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KIBALNYK Liubov

Doctor of Economics, Professor,
Bohdan Khmelnytsky National University of
Cherkasy, Cherkasy, Ukraine

ORCID ID: <https://orcid.org/0000-0001-7659-5627>

e-mail: liubovkibalnyk@vu.cdu.edu.ua

KIBALNYK Volodymyr

Educational and Scientific Testing Range for
High-Tech Weapons and Military Equipment,
Cherkasy, Ukraine

ORCID ID: <https://orcid.org/0009-0002-4117-7948>

e-mail: vmkibalnik@ukr.net

DANYLCHUK Hanna

Candidate of Economic Sciences, Associate
Professor, Bohdan Khmelnytsky National
University of Cherkasy, Cherkasy, Ukraine

ORCID ID: <https://orcid.org/0000-0002-9909-2165>

e-mail: abdanilchuk@vu.cdu.edu.ua

SEREDA Danylo

Master student, Bohdan Khmelnytsky National
University of Cherkasy, Cherkasy, Ukraine

ORCID ID: <https://orcid.org/0009-0002-4117-7948>

e-mail: vmkibalnik@ukr.net

MODELING THE IMPACT OF THE RUSSIAN-UKRAINIAN WAR ON THE FOREIGN EXCHANGE MARKET

The article is dedicated to modeling the foreign exchange market to assess the impact of the Russian-Ukrainian war. For this purpose, methods such as the calculation of the Hurst exponent, the local Hurst exponent, and recurrence analysis were utilized. The study examined currency pairs including BTC/USD, ETH/USD, EUR/USD, GBP/USD, CNY/USD, USD/RUB, and USD/UAH. Based on the modeling results, it was concluded that certain changes in the dynamics of these currency pairs were observed from 2022 to November 2024. The calculated Hurst exponent allowed for an assessment of the persistence of the currency pairs. The local Hurst exponent provided further insights into the states of the foreign exchange market at different points in the study period. Recurrence analysis was conducted, which helped refine conclusions regarding the impact of crises on the foreign exchange market.

The obtained models demonstrated that all analyzed currency pairs experienced negative effects due to Russia's full-scale invasion of Ukraine. The authors argue that the response of the EUR/USD currency pair can be explained by the European Union's dependence on Russian energy resources. Additionally, the introduction of economic and political sanctions against Russia has had a significant impact on the foreign exchange market, as these sanctions restrict access to international financial markets, reduce foreign investment and trade volumes, thereby decreasing liquidity and increasing the volatility of the national currency. Moreover, sanctions create significant uncertainty among investors, disrupt supply chains, and force the country to seek alternative financial and economic partnerships, ultimately affecting the stability of the foreign exchange market and the overall economic situation.

Evidently, the war in Ukraine has also influenced the USD/UAH and USD/RUB currency pairs, as the hryvnia and ruble are the national currencies of Ukraine and Russia, respectively. An interesting result was observed in the modeling of the CNY/USD currency pair. The war in Ukraine was found to have an impact on this pair as well, given that China, while maintaining ties with Russia, seeks to strengthen its global position, whereas the United States supports Ukraine, further influencing the foreign exchange market. This occurs in the broader context of U.S.-China rivalry.

For cryptocurrency pairs, the models demonstrated a relatively low dependence on events in Ukraine. The findings of the study suggest that the use of fractal and recurrence analysis is advisable, as these methods offer new opportunities for a deeper understanding of the foreign exchange market and the development of adaptive strategies for managing economic risks, which is particularly relevant in the context of global instability.

Keywords: foreign exchange market; currency pairs; cryptocurrency pairs; volatility; Hurst exponent; local Hurst exponent; recurrence analysis; Russian-Ukrainian war.

Problem statement. The Russian-Ukrainian war has emerged as a global challenge that has significantly impacted not only Ukraine's economy but also the global foreign exchange market. This war has disrupted the stability of international trade, caused economic uncertainty, and affected trust in global financial institutions. Russia's actions, particularly the imposition of sanctions against it, have altered the structure of international financial flows, influencing the exchange rates of major currencies such as the US dollar, the euro, the yuan, as well as the currencies of developing countries.

