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THE RELATIONSHIP BETWEEN USD/TL EXCHANGE RATE FLUCTUATIONS AND PETKIM STOCK PRICES: AN ECONOMETRIC ANALYSIS

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Astract. The paper investigates the long-term relationship between the stock price of Turkey's leading petrochemical company Petkim and the USD/TL exchange rate. To analyze the data, methods such as Granger causality, Johansen's cointegration test and the Vector Error Correction Model (VECM) were employed.

Keywords: Stock price, exchange rates, Granger casuality, cointegration.

USD/TL MƏZƏNNƏLƏRİNİN DƏYİŞMƏLƏRİ İLƏ PETKİM SƏHM QİYMƏTLƏRİ ARASINDA ƏLAQƏLƏR: EKONOMETRİK ANALİZ

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Xülasə. Məqalədə Türkiyənin aparıcı neft-kimya şirkəti olan Petkim səhmlərinin qiyməti ilə USD/TL məzənnəsi arasında uzunmüddətli əlaqə araşdırılır. Məlumatları təhlil etmək üçün Qrancer səbəbliliyi, Yohansenin kointeqrasiya testi və vektor xətalarının korreksiyası modeli (VECM) kimi üsullardan istifadə edilmişdir.
Açar sözlər: Səhm qiyməti, valyuta məzənnələri, Granger səbəbiyyət, kointeqrasiya.

СВЯЗЬ МЕЖДУ КОЛЕБАНИЯМИ ОБМЕННОГО КУРСА USD/TL И ЦЕНОЙ АКЦИЙ PETKIM: ЭКОНОМЕТРИЧЕСКИЙ АНАЛИЗ

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Резюме. В статье исследуется долгосрочная связь между ценой акций Petkim, ведущей нефтехимической компании Турции, и обменным курсом USD/TL. Для анализа данных использовались такие методы, как причинность по Грейнджеру, тест на коинтеграцию Йохансена и модель коррекции векторных ошибок (VECM).
Ключевые слова: Цена акций, обменные курсы, случайность по Грейнджеру, коинтеграция.

1. Introduction

The relationship between fluctuations in the USD/TL exchange rate and the volatility of Petkim's stock prices holds significant importance for economic analysis. This connection directly influences the overall state of the economy, the efficiency of financial markets and the stability of financial markets in Turkey. Similarly, the volatility of Petkim's stock prices impacts investor confidence, which, in turn, has broader implications for financial markets and the economy as a whole. Since 2021, the Turkish lira has faced substantial volatility due to a variety of economic, political and external factors. This period has been marked by numerous events that have shaped the currency's trajectory, reflecting the complex interplay between domestic policy and global economic conditions.

In 2021, Turkey's monetary policy played a critical role in the depreciation of the lira. Under the influence of President Erdoğan, the Central Bank of Turkey pursued an

unconventional monetary policy, lowering interest rates despite rising inflation. This approach, based on Erdoğan's belief that high interest rates cause inflation, undermined investor confidence and led to a significant devaluation of the lira. Inflation surged throughout the year, with official rates reaching around 20%, while independent estimates suggested even higher figures. The CBRT's interventions in the currency market aimed at stabilizing the lira had limited success. Additionally, the depletion of foreign exchange reserves further weakened the currency's stability.

The geopolitical landscape in 2022, particularly the Russia-Ukraine conflict, had widespread effects on emerging markets, including Turkey. The conflict drove up energy prices and disrupted supply chains, exacerbating economic pressures on the Turkish lira. Despite these challenges, the CBRT maintained its low-interest-rate policy, which, coupled with high inflation, continued to fuel the lira's depreciation. Government measures such as the conversion of foreign currency deposits into lira deposits and the compulsory conversion of export revenues provided only temporary relief.

