İktisat Politikası Araştırmaları Dergisi
Journal of Economic Policy Researches
JEPR 2024, 11(1): 20–29
DOI: 10.26650/JEPR1317819

RESEARCH ARTICLE / ARAŞTIRMA MAKALESİ

Determining the Dependency Structure Between Selected Macroeconomic Variables Using the Copula Method

Seçilmiş makroekonomik değişkenler arasındaki bağımlılık yapısının kapula yöntemi ile belirlenmesi

Mervenur Sözen[1], Çağlar Sözen[2], Onur Şeyranlioğlu[3]

ABSTRACT

Macroeconomic variables reflect the overall economic situation of a country over a specific period. These variables reflect a country's expectations and economic activities for the future and have great importance, particularly for a country's development, strategic planning for the future, and international competitiveness. Because macroeconomic variables are assumed to be interrelated, examining the dependency structure among these variables plays a significant role in shaping countries' economic roadmaps. The main objective of this research is to model the dependency structure between selected macroeconomic variables using the copula method. The copula method is widely used in the fields of economics and finance due to its strength in characterizing dependency among variables without requiring any assumptions. This study uses data from the Consumer Price Index (CPI), Producer Price Index (PPI), exchange rate (USD/TRY), and interest rate (real interest) between 2007-2022. The pairwise dependency structures among the CPI, PPI, exchange rate, and interest rate variables have been determined using the most appropriate copula model, and the results are then interpreted. According to the analysis results, the Joe copula model was found to best model the dependency between the paired variables of CPI and PPI, of CPI and exchange rates, of PPI and exchange rates, and of PPI and interest rates. The Gaussian copula was identified as the most suitable model for capturing the dependency between CPI and interest rates, while the Frank copula was determined to best model the dependency between exchange rates and interest rates.

Keywords: copula, PPI, CPI, exchange rate, interest rate

Jel Code: E30, E31, E44

[1]Dr., Ondokuz Mayıs University, Department of Statistics,Samsun, Turkiye
[2]Assist. Prof. Giresun University, Department of Finance and Banking,Giresun. Turkiye
[3]Assist. Prof. Giresun University, Department of Business Administration, Giresun, Turkiye

Sorumlu yazar /
Corresponding author: Çağlar SÖZEN
E-mail / E-posta : caglar.sozen@giresun.edu.tr

Submitted / Başvuru : 21.06.2023
Revision Requested / Revizyon Talebi : 07.11.2023
Last Revision Received / Son Revizyon : 16.11.2023
Accepted / Kabul : 07.12.2023

ÖZ

Makroekonomik değişkenler, belirli bir süre boyunca bir ülkenin genel ekonomik durumunu yansıtmaktadır. Ülkelerin geleceğine ilişkin beklentileri ve ekonomik faaliyetlerini yansıtan bu değişkenler, özellikle bir ülkenin kalkınması, geleceğe dair stratejik planlar yapması ve dolayısıyla uluslararası düzeyde rekabet etmesi için büyük önem taşır. Makroekonomik değişkenler, birbirleri ile ilişkili oldukları varsayıldığından bu değişkenler arasındaki bağımlılık yapısının incelenmesi ülkelerin ekonomik yol haritalarını çizmede önemli rol oynar. Bu araştırmanın temel amacı, makroekonomik değişkenler arasındaki bağımlılık yapısının kapula ile modellenmesidir. Kapula yöntemi, herhangi bir varsayım gerektirmediği ve değişkenler arasındaki bağımlılığı karakterize etmede güçlü bir araç olması sebebiyle ekonomi ve finans alanında kullanımı çok yaygındır. Araştırmada, 2007-2022 yılları arasındaki Tüketici Fiyat Endeksi (TÜFE), Üretici Fiyat Endeksi (ÜFE), döviz Kuru (Dolar/TL) ve faiz oranı (reel faiz) verileri kullanılmıştır. TÜFE, ÜFE, döviz kuru ve faiz oranı değişkenleri arasındaki ikili bağımlılık yapıları, en uygun kopula modeli kullanılarak belirlendi ve elde edilen sonuçlar yorumlandı. Analiz sonuçlarına göre, TÜFE-ÜFE, TÜFE-döviz kurları, ÜFE-döviz kurları ve ÜFE-faiz oranları arasındaki bağımlılığı en iyi modelleyen Joe kapula, TÜFE ile faiz oranları arasındaki bağımlılığı en iyi modelleyen Gaussian kapula ve döviz kurları ile faiz oranları arasındaki bağımlılığı en iyi modelleyen ise Frank kapula olmuştur.

