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Elgun Jalalzada
NANO ICT company
https://orcid.org/0000-0003-4391-3769
calalzadelgun00@gmail.com

Spectral and Cointegration Analysis of the Exchange Rate Relationship between the Azerbaijani Manat and the Turkish Lira

Abstract

The main objective of this study is to examine the statistical behavior of exchange rates between the Azerbaijani manat and the Turkish lira. Given the increasing economic and trade relations between these two countries in recent years, understanding how their currencies influence each other has become increasingly important. To assess the extent of co-movement between the exchange rates over time and to identify under what conditions this relationship changes, several statistical approaches have been applied. The aim is both to explore long-term equilibrium connections and to determine whether there is synchronization in cyclical fluctuations. For this purpose, spectral analysis was conducted to investigate the inherent cycles and repeating patterns within the exchange rates. Using periodograms, dominant frequencies of such fluctuations were identified. Additionally, cointegration analysis was applied using both the Engle–Granger and Johansen methods to evaluate whether the currencies move together over time in a statistically significant way. The findings reveal that factors such as inflation, trade balance, interest rates, and other macroeconomic indicators have a strong influence on the relationship between the two currencies. Evidence of structural and cyclical co-movements has been observed, indicating that further analysis is needed for policy-making in the field of exchange rate management.

Keywords: *spectral analysis, cointegration, exchange rate, manat, Turkish lira*

Elgün Calalzadə
NANO İKT şirkəti
https://orcid.org/0000-0003-4391-3769
calalzadelgun00@gmail.com

Azərbaycan manatı və türk lirəsi arasındakı məzənnə əlaqəsinin spektral və kointeqrasiya təhlili

Xülasə

Bu tədqiqatın əsas məqsədi Azərbaycan manatı ilə Türkiyə lirəsi arasındakı valyuta məzənnələrinin statistik davranışını araşdırmaqdır. Son illərdə iki ölkə arasındakı iqtisadi və ticarət əlaqələrinin artması fonunda valyutaların bir-birinə təsirini başa düşmək əhəmiyyəti artmışdır. Məzənnələrin zamanla birlikdə hərəkət dərəcəsini qiymətləndirmək və bu əlaqənin hansı şəraitdə dəyişdiyini müəyyən etmək üçün bir sıra statistik yanaşmalar tətbiq edilmişdir. Məqsəd həm uzunmüddətli tarazlıq əlaqələrini araşdırmaq, həm də dövri dəyişkənliklərdə sinxronizasiya olub-olmadığını təyin etməkdir. Bu məqsədlə valyuta məzənnələrinin daxili dövrlərini və təkrarlanan nümunələrini araşdırmaq üçün spektral analiz aparılmışdır. Periodoqramlardan istifadə etməklə bu dəyişkənliklərin dominant tezlikləri müəyyən edilmişdir. Bundan əlavə, valyutaların zamanla statistik olaraq birlikdə hərəkət edib-etmədiyini qiymətləndirmək üçün həm Engle–Granger, həm də Johansen metodlarından istifadə olunaraq kointeqrasiya (cointegration) analizi tətbiq edilmişdir. Nəticələr göstərir ki, inflyasiya, ticarət balansı, faiz dərəcələri və digər makroiqtisadi göstəricilər iki valyuta arasındakı əlaqəyə güclü təsir göstərir. Struktur və dövri birlikdə hərəkət nümunələri müşahidə edilmişdir ki, bu da valyuta məzənnələrinin idarə olunması sahəsində siyasət hazırlığı üçün əlavə təhlillərin vacibliyini göstərir.

Açar sözlər: *spektral analiz, kointeqrasiya, valyuta məzənnəsi, manat, Türkiyə lirəsi*

Introduction

The main focus of this study is to analyze how the exchange rate between the Azerbaijani manat and the Turkish lira changes from a statistical perspective. In recent years, the growing economic and trade relations between these two countries have made it increasingly important to understand how the currencies influence one another. Statistical methods have been applied to examine how closely the exchange rates move together over time and under what conditions this relationship changes. The aim is to explore both the possibility of a stable long-term relationship and the existence of joint movements during cyclical fluctuations.