In February 2023, Turkey was hit by a series of devastating earthquakes, compounding the country's financial strain. The earthquakes, with magnitudes of 7.8 and 7.5, were followed by thousands of aftershocks and another 6.7-magnitude earthquake on February 20. Official statistics report over 50,000 deaths, 107,000 injuries, damage to or destruction of 1.9 million residential buildings and the displacement of 3.3 million people, two million of whom are in need of shelter. The recovery and reconstruction needs from these earthquakes have been estimated at approximately $81.5 billion, according to assessments conducted by the Turkish government with support from the EU, the United Nations (UN) and the World Bank Group. This disaster has added significant pressure to Turkey's financial resources.

Despite these challenges, Turkey's economy grew by 4.5% in 2023. However, high inflation persisted due to supply chain issues and increased demand following the pandemic. After the May 2023 elections, a new economic team initiated comprehensive policies aimed at addressing macroeconomic imbalances and curbing high inflation.

2. Analysis of recent publications

In [1] an ECM model (error correction model) of the relationship between the trade turnover of Azerbaijan with Ukraine per capita of Azerbaijan and GDP of these countries in per capita aspect for the period 1994-2022 was constructed, the last indicators of which reflect the level of activity and standard of living in these countries. The article used econometric methodology of gravitational modeling of relationship between non-stationary time series. Various methods including the augmented Dickey-Fuller unit root test, Granger causality test, Engle-Johansen cointegration tests, vector error correction model was correctly used in modeling. The existence of one statistically significant cointegration relationship of the equilibrium long-run relationship between the analyzed indicators was substantiated.

In [2] article, the integration processes between Azerbaijan, Ukraine and Georgia were considered through the indicators of integratedness of Azerbaijan's GDP and the trade turnover of this country with the other two. All the time series considered were non-stationary. Therefore, the construction of a model of correlation-regression analysis led to the obtainment of shifted estimates of the coefficients. So, there were problems of correct modeling of the corresponding time series, the components of which led to a deviation from stationarity. The publication used an econometric integration methodology for modeling the relationship between the non-stationary time series [3]. Scrutinized the prerequisites for the manifestation of cointegration associations amid the fluctuations in the AZN/TL and USD/TL exchange rates during the initial half of 2023, under the circumstances characterized by the precipitous depreciation of the Turkish lira. The study employed contemporary econometric methodologies, encompassing the Johansen cointegration test, Granger causality test, vector error correction and other pertinent approaches. The research dynamically scrutinized the underlying causes of the Turkish lira's devaluation, its impact on the economy of the Republic of Azerbaijan and its influence on the AZN/TL exchange rate.

Paper of [5] examined the validity of Purchasing Power Parity between Jordan and its major trading partners namely, Turkey, Qatar, Iraq, United Arab Emirates and Saudi Arabia. Unit root tests, Johansen cointegration test were employed to test the data covering the period of 2000Q1-2020Q4. The unit root tests demonstrated that all variables were integrated of order one. In [7] study on the basis of real indicators covering the period from 01.01.2013 to 10.01.2017, an econometric analysis of changes in the USD/AZN rate was conducted. As the USD/AZN rate found the relationship inter dependence with their endogenous variability were gained by carrying out empirical analysis.

The study employed modern econometric methodologies, including the Johansen cointegration test, Granger causality test, vector error correction and other relevant approaches. In this article, the mathematical model of the financial market in continuous time with models of stochastic moving technical dynamic systems was constructed, where the coordinates of this vector were established from the vector-matrix differential equation of the state vector of the financial market [8]. The unit root tests demonstrated that all variables are integrated of order one. The results of cointegration tests showed that there exists a cointegrating relationship between exchange rate, domestic and foreign price levels for the selected countries does have a cointegration relationship.

Statistical analysis methods necessary for constructing double regression models (variance analysis, correlation-regression analysis, statistical assumptions in data analysis) for theoretical analysis of forecast indicators [4], error variance decomposition and modeling calculations, as well as two-dimensional vector autoregression models and cointegration in these models, approaches to modern economic and mathematical modeling [9; 10], EXCEL software packages [11] and Eviews-12 software package [6] were used.

