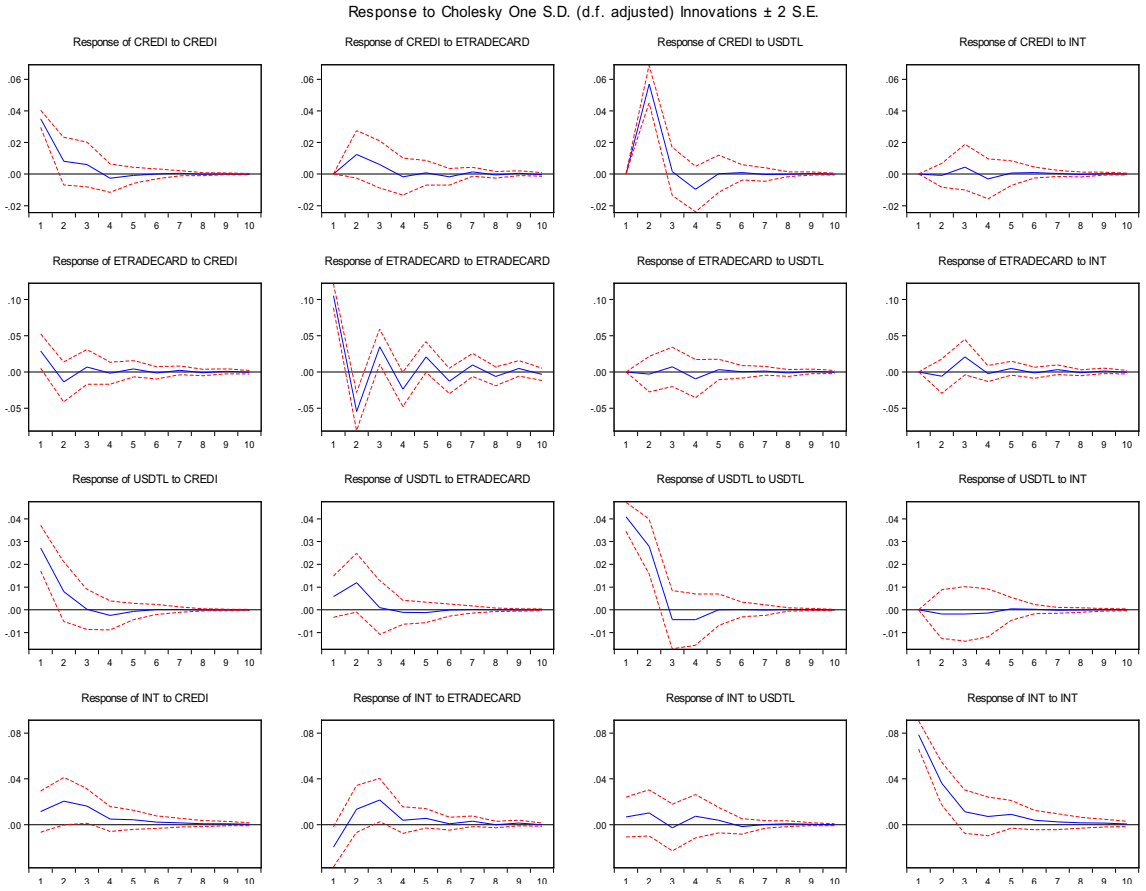

Figure 5. Model 2 Impulse Response Analysis Results

According to the impulse response graphs, when a shock is given to the credit variable, the reaction of the credit variable is positive for 3 periods. The response of the Loan (Commercial/Personal Loans) variable to the shock in the first quarter of the year is significant. This is particularly relevant to the impact of the shock to the ETRADECARD (online card transactions) variable. The increase in this period shows that the effect of card payments made over the internet is evident on loan demands.

Inflation in Turkey, which remains at double-digit levels, may reduce the purchasing power of consumers and cause them to save to offset price increases. In this case, consumers may turn more to online shopping because online shopping is often cheaper and offers a variety of options than traditional stores. Therefore, in an environment where inflation is high, it is possible for online shopping to increase. Additionally, in an environment of high inflation, individuals and businesses may shop for early access to goods and services in anticipation of future price increases. This may lead to an increase in online shopping. High inflation also has the potential to increase credit demand. Because consumers can use loans to cope with the additional financial pressures brought by inflation. At the same time, businesses may need financing to fight inflation and continue their operations. As a result, there may be a relationship between the increase in online shopping and the increase in loan demand in a high inflation environment. However, this relationship is complex and multifaceted and is influenced by various factors. **These factors include inflation levels, consumer habits, credit costs and economic uncertainties.**

The impact of the shock to the USDTL (Dollar/TL) variable on commercial and individual loans is clearly positive during the first 3 months. However, the uncertainty of long-term effects and the decay of the shock's subsequent impact must be taken into account.