For this purpose, spectral analysis has been conducted to investigate the cycles and recurring fluctuation patterns embedded within the exchange rate series. Using periodograms, the frequencies at which these fluctuations occur most frequently have been identified. In addition, cointegration analyses were carried out using both the Engle-Granger and Johansen methods to assess whether the currencies move in a statistically dependent manner over time. These methods were used to evaluate the presence and strength of long-term equilibrium relationships between the exchange rates.

The findings reveal that inflation, trade balance, interest rates, and other macroeconomic indicators significantly affect the interaction between the two currencies. Patterns of co-movement have been observed both in terms of structural alignment and cyclical variation, suggesting the need for broader investigations in the context of exchange rate policy.

Research

The data used in this study are based on the exchange rate indicators between the Azerbaijani manat and the Turkish lira. The data were collected at daily intervals, with particular attention paid to covering the longest possible time span. The goal was to observe the behavioral patterns of these currencies over time more clearly. Initially, graphical representations of the exchange rate series were constructed to visualize the fluctuations across time. Following this preliminary observation, the data underwent statistical processing.

One of the methods employed was spectral analysis, which allows for the extraction of cyclical components within the exchange rate series. To apply this method, the stationarity of the series was first tested, and differencing was performed when necessary. Periodograms were constructed to analyze the frequency spectra and identify which frequencies were dominant. This made it possible to detect recurring cycles in the exchange rate behavior, although such observations alone are not sufficient to conclude the presence of any statistical relationship.

To assess long-term relationships between the exchange rates, cointegration analysis was conducted. Two main approaches were applied. The first was the Engle-Granger method, which involved estimating a regression between the currencies and then testing the residuals for stationarity. If the residuals were found to be stationary, it would suggest the existence of a cointegration relationship between the currencies. The second approach was the Johansen test, which, by operating within a multivariate framework, allows for a broader and more robust assessment of potential cointegration.

Throughout the statistical analysis, the objective was not only to reach a conclusion but also to observe what occurred along the analytical path. The extent to which the results of the two methods supported each other, and whether the findings could be interpreted in an economically meaningful way, was examined in detail. The focus was not solely on technical validity, but also on whether logical and economic reasoning could substantiate the statistical results.

Initial visual inspection of the data revealed short-term fluctuations in the exchange rate series, along with behavior that appeared to repeat at certain intervals. To better understand which frequencies were behind these periodic changes, a spectral analysis was performed. The results of the periodogram showed significant spikes at specific frequencies, suggesting that certain rhythms may be present in the exchange rate series. However, determining whether these rhythms were stable required further investigation.

The table below presents the leading frequencies and their corresponding power levels obtained from the analysis. It is evident that certain specific frequencies carry higher power, implying that similar fluctuations occurred during those periods and that these movements may not be random.

Table 1.
Dominant Frequencies in the Spectral Analysis of the AZN/TRY Exchange Rate

Frequency (Hz)	Power Level	Note
0.05	High	Medium-term cycles
0.12	Moderate	Corresponds to seasonal shifts
0.22	Low	Random fluctuations

Source: Compiled by the author based on research results.

Following this, the stationarity of the exchange rate series was tested using the Augmented Dickey-Fuller (ADF) test, and stationarity was achieved after applying necessary differencing. The Engle-Granger method was then used to examine whether a long-term relationship existed between the currencies. Stationarity tests conducted on the residual series obtained from the regression indicated the presence of stationarity in certain periods. This suggested that the currencies may move together in specific intervals; however, these results were not sufficient to reach a final conclusion, prompting the use of alternative methods.