Anahtar Kelimeler: Kapula, ÜFE, TÜFE, Kur, Faiz

Jel Sınıflaması: E30, E31, E44

1. Introduction

Macroeconomic variables play a pivotal role in gauging the overall health, growth, and stability of national economies. These key indicators include the Consumer Price Index (CPI), Producer Price Index (PPI), exchange rate, and interest rate and serve as critical benchmarks closely linked to economic performance (Mishkin & Eakins, 2019). PPI serves as a measure of price changes by assessing the prices of domestically produced and sold goods over a specific timeframe. Its impact extends to company profits and production costs, where elevated PPI values can potentially dampen consumer demand by driving up product and service prices (Woodford & Walsh, 2005). The exchange rate reflects the value of one country's currency relative to another (e.g., US dollar) and plays a crucial role in international trade, investments, and operational costs for exporters and importers. Fluctuations in exchange rates can significantly influence economic relations and contribute to financial stability or volatility between nations (West & Cho, 1994). Interest rates represent the cost of borrowing or the return on lending and hold immense importance in investment decisions and the maintenance of economic equilibrium. Central banks wield interest rates as a tool to regulate economic activity, exerting substantial influence on borrowings, savings, investments, and stock markets (Seyrek & Mızrak, 2009).

Researchers use the copula method to understand the relationships among these variables (i.e., CPI, PPI, exchange rates, interest rates). This statistical approach examines how these variables are dependent on each other by modeling the partner variable's behavior independently of their distribution, thus leading to more accurate predictions. The copula method is particularly useful in finance for risk management and for optimizing investment portfolios. Using this method, one can increase the precision in modeling and estimating the interrelationships among such macroeconomic variables as CPI, PPI, exchange rates, and interest rates. For example, CPI and PPI as indicators of inflation may have a certain degree of correlation that the copula method can capture and measure more accurately (Nelsen, 2007).

Exchange rate and interest rate may also be related, because changes in interest rates often cause changes in exchange rates. These relationships may not be linear, and thus the copula method allows for modeling complex relationships among variables. Furthermore, the copula method can serves as a guide for understanding how these variables behave when they occur together.

This study determines the pairwise dependency structures between the annual frequency dataset and the variables of CPI, PPI, exchange rate, and interest rate for the 2007-2022 period using copula models that do not require any assumptions, as these are powerful tools for characterizing variable interdependencies. The study interprets the results obtained between variables from an economic perspective.

The second part of the study continues by presenting research summaries utilizing copula methods with economic and financial data, followed by a detailed explanation of the materials and the methodology section. The presentation of empirical findings is then carried out, concluding with a section on the research results.

2. Literature Review

Numerous studies are found in the literature to have employed copula methodology. Table 1 summarizes some of the research that has been conducted using copula methodology in fields related to finance and economics.

Table 1. Literature Review

Research	Variables	Method	Findings
Jowaheer and Ameerudden (2012)	American Dollar (USD), Indian Rupee (INR), and Mauritian Rupee (MUR).	t copula	The series exhibits an asymmetrical and fat-tailed nature, adhering to the hyperbolic distribution. The relationship between them is best represented by t copula, effectively capturing their dependence structure
Gülöksüz (2015)	The Consumer Price Index (CPI) and the exchange rate of the US Dollar against the Turkish Lira (USD/TRY).	Archimedean copula	According to the findings, the two-dimensional Archimedean copula function modeling the dependence structure between the Consumer Price Index (CPI) and the exchange rate of the US Dollar against the Turkish Lira (USD/TRY) has been estimated as Gumbel copula (θ=100). It is observed that the variables tend to increase together.
Büyükyılmaz (2016)	Producer Price Index (PPI) and Consumer Price Index (CPI).	Archimedean copula	The Gumbel-Hougaard copula family has been shown to better model the dependence between the Producer Price Index (PPI) and the Consumer Price Index (CPI).
Karakas and Doğan (2017)	The exchange rate of the US Dollar against the Turkish Lira (USD/TRY) and the deposit interest rate.	Joe Copula	There is a positive relationship between the exchange rate of the US Dollar and the deposit interest rate.
Eren and Erek (2020)	US 10-Year Bond Yield, Spot Gold, US Dollar, US Dollar Index, S&P 500, FTSE 100, NIKKEI 225 closing prices and Bitcoin.	Copula-Garch Approach	The analysis results indicate that there is not a strong mutual dependence between Bitcoin and leading financial indicators.
Karakaş et al. (2020)	Closing prices of Bitcoin, Bitcoin Cash, Ethereum, Litecoin and IOTA financial indicators.	CD Vine Copula Approach	D-vine copula is the most appropriate choice for modeling the dependence structure between indicators of cryptocurrencies.
Farnoudkıa and Purutçuoğlu (2020)	All sectors of Istanbul Stock Market (ISM).	R-Vine Copula	The sectoral relationship between construction and other sectors has been determined
Ünal (2020)	The Borsa Istanbul Electricity Company Stock Index and the exchange rate of the US Dollar against the Turkish Lira (USD/TRY).	Frank, Clayton, Gumbel copula	According to the calculations, the most suitable modeling based on the Mean Squared Error (MSE) is the Clayton copula. However, based on the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC), the Gumbel copula is determined to be the most appropriate.
Özgür and Sarıkovanlık (2021)	The 12 stocks traded on BIST 30.	R-Vine Copula	According to Expected Shortfall (ES) backtests, it has been found that R-vine copula GARCH demonstrates better performance in producing more accurate ES predictions.
Çelik (2022)	BIST 100 and USD/TRY.	t copula	The analysis results indicate that the model that best fits the data is determined to be the t-copula.
Yıldırım Külekci et al. (2023)	Shares of the banking sector traded on BIST 100.	Time Series and R-Vine Copula	When GARCH and R-Vine are jointly applied, findings suggest an improvement in Value at Risk (VaR) and expected ES risk measure predictions compared to traditional GARCH-based approaches.