3. The purpose of the study

The research paper examines an econometric analysis of the relationship between Petkim stock prices and USD/Tl exchange rate movements using monthly statistics from January 1, 2021 to July 1, 2023 [12; 13].

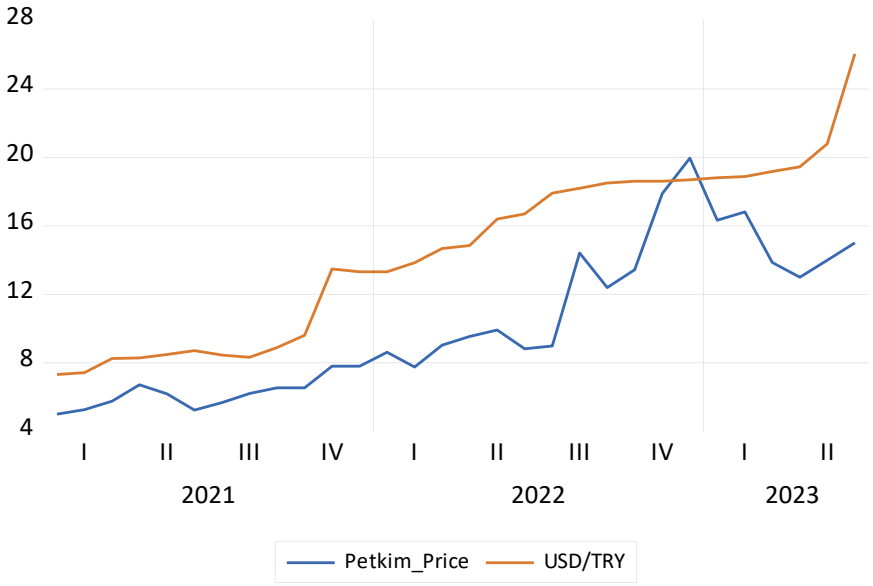

Figure 1. Dynamics of USD/TL and Petkim share prices

Table 1. Descriptive statistics

Date: 09/09/24 Time: 14:34			
Sample: 2021M01 2023M06			
Date: 09/09/24 Time: 14:34			
	PETKIM_PRICE	USD/TL	RESIDS
Mean	10.14800	14.46859	1.529101
Median	8.900000	14.76280	0.838340
Maximum	19.96000	26.05110	6.728130
Minimum	5.000000	7.314900	0.067600
Std. Dev.	4.317712	5.058806	1.602966
Skewness	0.635185	0.070081	1.537431
Kurtosis	2.209435	2.052428	5.008280
Jarque-Bera	2.798544	1.146923	16.85995
Probability	0.246777	0.563571	0.000218
Sum	304.4400	434.0578	45.87304
Sum Sq. Dev.	540.6365	742.1539	74.51550
Observations	30	30	30

The kurtosis for PETKIM prices is 2.209 and for USD/TL it is 2.052, indicating that these variables are relatively close to a normal distribution. However, the residuals have a kurtosis of 5.008, suggesting heavier tails and more extreme deviations from the mean.

The Jarque-Bera test results for PETKIM prices (2.798) and USD/TL (1.147) indicate that these variables exhibit normal distribution characteristics, with associated p-values of 0.247 and 0.564, respectively. On the other hand, the Jarque-Bera statistic for the residuals is 16.860, with a p-value of 0.000, signifying that the residuals deviate significantly from a normal distribution.

Table 2. Linear multivariate regression

Dependent Variable: PETKIM_PRICE				
Method: Least Squares				
Date: 09/09/24 Time: 14:22				
Sample: 2021M01 2023M06				
Included observations: 30				
Variable	Coefficient	Std. Error	t-Statistic	Prob.
USD/TL	0.586506	0.090235	6.499778	0.0000
RESIDS	0.807196	0.284772	2.834536	0.0086
C	0.427805	1.179785	0.362612	0.7197
R-squared	0.793790	Mean dependent var		10.14800
Adjusted R-squared	0.778515	S.D. dependent var		4.317712
S.E. of regression	2.032009	Akaike info criterion		4.350567
Sum squared resid	111.4847	Schwarz criterion		4.490687
Log likelihood	-62.25850	Hannan-Quinn criter.		4.395392
F-statistic	51.96723	Durbin-Watson stat		0.907891
Prob(F-statistic)	0.000000			