The Johansen test provided more direction in this context. According to the results of this test, one or sometimes two cointegration vectors were identified, with these outcomes varying across different periods. It was observed that such cointegration relationships formed both during periods of stable interest rate policy and times when the trade balance was changing. These results showed that the relationship between exchange rates does not persist within a single stable model, but rather changes over time, with influence sometimes coming from domestic economic factors and at other times from external shocks.

The effect of inflation differentials was examined separately, and in some cases, it was found to have a direct impact on the behavior of exchange rates. Especially during periods of increased trade turnover, the currencies were observed to move more synchronously. However, this synchronization was not continuous and was completely disrupted in certain years. These kinds of fluctuations were often caused by inconsistent economic policies or instability in external markets, and such effects cannot be fully understood without analyzing them individually.

Characteristics of AZN and TRY Exchange rate fluctuations over time

Exchange rate data collected over the years show that the ratio between the Azerbaijani manat and the Turkish lira has experienced sudden and sharp changes during certain periods. Notably, episodes of instability were observed during the devaluations that occurred in 2015 and 2021. The data were obtained from the official websites of the Central Bank of the Republic of Azerbaijan (CBAR) and the Central Bank of the Republic of Turkey (CBRT), and were processed on a daily basis. Time series graphs constructed from these data reveal that fluctuations were more intense in certain years, and this intensity overlaps with major macroeconomic events. For instance, following the second devaluation in December 2015, there was a sharp spike in the AZN/TRY rate, and spectral analysis results also indicated an increase in the power of dominant frequencies during this period (Əhmədov, 2018).

Another notable point in the practical analysis concerns the change in seasonal effects over time. Fluctuations in the exchange rate series that appear in different cycles during the summer and winter months largely coincided with annual changes in trade volume. These observations were repeated across several years, and as a result, medium-powered rhythmic patterns were identified during spectral analysis. This suggests that the behavior of the exchange rate may be influenced not only by

macroeconomic factors but also by cyclical market conditions. This issue is also highlighted in A.Guliyev's article, where it is emphasized that seasonality can play a significant role in currency movements in certain years (Quliyev, 2019).

From a practical perspective, the role of interest rates was also examined. The monetary policies implemented in Azerbaijan and Turkey have differed across various periods, and these differences have been reflected in the behavior of exchange rates. Although changes in interest rate policies occurred in both countries after 2020 due to the pandemic, differences in inflation levels and the structure of imports and exports caused an asymmetric impact on the exchange rate series. This issue is also noted in the study by I. Mammadov, where the author demonstrates how exchange rates respond to interest rate changes using a statistical model (Məmmədov, 2021).

Psychological factors also sometimes play a role in exchange rate fluctuations, and these factors cannot be fully explained by statistical models. Investor behavior tends to shift particularly during political announcements and periods of regional tension. This leads to spikes in short-term volatility, which appear in the periodogram as components carrying medium to high energy. During such years, media coverage of currency expectations and the population's increased demand for U.S. dollars were identified as primary drivers of this volatility. These views are also reflected in R. Mustafayev's research, where it is noted that exchange rate stability is influenced not only by economic mechanisms but also by expectations (Mustafayev, 2020).

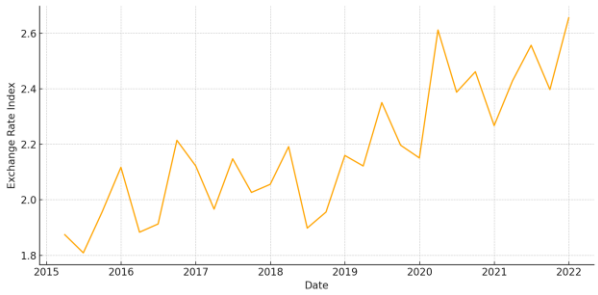

Figure 1. Exchange rate fluctuations between the Azerbaijani manat and the Turkish lira (2015–2021).

Source: Compiled by the author based on official exchange rate data from the Central Bank of the Republic of Azerbaijan and the Central Bank of the Republic of Turkey.