Upon reviewing the literature presented in Table 1, the relationships between macroeconomic variables have evidently been studied in a much more limited manner using copula methods. Macroeconomic indicators that reflect a country's overall economic situation over a specific period shape future expectations and economic activities and preferences based on these indicators. Considering the significance macroeconomic indicators have for a country, the primary motivation behind writing this research is the absence of studies in the literature that have comprehensively examined the variables of inflation, exchange rate, and interest rate through various copula methods.

3. Material and Methodology

Copulas are modeling tools used to understand the relationship between variables. To comprehend this dependency structure, a function is employed to describe the relationships between variables. Copulas represent these functions. Essentially, copulas have marginal distributions that are uniformly distributed over the range [0,1] for each variable individually. However, copulas link these univariate marginals to obtain multivariate distributions. In other words, copula functions are used to obtain multivariate distributions that reflect the dependency structure between variables. The main objective of copula functions is to obtain the most suitable multivariate distribution that fits the observed data. This distribution should accurately model the relationships and dependency structure between variables (Alhan, 2008). Consequently, one can better understand the characteristics of the data and the relationships between variables.

3.1. Two-Dimensional Copula

A two-dimensional copula, defined for I=[0,1], is described as follows:

$$C : I^2 \rightarrow I$$

$$(u, v) \rightarrow C(u, v)$$

$$C(u, 0) = C(0, v) = 0 \text{ for } \forall u, v \in I$$

$$C(u, 1) = u \text{ and } C(1, v) = v \text{ for } \forall u, v \in I$$

For $u_1, u_2, v_1, v_2 \in I$, if $u_1 \leq u_2$ and $v_1 \leq v_2$, then the following inequality hold:

$$C(u_2, v_2) - C(u_2, v_1) - C(u_1, v_2) + C(u_1, v_1) \geq 0 \quad (1)$$

The function C(u,v) that satisfies these conditions is a two-dimensional copula function (Nelsen, 2006) and represents the two-dimensional distribution of C(u,v). The value of the function depends on the marginal values of the point (u,v) and enables the accurate modeling of these marginal values. Moreover, the conditions of the function express the dependency structure between variables and require that this dependency follows a certain ordering and relationship.

3.1.1. Joe Copula

Joe copula is an Archimedean copula. The copula function of Joe copula, parametrized by θ, is expressed as follows:

$$c(u, v) = 1 - \left[(1-u)^{\theta} + (1-v)^{\theta} - (1-u)^{\theta}(1-v)^{\theta}\right]^{\frac{1}{\theta}}, 1 \leq \theta < \infty \quad (2)$$

In particular, as $\theta \rightarrow 1^+$, the Joe copula function converges to the product copula function $C(u, v) = \pi(u, v) = uv$. This indicates that as the θ parameter approaches 1, the Joe copula function approaches the independence copula function $\pi(u, v)$, implying that the variables u and v are independent (Evkaya et al., 2018).

The Joe copula exhibits right-tail dependence. This means that the *C(u,v)* function increases more rapidly as either the u or v variable increases. In other words, the relationship between the variables has a right-skewed distribution.