$$PETKIM\_PRICE = 0.587*USD/TL + 0.807*RESIDS + 0.427 \quad (1)$$

The coefficient of determination (R^2) of the model is 0.793790, indicating that the model explains approximately 79.4% of the observed variation in the dependent variable. To assess the significance of the fitted model, we perform the F-Fisher test.

If the calculated F-statistic is greater than the critical value from the F-distribution table, i.e., if $F_{\textbf{calculated}} > F_{table}$, the model is considered significant. Based on the regression results, the total number of observations (n) is 30 and the number of parameters in the model (m) is 2. The degrees of freedom for the numerator (k_1) and denominator (k_2) are calculated as: $k_1=m-1=2-1=1$ and $k_2=n-m=30-2=28$. At a 5% significance level ($\alpha = 0.05$), the critical value for $k_1 = 1$ and $k_2 = 28$ is approximately 3.85 (based on F-distribution tables). According to the regression model, $F_{\textbf{calculated}}= 51.96723$. Since $F_{\textbf{calculated}} > F_{table} = 4.196$, we reject the null

hypothesis. This indicates that USD/TL, the independent variable, has a statistically significant effect on Petkim stock price, the dependent variable.

To determine the significance of the model using the t-Student test, we compare the absolute value of the calculated t-statistic to the critical t-value. The degrees of freedom for the t-test (df) are calculated as: df=n−2=30−2=28. At the 5% significance level, the critical t-value is 1.96. For the USD/TL coefficient, the calculated t-statistic is $t_{calculated}$= 6.499778. Since |6.499778| > 1.7, the coefficient for USD/TL is significant.

Now, let's examine the Durbin-Watson statistic. Autocorrelation was tested using the Durbin-Watson d-statistic. With 30 observations, 1 explanatory variable and the given significance level, the critical values from the table for the d-statistic are d_{lower}= 1.26 and d_{upper} = 1.352. The observed Durbin-Watson value is $d_{observed}$= 0.907891. Since $d_{observed} < d_{lower}$ and $d_{observed} < d_{upper}$, the observed value does not fall into the zone of uncertainty, indicating that positive autocorrelation is present in the residuals of the regression model.

These results show that there is a statistically significant relationship between USD/TL and Petkim stock prices and the inclusion of residuals in the model has further increased its goodness of fit.

Table 3. Correlation matrix

	PETKIM_PRICE	USD/TL
PETKIM_PRICE	1.000000	0.855819
USD/TL	0.855819	1.000000

The proximity of the relationship between the factors is qualitatively assessed using the Cheddock scale. According to this scale, if the value of an element in the matrix is between 0.5 and 0.7, the proximity of the relationship between the respective factors is considered noticeable and if the value falls within the range of (0.7, 0.9), the proximity of the relationship between the respective pairs is deemed strong. The correlation coefficient of 0.855819 between the USD/TL exchange rate changes and Petkim stock prices indicates a strong relationship between these factors. This suggests that movements in the USD/TL exchange rate are strongly linked to changes in the price of PETKIM's shares.

The results of the extended Dickey-Fuller test showed that the original series are non-stationary, while the first-order differences are stationary. The test results are shown in Tables 4 and 5.