The war has led to a global increase in energy prices, which has had a heterogeneous impact on the currency markets of energy-exporting and energy-importing countries. Shifts in trade flows, capital redistribution, and financial support for Ukraine from international partners have introduced additional factors contributing to currency fluctuations. At the same time, interest in alternative currencies, particularly cryptocurrencies, has intensified as a means of protection against economic risks.

The issue lies in the fact that traditional foreign exchange market analysis models often fail to account for war-related factors that significantly alter the behavior of economic agents. The lack of a systematic analysis of the global impact of the Russian-Ukrainian war on the foreign exchange market complicates the forecasting of future trends and the development of effective policies to ensure financial stability. Therefore, modeling these processes is critically important for understanding the dynamics of the global foreign exchange market in the context of geopolitical conflicts.

Analysis of recent research and publications and identification of unresolved aspects of the problem. The study of foreign exchange markets has attracted significant attention from financial and economic researchers. For instance, Gonak I. [1] demonstrates the influence of negative and positive factors on the price dynamics of the cryptocurrency market. Based on statistical analysis, the author argues that major cryptocurrencies tend to increase in value during periods of crisis. The authors of [2] present the results of foreign exchange market modeling using R/S analysis, highlighting its effectiveness in identifying market states through the example of the USD/UAH and EUR/USD currency pairs. In the study [3], the authors propose a method for modeling the cryptocurrency market using econometric evaluation tools based on machine learning models. The developed models are designed for short-term forecasting. Short-term forecasts of exchange rate dynamics based on deep neural networks are the focus of study [4]. The authors confirm the effectiveness of this approach for predicting both fiat and cryptocurrencies. The study [5] examines the impact of geopolitical risks (using the Russian-Ukrainian war as an example) on foreign exchange markets. By applying univariate analysis, the authors conclude that the war has had a negative effect on foreign exchange rates, particularly in countries geographically close to Ukraine and Russia, as well as those highly dependent on Russian energy resources. The effects of the Russian-Ukrainian war and the COVID-19 pandemic on specific European currencies are analyzed in study [6]. The authors utilize the TVP-VAR dynamic connectivity method. The obtained results support previous findings, demonstrating the influence of energy dependence and the Russian ruble on the valuation of European currencies. The modeling of foreign exchange markets using nonlinear dynamics methods, such as fractal and entropy-based approaches, is the focus of studies [7-8]. In [7], the authors examine the impact of COVID-19 on the cryptocurrency market using fractal analysis and Tsallis entropy and wavelet entropy methods. The modeling results indicate an insignificant impact of the COVID-19 pandemic on this market. In [8], the authors apply the wavelet entropy method to model the impact of the Russian-Ukrainian war on globalization processes by analyzing global financial markets, particularly the foreign exchange market. The study demonstrates that, for the currency market, the war in Ukraine represents a geopolitical crisis. Furthermore, the effectiveness of the wavelet entropy method is highlighted in modeling the foreign exchange market, analyzing its response to crises, and conducting pre-forecast analysis.

Thus, the proposed topic remains highly relevant, as the prolonged Russian-Ukrainian war continues to reshape global economic conditions. The analysis of research by Ukrainian scholars reveals certain gaps in this field. Further study is required to explore the direct impact of military actions on fluctuations in major currencies (the US dollar, the euro, and the Ukrainian hryvnia), the mechanisms driving these fluctuations, the ways in which sanctions against Russia alter international financial flows, and how these changes affect the currency markets of countries participating in sanctions regimes, among other issues. Investigating these aspects will contribute to a deeper understanding of currency

market dynamics during geopolitical crises and facilitate the development of modern, adequate economic forecasting models for analyzing the impact of military factors. The results of such modeling will aid in formulating effective strategies for economic stabilization in crisis situations.

The aim of this article is to model the impact of Russia's full-scale invasion of Ukraine on the foreign exchange market using nonlinear dynamics methods and to identify the key factors driving foreign exchange market volatility.

Presentation of the main research material. The study of the foreign exchange market is crucial for understanding global financial processes and ensuring economic stability. Modeling negative impacts allows for the prediction and minimization of risks caused by sharp fluctuations in exchange rates. The Russian-Ukrainian war, as an example of a geopolitical crisis, demonstrates how military conflicts can significantly affect the foreign exchange market. Therefore, researching this issue and developing models using modern interdisciplinary methods is highly relevant for further designing effective strategies to adapt economic policies to conditions of high instability.