Increasing prices of foreign exchange indexed products may increase commercial and individual loan demands.

Cost Increase: The increase in exchange rates increases the cost of imported goods and services. Especially the prices of foreign currency indexed products may increase in parallel with the increase in foreign exchange rates. In this case, the cash flow of businesses may shrink and their financing needs may increase. The demand for commercial loans may increase in this situation because businesses can use loans to cover cost increases.

Decrease in Competitiveness: The increase in exchange rates may reduce the competitiveness of local products in foreign trade. Especially exporting businesses may experience a decrease in their income due to the increase in foreign exchange rates. In this case,

businesses may need to use loans to remain competitive in the domestic market and continue their production.

Increase in Individual Demand: An increase in exchange rates can reduce the purchasing power of individuals in some cases. Especially with the increase in the prices of import-based consumer products, the consumption tendency of individuals may decrease. In this case, individuals' loan demands may increase to meet their needs.

Risk Management: Increases in foreign exchange rates increase exchange rate risk for businesses and individuals. Businesses and individuals may increase their demand for credit to reduce the effects of exchange rate fluctuations.

As a result, it should be taken into consideration that an increase in exchange rates may result in an increase in the prices of foreign exchange-indexed products and therefore an increase in loan demands. This situation may cause a significant increase in loan demands due to the impact of fluctuations in economic conditions and exchange rates.

There is no significant evidence that a shock to the INT (Deposit Interest Rate) variable affects the CREDI variable. The coefficients are mostly close to zero. In addition, increasing deposit interest rates means that banks may also tend to increase loan interest rates. In this case, credit costs rise, which may affect the demand for commercial and personal loans. Therefore, increases in deposit interest rates, together with increases in loan interest rates, may cause a decrease in loan demand.

Variance decomposition is a method used to analyze how the total variance of a variable can be explained by the variances of other variables affecting this variable. This method reveals a component that represents the effect of each variable on the target variable. The table below shows the variance decomposition results of the VAR (1) model.

Table 13. Variance Decomposition Results of Commercial/Retail Loans

Variance Decomposition of CREDI:

Period	S.E.	CREDI	ETRADECARD	USDTL	INT
1	0.034972	100.0000	0.000000	0.000000	0.000000
2	0.068496	27.49104	3.286653	69.20676	0.015549
3	0.069171	27.69561	3.974599	67.91438	0.415412
4	0.069968	27.20779	3.944090	68.24844	0.599683
5	0.069981	27.21269	3.955546	68.22471	0.607053
6	0.070017	27.18505	4.015121	68.17590	0.623930
7	0.070033	27.17803	4.050177	68.14531	0.626487
8	0.070036	27.17594	4.055241	68.14043	0.628393
9	0.070039	27.17396	4.059860	68.13696	0.629226
10	0.070040	27.17327	4.062221	68.13529	0.629211

In Table 13, under the heading "Variance Decomposition of CREDI", a decomposition is presented showing how much of the variance of the Commercial/Retail Loan variable originates from other variables. In addition, for each period, standard deviations (S.E.), components expressed as a percentage of the variance of CREDI, and ratios showing the contributions of other variables are presented. In the first period (month), all (100%) of the variance of the CREDI variable originates from itself. Other variables have no effect. In the second period (month), approximately 27.5% of the variance of the CREDI variable originates from itself, approximately 3.3% from the ETRADECARD (online card purchases) variable, approximately 0.015% from the INT (deposit interest) variable, and approximately 69% from the USDTL variable. In this period, the effect of the USDTL variable is quite evident. In the tenth period (month), approximately 27.2% of the variance of the CREDI variable originates from itself, approximately 4% from the ETRADECARD (online card purchases) variable, approximately 0.62% from the INT (deposit interest) variable, and approximately 68% from the USDTL variable. . In this period, the effect of the USDTL variable is quite evident, although it decreases.

Similarly, in other periods, the variance of the CREDI variable originates from ETRADECARD and USDTL variables at different rates. However, the contribution of the INT variable is quite low

The graphs of the variance decompositions explained in the table above are presented below.