3.1.2. Gaussian Copula

The Gaussian copula is an elliptical copula. The copula function of the Gaussian copula, along with the θ dependence parameter, is expressed as follows:

$$C(u,v) = \Phi_G(\Phi^{-1}(u), \Phi^{-1}(v); \theta) = \int_{-\infty}^{\Phi^{-1}(u)} \int_{-\infty}^{\Phi^{-1}(v)} \frac{1}{2\pi\sqrt{1-\theta^2}} * \left(\frac{-(s^2 - 2\theta st + t^2}{2(1-\theta^2)} \right) dsdt \quad (3)$$

where ϕ represents the standard normal distribution function, and $\phi_G(u,v)$ represents the bivariate standard normal distribution function. This expression models the dependence structure and relationship between the variables in the Gaussian copula. The Gaussian copula function is represented by the θ dependence parameter, which corresponds to the Pearson correlation measure and is constrained to the range [-1, 1]. The θ parameter indicates the strength of the relationship between variables. As $\theta \to 0$, this corresponds to the independence copula, where the variables become independent. The Gaussian copula is a flexible model as it allows for both positive and negative dependencies to the same extent, capturing the nature of the relationship between variables in a flexible manner. The elliptical structure of the copula allows for accommodating various distribution shapes of the data (Trivedi & Zimmer, 2007).

3.1.3. Frank Copula

Frank copula is known as an Archimedean copula and is a copula function that can be expressed with the θ dependence parameter as follows:

$$C(u,v) = -\frac{1}{\theta} ln \left[1 + \frac{(e^{-\theta u} - 1)(e^{-\theta v} - 1)}{e^{-\theta} - 1} \right], \theta \in R - \{0\} \quad (4)$$

The θ parameter controls the shape and strength of the Frank copula function. Specifically, as $\theta \to 0$, the Frank copula function converges to the independence copula, $C(u,v) = \pi(u,v) = uv$. In this case, the variables u and v become independent. The Frank copula has a wide parameter space and can also model negative dependence between margins. This copula function is used to model observations with a strong negative or positive dependence (Meester & Mackay, 1994).

4. Findings and Discussion

This study uses the CPI, PPI, exchange rate, and interest rate data published by the Turkish Statistical Institute (TUIK, 2022) between 2007-2022. Table 2 presents descriptive statistics for the following variables:

- The CPI variable indicates a significant fluctuation in consumer prices when evaluating the mean and standard deviation. Additionally, positive kurtosis and positive skewness values suggest that consumer prices tend to deviate from the mean and exhibit a right-skewed distribution.
- The PPI variable has a high standard deviation and positive skewness, thus signifying a noticeable deviation from the mean in producer prices and indicating a right-skewed distribution. This implies fluctuations in prices within the producer sector.
- The exchange rate variable is characterized by a high standard deviation and positive skewness. It tends to deviate from the mean and exhibits a right-skewed distribution.
- The interest rate variable displays a relatively stable outlook compared to the other variables. However, the positive skewness value indicates that interest rates have a right-skewed distribution.

Table 2. Descriptive Statistics

	CPI	PPI	Exchange rate	Interest rate
Mean	14.99	20.77	4.71	9.66
Standart Deviation	15.09	27.8	5.02	5.53
Kurtosis	8.05	4.08	5	0.30
Skewness	2.78	2.22	2.23	0.75

CPI, PPI, exchange rates, and interest rates are considered random variables, and the optimal copula model has been identified for capturing the pairwise dependence structures among these variables. The parameters characterizing the dependence structure have been obtained using the maximum likelihood method, which is a parametric approach. These parameters play a significant role in determining dependence structures. Meanwhile, copula models are functions that define probability distributions. The most suitable copula model has been determined from among the obtained models by examining the Akaike information criterion (AIC) and Bayesian information criterion (BIC) values. The copula model with the minimum AIC or BIC value represents the best model for capturing the dependence between two variables.

The study examines the pairwise dependence structures between the variables of CPI and PPI, of CPI and exchange rates, of CPI and interest rates, of PPI and exchange rates, of PPI and interest rates, and of exchange rates and interest rates. Table 2 shows the AIC and BIC values that were obtained for the copula models. The pairwise dependence structures between variables have been determined based on the minimum AIC and BIC values. Table 3 presents the selected optimal copula models for the variables and their respective parameter values.

With a parameter value of 5.8, the Joe copula model best captures the dependence between the CPI and PPI variables, between which a strong right-tail dependence is found. This means that the CPI and PPI variables are more likely to increase than decrease together. In other words, when CPI increases, PPI also tends to increase.