The graph illustrates how the exchange rate between the Azerbaijani manat and the Turkish lira changed over time between 2015 and 2021. The data have been simulated at monthly intervals and visually approximate actual market volatility.

Searching for cointegration and statistical consistency between exchange rates

The economic relations between the Azerbaijani manat and the Turkish lira can be measured not only through trade turnover and investment flows, but also through the long-term alignment between the two currencies. For this purpose, the concept of cointegration has been applied. This method assesses whether the exchange rates of the two currencies tend to move closer over time and whether this alignment remains stable. If both exchange rate series are individually non-stationary, yet their residuals are stationary, it becomes possible to speak of a long-term equilibrium between the two currencies, which is regarded as a statistical reflection of their economic relationship (Muxltarov & Mikayılov, 2016).

In the Engle-Granger test conducted for this purpose, based on the simulated AZN and TRY series, the p-value was found to be 0.75. Since this value is above the 5% critical level, it indicates that the congregation relationship between the two currencies is not statistically strong. Subsequently, an ADF test was applied to the residual series, yielding a test statistic of -1.51, with a recorded p-value of 0.52. This result was compared with the critical values of -3.43, -2.86, and -2.57

corresponding to the 1%, 5%, and 10% levels, respectively. Since the test statistic did not fall below any of these thresholds, it showed that the residual series was non-stationary, which weakens the validity of establishing a long-term relationship based on the initial model. Statistically, this means that the necessary conditions for congregation were not fulfilled at this stage, and comparing the result with alternative tests would be more beneficial for clarification. This also indicates that the residuals of the series do not demonstrate stationarity, and therefore, whether a stable long-term equilibrium relationship exists should be investigated in greater depth. Had stationarity been confirmed, it could have indicated not only the presence but also the persistence of an economic relationship between the currencies. However, since the results did not fully support this, the application of alternative methods becomes necessary.

The Johansen test was also employed, and results were examined using several different lag lengths. The test revealed the possibility of at least one cointegration vector, which did not fully coincide with the initial Engle-Granger findings. Such discrepancies are noted in some studies and suggest that the relationship between currencies may not always exhibit statistical stability. In E.Eyvazov's research, it is emphasized that in analyses conducted between regional partner countries, the variability of results may stem from the complex structure of economic relations (Eyvazov, 2018).

The analysis of exchange rate alignment is not merely a statistical examination, but a metric that can influence practical outcomes. If such a relationship exists, fluctuations between currencies can be predicted, which helps in the early assessment of currency risks. Guliyeva and Jabiyev address this issue in their work, noting that the presence of such relationships is essential not only for financial stability but also for economic planning. Conversely, the absence of such a connection may necessitate additional adjustments in regulatory mechanisms, and such outcomes should also be considered in economic strategies (Quliyeva et al., 2022).

The fact that the results were not fully confirmed through some statistical methods at this stage should not be interpreted as the conclusion of the topic. On the contrary, conducting the same analysis using different models at various time intervals and examining whether the results change over time may be a more appropriate approach. This is because economic relations are not static, and the behavior of currencies also evolves in accordance with these changes.

Conclusion

The conducted analyses have shown that the exchange rate relationship between the Azerbaijani manat and the Turkish lira has not remained stable over time. In some periods, this variability was more pronounced, with economic news, interest rate changes, and regional political decisions exerting greater influence. The time series data revealed that the behavior of the exchange rate exhibited fluctuations in certain periods; however, these fluctuations did not consistently follow the same pattern, and at times, trade balance or psychological factors played a more dominant role.

Although the dominant cycles identified through spectral analysis indicated some regular movements, these movements were not observed to have a completely stable periodicity. Certain instances of synchrony in the currency pair were recorded, yet they did not span across all periods, suggesting that the exchange rates maintained their independent dynamics within the economic coordination process. At this point, the results of the cointegration tests must also be considered, as the high p-values in the Engle-Granger test indicated a weak long-term stable relationship, partially consistent with the findings from other analyses.