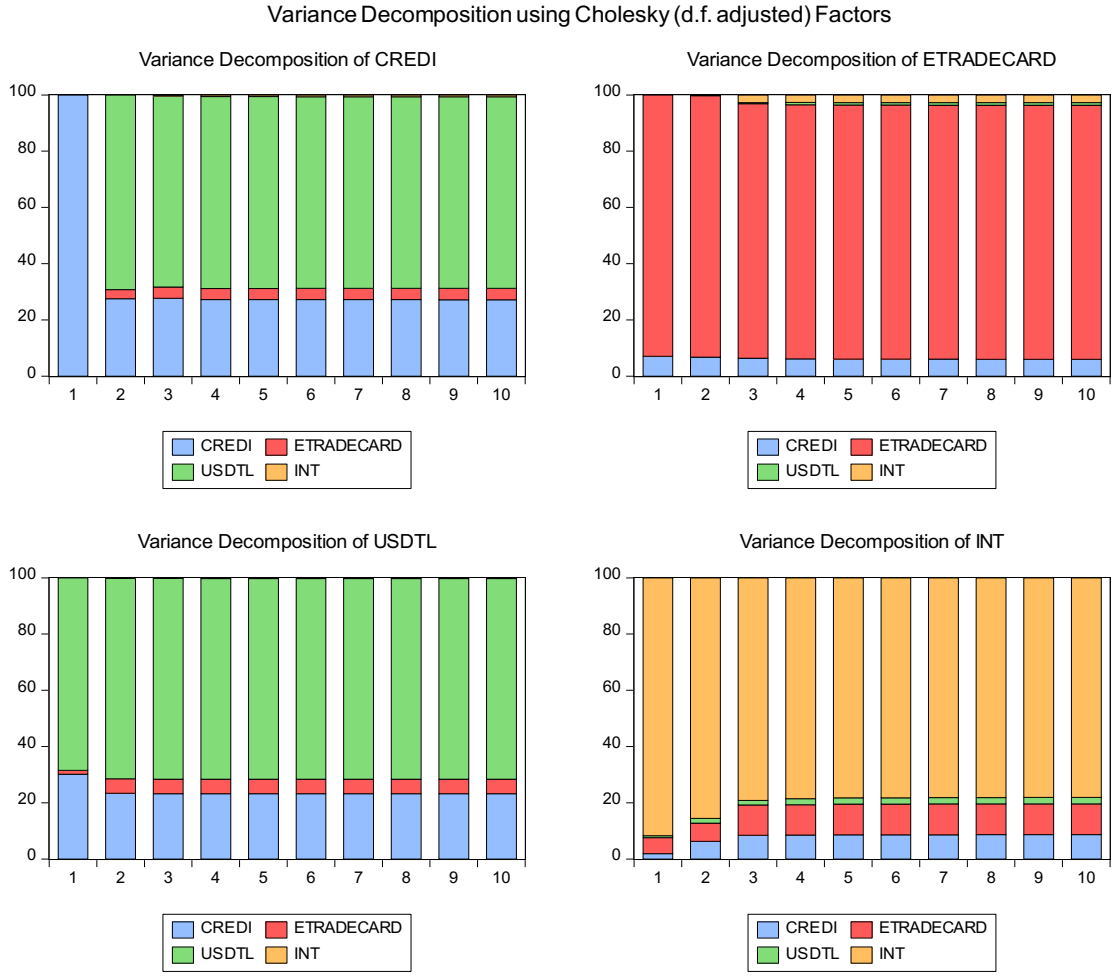

Figure 6. Variance Decomposition Graphs

The blue bars in the charts represent the CREDI (commercial/personal loans) variable, the red bars represent ETRADECARD (online card transactions), the green bars represent USDTL (Dollar/TL) and the yellow bars represent INT (deposit interest). When we look at the first chart, we see that the dollar exchange rate has a significant share in the CREDI variable. When we look at the second graph, it is understood that the CREDI (commercial/personal loans) variable has a significant share in online card transactions. This is followed by the INT (deposit interest) variable and the USDTL (Dollar/TL) variable. In the light of this information, it can be seen that the variability of commercial and individual loans is largely due to card payments made over the internet and fluctuations in the Dollar / TL exchange rate.

5. Conclusion

Among financial variables, exchange rates and interest rates are important factors on retail sales and commercial/personal loans. In the digital transformation process, the importance of e-commerce has increased with the rapid development of technology, and the volume of e-commerce has grown significantly with the expansion of card shopping and internet infrastructure. This study aims to examine the transformation of the retail sector and commercial/personal loans in Turkey and evaluate the impact of e-commerce (online card purchases (domestic)), exchange rate (Dollar/TL) and deposit interest rates in these areas. The analysis was conducted using the Vector Autoregression (VAR) model to determine the impacts on retail sales and commercial/personal loans during the period 2017:M01–2023:M12.