With a parameter value of 3.82, the Joe copula model stands out again as the most effective model for capturing the relationship between CPI and exchange rates. While the dependency between CPI and exchange rates may not be as pronounced as the one between CPI and PPI, a notable right-tail dependence is still found to be present. In other words, when CPI experiences an upward trend, exchange rates also tend to increase.

With a parameter value of 0.75, the Gaussian copula model best captures the dependence between CPI and interest rates. This result indicates a strong positive dependence between CPI and interest rates. In other words, when CPI increases, interest rates also tend to increase, and when CPI decreases, interest rates also tend to decrease.

With a parameter value of 3.06, the Joe copula model is the best model for capturing the dependence between PPI and exchange rates. Although not as strong as the CPI-exchange rate dependence, a right-tail dependence is also found between PPI and exchange rates. One can say that when PPI increases, exchange rates also tend to increase. Namely, PPI and exchange rates are more inclined to increase together.

With a parameter value of 1.72, the Joe copula model is also the best model for capturing the dependence between PPI and interest rates. The PPI-interest rate variables exhibit right-tail dependence. However, the relationship is weaker compared to the dependence between CPI-PPI, between CPI-exchange rates, and between PPI-exchange rates. Namely, when PPI increases, interest rates also tend to increase, and PPI and interest rates are more inclined to increase together.

With a parameter value of 2.74, the Frank copula model best captures the dependence between exchange rates and interest rates. A moderate level of positive dependence exists between exchange rates and interest rates.

Figure 1 illustrates the dependence structures between the variables of CPI and PPI, of CPI and exchange rates, of CPI and interest rates, of PPI and exchange rates, of PPI and interest rates, and of exchange rates and interest rates. The economic variables can be observed to tend to move together, indicating a tendency for joint movement. CPI and PPI generally exhibit a strong mutual correlation, indicating that changes in consumer prices are often associated with changes in producer prices. This relationship can be attributed to factors such as raw material costs, production expenses, and overall market dynamics. A strong dependency exists between CPI and exchange rates. Fluctuations in consumer prices impact currency values; conversely, changes in exchange rates also affect the cost of imported goods, subsequently influencing CPI. Understanding the relationship between CPI and interest rates is critical for comprehending the impact monetary policy has on inflation. Central banks often adjust interest rates to control inflation, thus revealing the complex interplay between CPI and interest rates.

A relationship has been observed to occur between PPI and exchange rates, reflecting how changes in production costs and the value of a currency can affect each other. This connection is associated with the dynamics of international trade and production expenses. Understanding the relationship between PPI and interest rates is crucial, as interest rates affect borrowing costs and, consequently, production expenses. The interaction between exchange rates and interest rates is a fundamental aspect of the global economy. Discrepancies in interest rates influence capital flows and can impact currency values, while in turn, exchange rate movements affect export and import dynamics and interest rate expectations.

Table 3. The AIC and BIC values of Copula Models

Variables	Copula	AIC	BIC
CPI-PPI	Gaussian	-14.8	-14.1
	Student's t	-18.3	-16.88
	Clayton	-10.28	-9.57
	Gumbel	-19.83	-19.13
	Frank	-13.12	-12.41
	Joe	**-22.46**	**-21.76**
CPI-exchange rates	Gaussian	-10.26	-9.55
	Student's t	-8.14	-6.73
	Clayton	-3.83	-3.13
	Gumbel	-12.68	-11.97
	Frank	-9.4	-8.69
	Joe	**-14.92**	**-14.21**
CPI-interest rates	**Gaussian**	**-7.19**	**-6.48**
	Student's t	-5.12	-3.7
	Clayton	-6.61	-5.9
	Gumbel	-5.89	-5.18
	Frank	-6.26	-5.56
	Joe	-4.05	-3.35
PPI-exchange rates	Gaussian	-6.74	-6.03
	Student's t	-4.59	-3.18
	Clayton	-2.25	-1.54
	Gumbel	-8.39	-7.68
	Frank	-5.31	-4.6
	Joe	**-10.02**	**-9.31**
PPI-interest rates	Gaussian	-0.36	0.35
	Student's t	1.72	3.14
	Clayton	0.88	1.58
	Gumbel	-0.64	0.06
	Frank	0.16	0.86
	Joe	**-0.96**	**-0.26**
Exchange rates-interest rates	Gaussian	0.56	1.27
	Student's t	1.72	3.13
	Clayton	1.05	1.75
	Gumbel	0.06	0.77
	Frank	**-0.04**	**0.67**
	Joe	0.08	0.79