In this study, model calculations were performed based on data from the Global Foreign Exchange Market Index Statistics website [9]. The research focuses on two cryptocurrencies with the largest market capitalization—Bitcoin (BTC) and Ethereum (ETH)—as well as the currency pairs EUR/USD, GBP/USD, CNY/USD, USD/RUB, and USD/UAH for the period from January 1, 2018, to November 12, 2024. The authors apply elements of fractal analysis, specifically the Hurst exponent [10] and the local Hurst exponent [11]. The calculation of the Hurst exponent allows for the assessment of trend persistence, while the method of calculating the local Hurst exponent using a moving window procedure enables tracking its dynamics and identifying specific periods of currency response to crisis events. Additionally, recurrence analysis [12, 13] is used to detect market states resulting from the negative impact of the Russian-Ukrainian war.

Figure 1 presents the dynamics of the analyzed currency pairs.

The analysis of Fig. 1 shows that the EUR/USD and GBP/USD currency pairs exhibited a downward trend during 2018–2019 (around points 310–350). The euro gradually weakened against the dollar due to the slowdown in economic growth in the EU and several political challenges, including BREXIT. In the case of GBP/USD, BREXIT was the dominant factor during this period, while the subsequent trade agreement with the EU contributed to the partial stabilization of the pound.

The Chinese yuan weakened against the dollar, primarily due to the U.S.-China trade war. The Russian ruble showed a declining trend, which can be explained by the sanctions imposed on Russia since 2014. Similarly, the Ukrainian hryvnia to the dollar was characterized by instability, influenced by economic and political events of that time. The cryptocurrency market, after peaking in 2017, also experienced a significant decline.

In 2020 (around points 620–1050), the situation became even more complex for global markets due to the announcement of the COVID-19 pandemic, which led to fluctuations in currency pairs with an overall downward trend. Initially, the pandemic weakened the euro, but large-scale economic stimulus measures in the EU contributed to its stabilization. A similar effect was observed for the pound and the Chinese yuan. The USD/RUB and USD/UAH currency pairs experienced sharp declines, while the cryptocurrency market, despite general instability, showed an upward trend. In 2020–2021, China strengthened its position thanks to its rapid recovery from the pandemic.

During 2021–2024, the euro experienced fluctuations due to the ECB's monetary policy and the increase in interest rates in the U.S., which reinforced the dollar's role as a «safe-haven» asset. The GBP/USD currency pair, which suffered from the impact of COVID-19 in 2020–2021, gradually showed an increase in the pound's value due to the improving economic situation in the UK during 2022–2024. Tensions between China and the U.S. in 2023–2024 once again affected the yuan's exchange rate. In 2022, following the outbreak of the war in Ukraine, the Russian ruble initially plummeted but partially recovered due to the implementation of strict currency controls, whereas the hryvnia faced significant pressure, leading to depreciation. However, since 2023, it has begun to stabilize due to international financial support.