Table 4. ADF test for Petkim stock prices

Null Hypothesis: PETKIM_PRICE has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=4)				
	Level			
	intercept		trend and intercept	
	t-Statistic	Prob.*	t-Statistic	Prob.
Augmented Dickey Fuller test statistic	-1.145320	0.6837	-2.502040	0.3248
Critical value 1%	-3.679322		-4.309824	
Critical value 5%	-2.967767		-3.574244	
Critical value 10%	-2.622989		-3.221728	
Null Hypothesis: D(PETKIM_PRICE) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=5)				
	1st difference			
	intercept		trend and intercept	
	t-Statistic	Prob.*	t-Statistic	Prob.
Augmented Dickey-Fuller test statistic	-5.726949	0.0001	-5.616341	0.0005
Critical value 1%	-3.689194		-4.323979	
Critical value 5%	-2.971853		-3.580622	
Critical value 10%	-2.625121		-3.225334	

Table 5. ADF test for USD/TL

Null Hypothesis: USD/TL has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=4)				
	Level			
	intercept		trend and intercept	
	t-Statistic	Prob.*	t-Statistic	Prob.
Augmented Dickey Fuller test statistic	0.793374	0.9921	-1.812333	0.6726
Critical value 1%	-3.679322		-4.309824	
Critical value 5%	-2.967767		-3.574244	
Critical value 10%	-2.622989		-3.221728	
Null Hypothesis: D(USD/TL) has a unit root				
Exogenous: Constant				
Lag Length: 0 (Automatic - based on SIC, maxlag=5)				
	1st difference			
	intercept		trend and intercept	
	t-Statistic	Prob.*	t-Statistic	Prob.
Augmented Dickey-Fuller test statistic	-2.761190	0.0768	-2.774500	0.2174
Critical value 1%	-3.689194		-4.323979	
Critical value 5%	-2.971853		-3.580622	
Critical value 10%	-2.625121		-3.225334	

The Granger causality test examines the predictive relationship between the USD/TL exchange rate and PETKIM stock price over different lag lengths. The test aims to determine whether past values of one variable contain information that helps predict the future values of the other. The results of the Granger causality test are presented in Table 6.

Table 6. Granger causality test

Null Hypothesis:	m=1		m=2		m=3	
	F-stat.	Prob.	F-stat.	Prob.	F-stat.	Prob.
USD/TL does not Granger Cause PETKIM_PRICE	7.09127	0.0131	3.30578	0.0547	1.87361	0.1666
PETKIM_PRICE does not Granger Cause USD/TL	1.01578	0.3228	0.32206	0.7279	0.27469	0.8429

The Granger causality test reveals an asymmetric relationship between USD/TL and PETKIM stock price. Specifically, changes in the USD/TL exchange rate significantly Granger cause changes in PETKIM stock price at shorter lags (m=1), while there is no evidence to suggest that the PETKIM stock price Granger causes the USD/TL exchange rate. This result may reflect the sensitivity of the PETKIM stock price to macroeconomic factors, such as exchange rate fluctuations, while the broader USD/TL exchange rate is less influenced by individual stock movements.

The results of Johansen cointegration test is reflected below.

Table 7. Johansen cointegration test

Date: 09/09/24 Time: 12:10					
Sample: 2021M01 2023M06					
Included observations: 25					
Series: PETKIM_PRICE USD/TL					
Lags interval: 1 to 4					
Selected (0.05 level*) Number of Cointegrating Relations by Model					
Data trend:	None	None	Linear	Linear	Quadratic
Test type	No Intercept	Intercept	Intercept	Intercept	Intercept
	No Trend	No Trend	NoTrend	Trend	Trend
Trace	2	0	0	1	2
Max-Eig	2	0	0	1	2
*Critical values based on MacKinnon-Haug-Michelis (1999)					
Information Criteria by Rank and Model					
Data trend:	None	None	Linear	Linear	Quadratic
Rank or	No Intercept	Intercept	Intercept	Intercept	Intercept
No. of CEs	No Trend	No Trend	No Trend	Trend	Trend
Log Likelihood by Rank (rows) and Model (columns)					
0	-90.93589	-90.93589	-87.72337	-87.72337	-87.10192
1	-85.10952	-84.82603	-81.63914	-74.92296	-74.65799
2	-81.79697	-81.36147	-81.36147	-70.49029	-70.49029