According to the analysis results, shocks applied to retail sales generally have a positive effect in the short term. While shocks applied to e-commerce increase retail sales in the short term, the effects of exchange rate and deposit interest shocks vary over time. Shocks applied to commercial and individual loans generally have a positive effect in the short term. It should be taken into consideration that double-digit inflation levels in Turkey negatively affect consumer purchasing power. High inflation may cause consumers to limit their spending and save money. In this case, consumers' interest and demand for online shopping may increase. Online shopping often offers competitive prices and a variety of benefits and can therefore be the choice of consumers during periods of high inflation. High inflation may also increase demand for credit

because consumers and businesses may be tempted to shop early to hedge against future price increases. It is also noteworthy that exchange rate increases affect commercial and individual loan demands. The rise in exchange rates may increase the financing needs of businesses and reduce their competitiveness by increasing imported input costs. At the same time, it may reduce individuals' demand for import-based consumer products and increase their demand for credit.

The findings of this study offer critical insights into the interconnected effects of financial and digital transformations on the retail and credit sectors. For instance, the results indicate that e-commerce not only fosters growth in retail sales but also positively impacts credit demand. This suggests that digital shopping platforms act as a stimulus for both consumer behavior and financial market dynamics. Furthermore, the nuanced findings about exchange rates and interest rates underscore the complexity of these relationships. While interest rate shocks align with previous literature in affecting loan demand, the interplay between exchange rate fluctuations and credit requirements highlights the intricate nature of financial decision-making by businesses and consumers. These results emphasize the importance of tailoring economic policies to address sector-specific challenges and opportunities in periods of both stability and volatility.

As a result, the impact of financial variables on retail sales and credit demands is complex and depends on a variety of factors. Analysis results show that these variables are interrelated and that economic conditions and consumer behavior are decisive on this interaction. Therefore, it is important to understand the interaction of these variables to ensure financial stability and promote economic growth.

The findings of the study are consistent with Eryüzlü & Kurtoğlu (2021), in the literature summary, positive shocks in e-commerce cause an increase in consumer loans. Aimer, Lusta & Abomahdi (2017) found positive effects of e-commerce on economic growth. We can match it with the finding that e-commerce increases retail sales. Qidi (2021) also supports this. Additionally, Doğanalp (2022), Bakkal, (2022) and Özçelik & Süsay (2022) determined a bidirectional causality relationship between interest rates and loan volume. The analysis result of the study is compatible with the effect of interest rates on loan demands. The Study of Eryüzlü & Aşkar (2021) in the literature is also related to the finding that the exchange rate affects loan demands.

Based on the results of this study, some suggestions can be made for future researchers:

This study covers the period 2017:M01–2023:M12. Future studies could also include data from different economic periods and compare the effects of financial variables in these periods on retail sales and credit demands. Vector Autoregression (VAR) model was used in the study. Future research could confirm and extend the results by applying different econometric models. This study focuses on the general retail industry. Future research could obtain more detailed results by analyzing specific retail subsectors or different industries. Key variables such as exchange rates, interest rates and online shopping were discussed in the study. Future research could conduct more in-depth analysis by examining subcomponents of these variables or more specific financial indicators.

The contribution of this study to the literature represents an important step towards understanding the relationship between the retail sector and financial markets in Turkey. In particular, it offers a new perspective on the existing literature by associating the effects of digital transformation with financial variables. Additionally, this study provides important clues for policy makers by evaluating the effects of changes in financial markets on consumer behavior and their potential impact on economic growth.

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Attachments

The unit root test results for the variables in both models are presented in Table 3.

Table 3. Unit Root Results

UNIT ROOT TEST TABLE (PP)

	At Level					
		RETSALVI	TICBRCREDI	ETRADCARD	USDTL	INT
With Constant	t-Statistic	-9.393348	-8.404769	-17.44010	-5.783027	-5.741989
	Prob.	0.0000	0.0000	0.0000	0.0000	0.0000
		***	***	***	***	***
With Constant & Trend	t-Statistic	-17.36166	-8.469570	-26.74309	-5.868404	-5.710314
	Prob.	0.0000	0.0000	0.0001	0.0000	0.0000
		***	***	***	***	***
Without Constant & Trend	t-Statistic	-7.908905	-7.704553	-12.26754	-5.295067	-5.523322
	Prob.	0.0000	0.0000	0.0000	0.0000	0.0000
		***	***	***	***	***