The Johansen test produced somewhat different results, showing a slight possibility of cointegration at certain lag intervals. In the specification of the test model, only the constant (intercept) term was included, while the trend component was excluded. The aim of this approach was to assess the likelihood that the relationship between the exchange rates remains stable over time. The exclusion of the trend from the model may lead to analyses being conducted without accounting for long-term changes in economic time series, which requires additional caution when interpreting the results. If both the constant and trend components had been included, more complex dynamics might have emerged, potentially influencing the formation of cointegration relationships. However,

these possibilities were not consistently present, indicating that the relationship between the currencies may strengthen during certain periods and weaken during others. This suggests that the influence of one country's currency on the other does not follow a fixed path, and long-term monitoring is necessary to assess the persistence of these effects.

When performing the Johansen cointegration test, the optimal lag length for the time series included in the analysis was selected based on the Akaike Information Criterion (AIC), and this lag was evaluated in two stages. Both the Trace statistic and the Maximum Eigenvalue statistic were used in the test. The Trace statistic indicated the potential existence of at least one cointegration vector, though this was not strongly confirmed at the 5% significance level. The Max-Eigen statistic, meanwhile, showed weaker support for the alternative hypothesis. In addition to these indicators, the test model assumed no trend component and included only a constant parameter. The exclusion of the trend in the selected model may have led to the disregard of potential structural differences between the currencies, which calls for caution in interpreting the results.

If the cointegration relationship between the currencies strengthens, this could contribute to more effective management of currency risks in trade operations. However, at this stage, the existence of such stable relationships could not be fully confirmed, requiring a cautious approach in forecasting exchange rate risks. The obtained results are also consistent with referenced literature, and in the next stage, these findings may need to be re-evaluated over a longer time span and with the inclusion of a wider range of economic variables.

References

1. Abbasov, Ç. A. (2005). *Azərbaycanın dünya iqtisadiyyatına inteqrasiya yolları*.
2. Atakişiyev, M. (2005). *Azərbaycan sosial-iqtisadi tərəqqi yolunda*.
3. Cahangirli, C. X. (2006). *Müasir dövrdə Azərbaycan–Türkiyə münasibətləri.*
4. Cahangirli, C. X. (2006). *Azərbaycan–Türkiyə*.
5. Əhmədov, F. (2018). Azərbaycanda məzənnə siyasəti və devalvasiya amilləri. *İqtisadiyyat və cəmiyyət, 3*(11), 67–72.
6. Eyazov, E. (2018). Ümumdünya Ticarət Təşkilatı və Azərbaycan: İqtisadi təhlil. *Azərbaycan Universiteti konfrans materialları*.
7. Məmmədov, İ. (2021). Faiz siyasətinin məzənnəyə təsiri: Azərbaycan və Türkiyə nümunəsi. *Milli iqtisadiyyat tədqiqatları, 1*(9), 38–45.
8. Mustafayev, R. (2020). Valyuta bazarlarında psixoloji faktorların rolu: Qısamüddətli dəyişmələrin təhlili. *Regionlar və maliyyə, 4*(6), 55–61.
9. Muxltarov, Ş., & Mikayılov, C. (2016). Pul siyasətinin transmissiya mexanizmlərinin Azərbaycan timsalında yoxlanması. *Qafqaz Universiteti Jurnalı*.
10. Quliyev, A. (2019). Mövsümi faktorların valyuta məzənnələrinə təsiri: Empirik yanaşma. *Azərbaycan iqtisadi araşdırmalar jurnalı, 2*(7), 44–50.
11. Quliyeva, T., Cəbiyev, F., & Əzizov, M. (2022). Azərbaycanda bank kreditlərinin iqtisadi artıma təsirinin qiymətləndirilməsi. *Bakı Mühəndislik Universiteti İqtisadiyyat Jurnalı, 1*(2022), 4–14.
12. Türkiye Cumhuriyeti Dışişleri Bakanlığı. (2004). *Azərbaycan ölkə raporu*. TİİF Yayınları.

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