Table 4. The most suitable copula models and parameter values of the variables

Variables	**Copula**	**par1**	**par2**	**Tau**
CPI-PPI	Joe	5.8	0	0.71
CPI- exchange rates	Joe	3.82	0	0.60
CPI- interest rates	Gaussian	0.75	0	0.54
PPI- exchange rates	Joe	3.06	0	0.52
PPI-interest rates	Joe	1.72	0	0.29
Exchange rates- interest rates	Frank	2.74	0	0.28

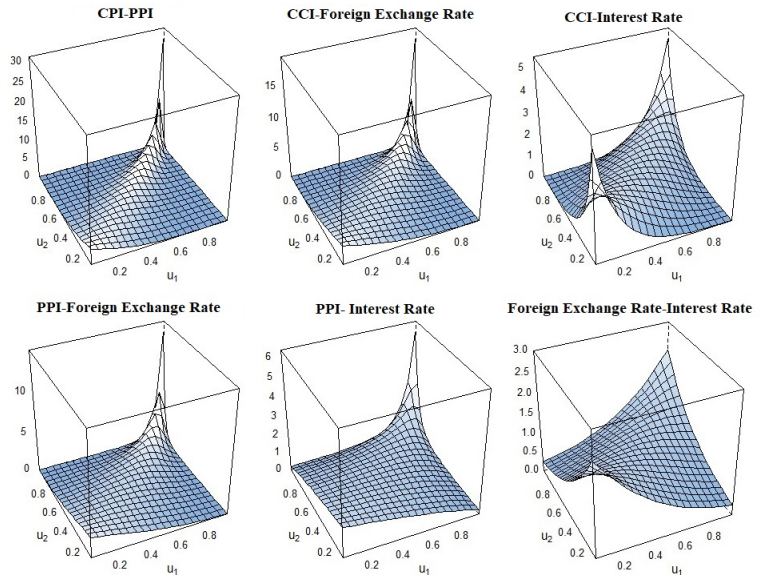

Figure 1. Dependency Structures Between Variables

Figure 2 presents the correlations between the pairs of economic variables. Upon examining Figure 2:

- A high positive correlation is observed between CPI and PPI (p=0.79), indicating that CPI and PPI tend to change similarly and are closely dependent on each other.
- A high positive correlation also exists between exchange rates and CPI (p=0.76), indicating that when the value of the Turkish lira decreases, the cost of imported goods increases, leading to an increase in CPI.
- The correlation between PPI and exchange rate is lower than the correlation between CPI and exchange rate (p=0.64), indicating that PPI is less associated with exchange rates compared to CPI.
- A moderate positive correlation is found between interest rates and CPI (p=0.66). This suggests that CPI tends to decrease alongside a rise in interest rates rise and increase in credit interest, which result in a decrease in consumer spending. The correlation between interest rates and exchange rates is low (p=0.34), indicating that interest rates have a limited influence on exchange rates and that other factors have a larger impact on exchange rate fluctuations.

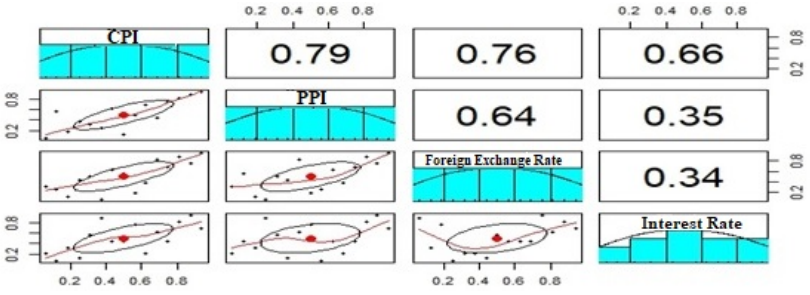

Figure 2. Correlation Between Selected Economic Variables

5. Conclusions

The main purpose of this research is to investigate the interrelationships between key macroeconomic variables, especially CPI, PPI, exchange rates, and interest rates in Türkiye. These variables have crucial importance in determining price levels within the country, and analyzing dependency patterns is crucial for a comprehensive understanding of the overall economic situation. In addition, the study includes other important economic factors that have a significant impact on price levels, such as exchange rates and interest rates.

The copula method has been used to model the relationship between these variables. Unlike traditional approaches

that assume the data to be normally distributed, the copula method offers a more realistic and flexible framework. The study uses the copula method and CPI, PPI, exchange rates, and interest rate data to examine the dependency structures of economic variables. The selection of the most suitable copula model has been based on the minimization of the AIC and BIC values.