UNIT ROOT TEST TABLE (KPSS)

	At Level					
		RETSALVI	TICBRCREDI	ETRADCARD	USDTL	INT
	KPSS					
With Constant	test statistic	0.254419	0.159324	0.376221	0.236760	0.164946
	%10	0.347000	0.347000	0.347000	0.347000	0.347000
		***	***	**	***	***
	KPSS					
With Constant & Trend	test statistic	0.193732	0.040166	0.131835	0.038429	0.101060
	%10	0.119000	0.119000	0.119000	0.119000	0.119000
		**	***	**	***	***

*MacKinnon (1996) one-sided p-values.

*Kwiatkowski-Phillips-Schmidt-Shin (1992, Table 1)

*Bandwidth: (Newey-West automatic) using Bartlett kernel

*Statistically significant at the 10% level, **at the 5% level, and ***at the 1% level.

The test statistics calculated for all variables are smaller than all critical values at the 5% significance level, leading to the rejection of the null hypothesis. Therefore, it can be concluded that the series do not contain unit roots and are stationary.

Appendix 1. Econometric Outputs of Model 1

Table 4. Determination of VAR Lag Length

VAR Lag Order Selection Criteria
Endogenous variables: RETAİLSALES ECARD USDTL INT
Exogenous variables: C
Sample: 2017M01 2023M12
Included observations: 77

Lag	LogL	LR	FPE	AIC	SC	HQ
0	357.2204	NA	1.22e-09	-9.174557	-9.052801	-9.125855
1	397.2227	74.80937	6.53e-10	-9.797991	**-9.189211***	-9.554484*
2	416.6509	34.31472*	6.00e-10*	-9.887035*	-8.791230	-9.448723
3	431.5098	24.70059	6.23e-10	-9.857398	-8.274568	-9.224280
4	437.7894	9.786348	8.16e-10	-9.604919	-7.535065	-8.776996
5	445.9538	11.87549	1.03e-09	-9.401397	-6.844518	-8.378668
6	456.5382	14.29586	1.23e-09	-9.260733	-6.216830	-8.043198
7	465.7467	11.48069	1.56e-09	-9.084330	-5.553402	-7.671990

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

As seen in Table 2, lag length 1 was preferred according to the SC criterion.

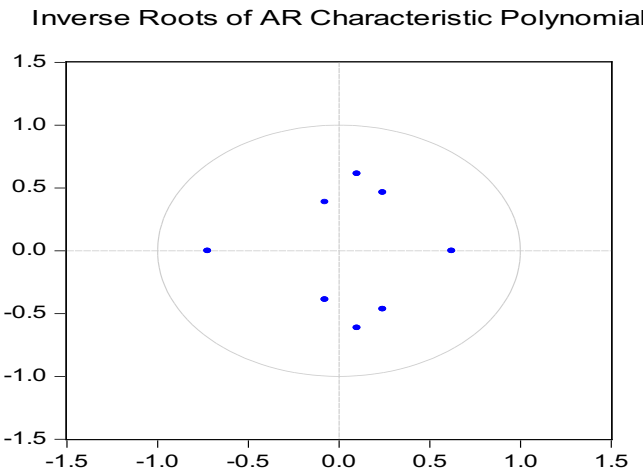

Figure 1. Unit Circle Graph for VAR Stability Condition

The graph indicates that the stability condition is satisfied.

Table 5. Autocorrelation LM Test

VAR Residual Serial Correlation LM Tests
Sample: 2017M01 2023M12
Included observations: 82

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	23.63914	16	0.0977	1.511806	(16, 202.3)	0.0980
2	21.50442	16	0.1599	1.368161	(16, 202.3)	0.1603
3	25.01101	16	0.0696	1.604895	(16, 202.3)	0.0699

As seen in the table, it is understood that there is no serial autocorrelation in the residuals up to 3 lags (P>0.01). In this context, the null hypothesis cannot be rejected for each of the four lags.

Table 6. White Heteroskedasticity Test

VAR Residual Heteroskedasticity Tests (Levels and Squares)
Sample: 2017M01 2023M12
Included observations: 82

Joint test:

Chi-sq	df	Prob.
194.0706	160	0.0343

According to the results in the table, the null hypothesis of constant variance cannot be rejected. P= 0.0343 > 0.01, hence there is no issue of varying variance in the estimated model.