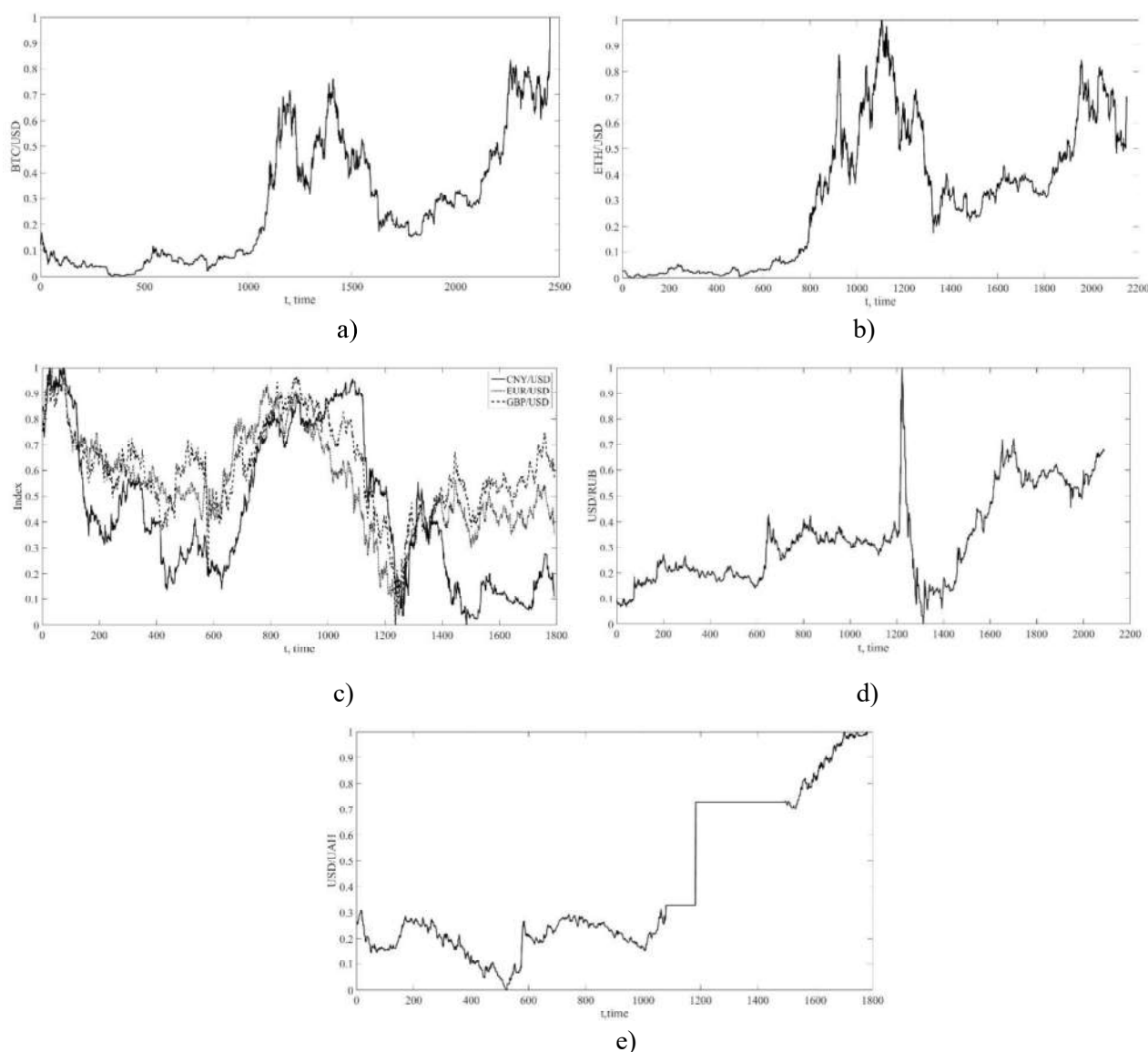


Figure 1. - Dynamics of currency pairs: (a) BTC/USD, (b) ETH/USD, (c) EUR/USD, GBP/USD, CNY/USD, (d) USD/RUB, (e) USD/UAH

Source: constructed by the authors based on data from [9]

In 2022, cryptocurrencies experienced a decline due to the bankruptcies of key platforms and increased regulatory pressure. However, in 2023–2024, a partial recovery was observed, driven by the introduction of new technologies and a gradual increase in trust in digital assets. Thus, during the analyzed period, the currency market experienced numerous negative events, including the COVID-19 pandemic, political and economic tensions, and the full-scale invasion of Ukraine by Russia.

To analyze the current state of the currency market based on the studied currency pairs, the Hurst exponent was calculated. The results of these calculations are presented in Table 1.

Table 1 - Hurst exponent values for currency pairs, H

Currency pairs	H
EUR/USD	0,56
GBP/USD	0,57
CNY/USD	0,67
USD/RUB	0,65
USD/UAH	0,75
BTC/USD	0,7
ETH/USD	0,68

Source: calculated by the authors based on data from [9]

The obtained Hurst exponent values for all currency pairs range between 0.5 and 1, indicating the presence of persistence, i.e., the continuation of certain trends in the dynamics over a defined period.