The analysis reveals the Joe copula model to be the most suitable one for capturing the dependence between the variable pairs of CPI and PPI, of CPI and exchange rates, of PPI and exchange rates, and of PPI and interest rates with respective parameter values of 5.8, 3.82, 3.06, and 1.72. These findings suggest that there is a right-tailed dependency among the variables, indicating tendencies to act together.

Similarly, the Gaussian copula model with a parameter value of 0.75 was determined as the most suitable model for capturing the dependence between CPI and interest rates. This implies a relationship characterized by a Gaussian distribution. This result indicates a strong positive relationship between CPI and interest rates. In other words, CPI and interest rates tend to move together. The Frank copula model revealed the best dependence between exchange rates and interest rates with a parameter value of 2.74, indicating a moderately positive dependence between these variables. Therefore, exchange rates and interest rates are related and tend to move together.

A high positive correlation and a strong relationship are found between CPI and PPI. This shows that a strong link to exist between the prices consumers pay and the costs producers incur. A high positive correlation and a strong relationship are found between CPI and exchange rates. This shows that changes in exchange rates have a significant effect on consumer prices. The moderate relationship between CPI and interest rates indicates that changes in interest rates have a moderate effect on consumer prices. A moderate positive correlation and relationship exist between PPI and exchange rates, while the relationship between PPI and interest rates is weak. This shows a moderate relationship to be present between producer costs and exchange rates, whereas interest rates have a minimal effect on producer costs. A very weak positive correlation and relationship have been found between exchange rates and interest rates, indicating a minimal relationship between these two variables. The primary reason for this situation is that market participants expect a specific change in interest rates, and the failure to meet this expectation indicates a weak relationship between the two variables.

This study is an important step in analyzing the dependency structures between the variables that determine price levels in Türkiye and in modeling this structure more accurately using the copula method. Moreover, given the applicability the copula method has toward other variables, this study can serve as a valuable reference for economic research. The findings of this study can be used in various fields such as economic policy planning and future price level forecasting.

The accurate modeling and prediction of future values for macroeconomic indicators or the relationships between these indicators in a country has great importance in shaping expectations and economic activities. These indicators are closely monitored not only by domestic stakeholders but also by external market players and provide insights into a country's economic stability. The results presented in this research are considered to be particularly valuable as an guide for helping policymakers understand the level of relationships between macroeconomic indicators compared to econometric models. This study can serve as an example for advanced research aimed at determining relationships between paired macroeconomic indicators, and the results can be compared with other research conducted using econometric models.

Hakem Değerlendirmesi: Dış bağımsız.

Yazar Katkıları: Çalışma Konsepti/Tasarım- M.S., Ç.S.; Veri Toplama- M.S., Ç.Ş., O.Ş.; Veri Analizi/Yorumlama- M.S., Ç.Ş.; Yazı Taslağı- M.S., Ç.Ş. ; İçeriğin Eleştirel İncelemesi- M.S., Ç.Ş., O.Ş.; Son Onay ve Sorumluluk- M.S., Ç.Ş., O.Ş.

Çıkar Çatışması: Yazarlar çıkar çatışması beyan etmemişlerdir.

Finansal Destek: Yazarlar finansal destek beyan etmemişlerdir.

Peer Review: Externally peer-reviewed.

Author Contributions: Conception/Design of Study- M.S., Ç.Ş.; Data Acquisition- M.S., Ç.Ş., O.Ş.; Data Analysis/Interpretation- M.S., Ç.Ş.; Drafting Manuscript- M.S., Ç.Ş.; Critical Revision of Manuscript- M.S., Ç.Ş., O.Ş. ; Final Approval and Accountability- M.S., Ç.Ş., O.Ş.

Conflict of Interest: Authors declared no conflict of interest.

Financial Disclosure: Authors declared no financial support.

ORCID:

Mervenur Sözen 0000-0001-5603-5382
Çağlar Sözen 0000-0002-3732-5058
Onur Şeyranlioğlu 0000-0002-1105-4034

REFERENCES / KAYNAKLAR

Alhan, A. (2008). Bağımsızlık kapulasını içeren kapula aileleri, kapula tahmin yöntemleri ve İstanbul Menkul Kıymetler Borsasında sektörler arası bağımlılık yapısı. Doktora Tezi, Gazi Üniversitesi Fen Bilimleri Enstitüsü İstatistik Anabilim Dalı, 162, Ankara.