Akaike Information Criteria by Rank (rows) and Model (columns)					
0	8.554871	8.554871	8.457869	8.457869	8.568154
1	8.408761	8.466082	8.291131	7.833837*	7.892639
2	8.463757	8.588917	8.588917	7.879223	7.879223
Schwarz Criteria by Rank (rows) and Model (columns)					
0	9.334952	9.334952	9.335460	9.335460	9.543254
1	9.383862	9.489938	9.363742	8.955202*	9.062760
2	9.633878	9.856548	9.856548	9.244364	9.244364

$$D(PETKIM_{PRICE})_t = -0.946885822342 * \Big(PETKIM_{PRICE}{}_{t-1} + 0.883453206504 * \frac{USD}{TL}{}_{t-1} - 1.01987894176 * @TREND(21M01) - 6.64336277904 \Big) + 0.604999122437 * D\big(PETKIM_{PRICE}{}_{t-1}\big) + 0.542892719493 * D\big(PETKIM_{PRICE}{}_{t-2}\big) + 0.6712836334 * D\big(PETKIM_{PRICE}{}_{t-3}\big) + 0.457981236142 * D\big(PETKIM_{PRICE}{}_{t-4}\big) + 0.313752571935 * D\left(\frac{USD}{TL}{}_{t-1}\right) + 0.212940032365 * D\left(\frac{USD}{TL}{}_{t-2}\right) + 0.273362135606 * D\left(\frac{USD}{TL}{}_{t-3}\right) + 0.171226387812 * D\left(\frac{USD}{TL}{}_{t-4}\right) - 0.888101446709 \quad (2)$$

This equation models the change in Petkim's stock price as a function of its previous deviation from the cointegration relationship and its past values, as well as past changes in the USD/TL exchange rate.

The coefficient of -0.946886 for the error correction term suggests a strong and statistically significant adjustment towards long-term equilibrium when Petkim's price deviates from the value predicted by the cointegration equation. This indicates a strong reversion mechanism, quickly correcting any imbalances that arise from shocks or other short-term effects.

The positive coefficients of the first three lags of D(PETKIM_PRICE) (0.605, 0.543 and 0.671) indicate that past increases in Petkim's stock price are followed by further increases, showing momentum in stock price movements.

$$D(USD/TL)_t = -0.862148026718 * (PETKIM\_PRICE_{t-1} + 0.883453206504 * USD/TL_{\,t-1} - 1.01987894176 * @TREND(21M01) - 6.64336277904) + 0.65246270021 * D(PETKIM\_PRICE_{t-1}) + 0.55844180271 * D(PETKIM\_PRICE_{t-2}) + 0.279122847803 * D(PETKIM\_PRICE_{t-3}) + 0.248312620311 * D(PETKIM\_PRICE_{t-4}) + 0.173722530625 * D(USD/Tl_{t-1}) - 0.0243048315309 * D(USD/TL_{t-2}) - 0.0934110109624 * D(USD/TL_{t-3}) - 0.18208386304 * D(USD/TL_{t-4}) + 0.189254589128 \quad (3)$$

The significance is evident. With a t-statistic of 3.01675 and a coefficient of 0.883453 for USD/TL, it shows that changes in the USD/TL exchange rate have a substantial long-term

impact on Petkim's stock price. The error correction terms for D(PETKIM_PRICE) and D(USD/TL) are -0.946886 and -0.862148, respectively. Both are statistically significant, indicating that deviations from the long-term equilibrium are corrected relatively quickly. The negative signs imply that any imbalances are corrected by reversing any increases or decreases from the previous period.

The adjustment speed is higher with D(USD/TL), which suggests that the exchange rate adapts more quickly to shocks compared to Petkim's stock price. The presence of a trend component and the adjustment dynamics imply that economic or policy changes affecting the exchange rate can have long-term effects on Petkim's stock prices.

Conclusion. The model indicates that shocks to either Petkim stock prices or USD/TL result in significant, but short-term deviations from equilibrium, with a relatively quick return to the long-term relationship. The equilibrium relationship shows that Petkim's stock prices are highly sensitive to changes in the USD/TL exchange rate.

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