Table 7. Jarque-Bera test

Component	Jarque-Bera	df	Prob.
2	1.168190	2	0.5576

According to the JB test, the residuals (P > 0.01) conform to a multivariate normal distribution at the 0.01 significance level.

Appendix 2. Econometric Outputs of Model 2

Diagnostic tests for Model 2

Table 9. Determination of VAR Lag Length

VAR Lag Order Selection Criteria
Endogenous variables: CREDI ETRADECARD USDTL INT
Exogenous variables: C
Sample: 2017M01 2023M12
Included observations: 77

Lag	LogL	LR	FPE	AIC	SC	HQ
0	355.9510	NA	1.26e-09	-9.141584	-9.019828	-9.092882
1	437.6528	152.7930	**2.29e-10***	**-10.84812***	**-10.23934***	**-10.60462***
2	449.7509	21.36818	2.54e-10	-10.74678	-9.650972	-10.30846
3	466.4928	27.83057*	2.51e-10	-10.76605	-9.183216	-10.13293
4	470.1115	5.639562	3.52e-10	-10.44445	-8.374600	-9.616530
5	475.8626	8.365273	4.72e-10	-10.17825	-7.621371	-9.155520
6	484.6278	11.83867	5.94e-10	-9.990332	-6.946428	-8.772797
7	487.7668	3.913628	8.79e-10	-9.656281	-6.125353	-8.243941

* indicates lag order selected by the criterion
LR: sequential modified LR test statistic (each test at 5% level)
FPE: Final prediction error
AIC: Akaike information criterion
SC: Schwarz information criterion
HQ: Hannan-Quinn information criterion

As seen in Table 9, the lag length has been selected according to the SC criterion. Consequently, the suitable lag model for econometric analysis will be the VAR (1) model.

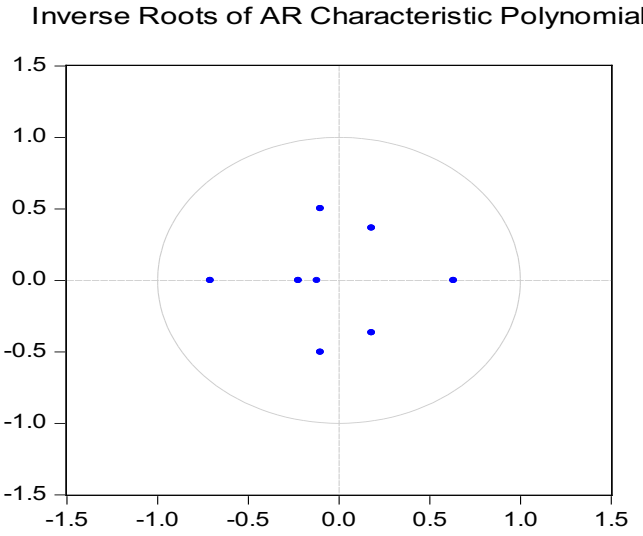

Figure 4. Unit Circle Graph for VAR Stability Condition

The graph indicates that the stability condition is satisfied.

Table 10. Autocorrelation LM Test

VAR Residual Serial Correlation LM Tests
Included observations: 82

Null hypothesis: No serial correlation at lag h

Lag	LRE* stat	df	Prob.	Rao F-stat	df	Prob.
1	24.21759	16	0.0849	1.550983	(16, 202.3)	0.0851
2	26.32943	16	0.0496	1.694934	(16, 202.3)	0.0498
3	17.50941	16	0.3534	1.103243	(16, 202.3)	0.3539

As seen in the table, it is understood that there is no serial autocorrelation in the residuals up to 3 lags (P>0.01). In this context, the null hypothesis cannot be rejected for each of the four lags.

Table 11. White Heteroskedasticity Test

VAR Residual Heteroskedasticity Tests (Levels and Squares)
Sample: 2017M01 2023M12
Included observations: 82
Joint test:

Chi-sq	df	Prob.
202.6923	160	0.0126

According to the results in the table, the null hypothesis of constant variance cannot be rejected. P= 0.0126 > 0.01, hence there is no issue of varying variance in the estimated model.

Table 12. Jarque-Bera test

Component	Jarque-Bera	df	Prob.
2	0.207975	2	0.9012

According to the JB test, the residuals (P > 0.01) conform to a multivariate normal distribution at the 0.01 significance level.

The diagnostic tests conducted indicate that the VAR (1) model constructed satisfies the conditions of stability, absence of serial correlation, constant variance, and normality at the 0.01 significance level.