Büyükyılmaz, A. (2016). Some Archimedean Copulas On Producer Price Index And Consumer Price Index: A Case Of Turkey. Mehmet Akif Ersoy Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 1(13), 206-215.

Çelik, S. Copula ile Portföy Riskinin Hesaplanması: BİST100 ve USD Kuru Üzerine Bir Uygulama.

Eren, B. S., and Erek, M. (2020). The Interdependence of Bitcoin and Financial Markets: A Copula-Garch Approach. Liberal Düşünce Dergisi, 25 (98), 35-63. DOI: 10.36484/liberal.662625

Evkaya, O. O., Yozgatligil, C., and Selcuk-Kestel, A. S. (2018). Measuring Dependence between Electricity Consumption and Contributing Indicators via Copulas: Turkish Case. *Gazi University Journal of Science, 31*(4), 1284-1296.

Farnoudkıa, H., and Purutçuoğlu, V. (2020). Application of r-vine copula method in Istanbul stock market data: A case study for the construction sector. Journal of Turkish Operations Management,4(2),509-518.

Gülöksüz, Ç. T. (2015). Dolar kuru ile tüketici fiyat endeksi arasındaki ilişkinin Archimedean Kapula ile modellenmesi. *Bankacılık ve Sigortacılık Araştırmaları Dergisi, 2*(7), 53-62.

Jowaheer, V., and Ameerudden, N. Z. B. (2012). Modelling the Dependence Structure of MUR/USD and MUR/INR Exchange Rates using Copula. International Journal of Economics and Financial Issues, 2 (1), 27-32.

Karakas, A., and Doğan, M. (2017). With Copula function analysis of structure dependence relation between Exchange rate of dollars and Deposit rate of Turkey. Natural Science and Discovery, 3 (1), 1-12. DOI: 10.20863/nsd.297636.

Karakaş, A., Demir, A., and Çalik, S. (2020). Interdependence of Bitcoin and Other Crypto Money Indicators: CD Vine Copula Approach, *Bitlis Eren Üniversitesi Fen Bilimleri Dergisi*, c. 9, sayı. 4, ss. 1527-1536.

Meester S. G., and Mackay, J. (1994). A parametric model for cluster correlated categorical data. Biometrics 954-963.

Mishkin, F. S., and Eakins, S. G. (2019). Financial markets. Pearson Italia.

Nelsen, R. B. (2006). Archimedean copulas. *An introduction to copulas*, 109-155.

Nelsen, R. B. (2007). *An introduction to copulas*. Springer science & business media.

Ozgur, C., and Sarikovanlik, V. (2021). An application of Regular Vine copula in portfolio risk forecasting: evidence from Istanbul stock exchange. *Quantitative Finance and Economics, 5*(3), 452-471.

Seyrek, İ., and Mızırak, Z. (2009). Faiz teorileri üzerine bir inceleme: Finansal istikrarsızlık hipotezinin temel dayanağı. Selçuk Üniversitesi Sosyal Bilimler Enstitüsü Dergisi, 22, 383-394.

Trivedi P., and Zimmer D. (2007). Copula modeling: An introduction for practitioners. Foundations and Trends in Econometrics 1(1): 1-111.

TUİK, Türkiye İstatistik Kurumu. Tüketici Fiyat Endeksi, Üretici Fiyat Endeksi, Döviz Kuru, Faiz oranı (10 Mayıs 2022). https://tuik.gov.tr

Ünal, T. (2022). Modelıng the dependence structure of financial data with A copula: Electricity index – an example of the dollar exchange rate. AYBU Business Journal, 2 (1),35-45.

West, K. D., and Cho (1994). The predictive ability of several models of exchange rate volatility. Journal of Econometrics, 69, 367-391.

Woodford, M., and Walsh, C. E. (2005). Interest and prices: Foundations of a theory of monetary policy. *Macroeconomic Dynamics, 9*(3), 462-468.

Yıldırım Külekci, B., Poyraz, G., Gür, İ. And Evkaya, O. (2023). BIST100 Bankacılık Sektöründeki Bağımlılığın Asma Kopula ile İncelenmesi . İstanbul İktisat Dergisi , 73 (1) , 55-82 . DOI: 10.26650/ISTJECON2022-1229039

How cite this article / Atıf biçinmi

Sözen, M., Sözen, Ç., Şeyranlioğlu, O. (2024). Determining the dependency structure between selected macroeconomic variables using the copula method. *İktisat Politikası Araştırmaları Dergisi - Journal of Economic Policy Researches, 11*(1), 20–29. https://doi.org/10.26650/JEPR1317819