To identify changes in the dynamics of currency pairs caused by crisis events, the local Hurst exponent was calculated. The results of this analysis are presented in Fig. 2.

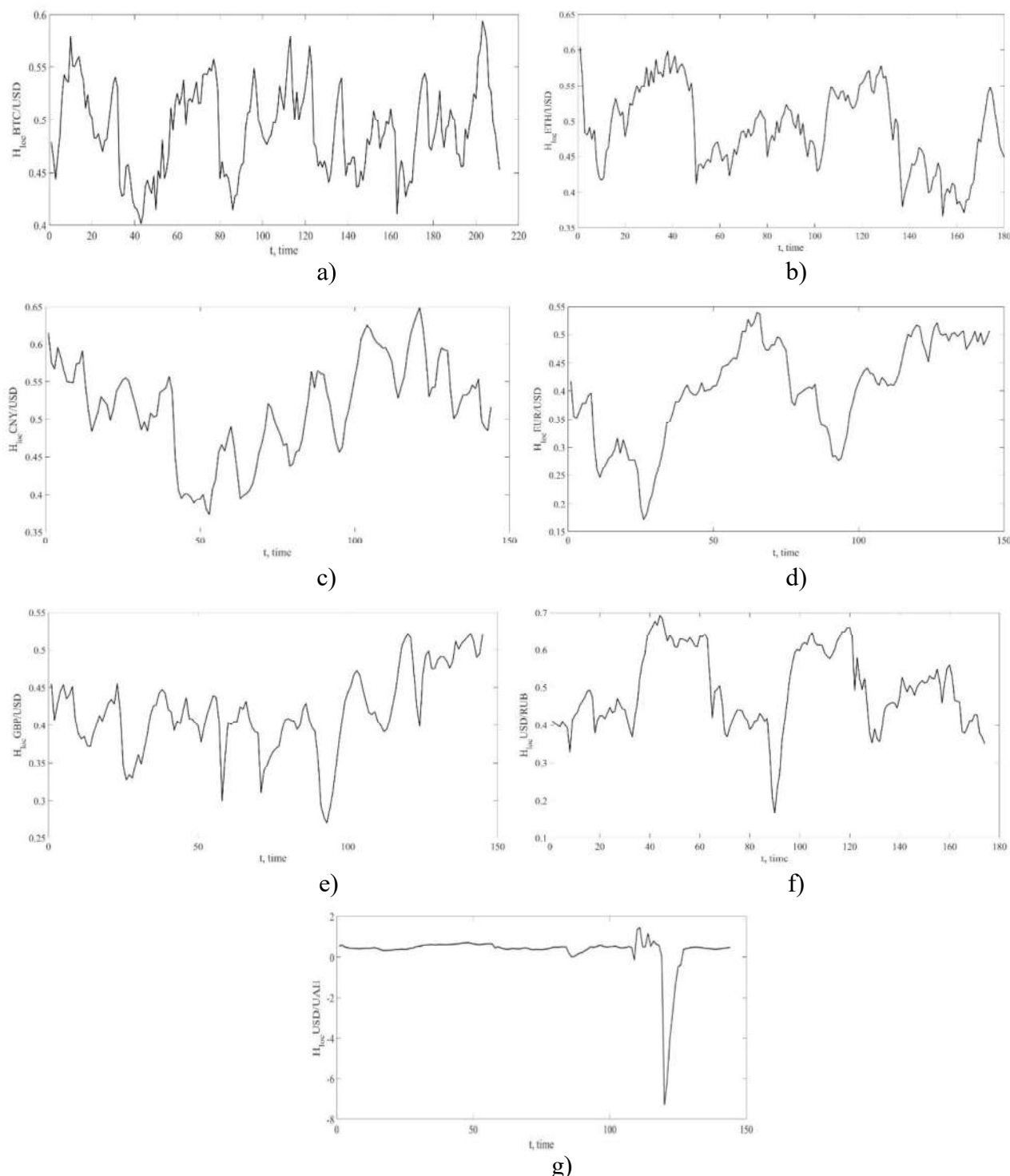


Figure 2 - Dynamics of the Local Hurst Exponent for Currency Pairs: (a) BTC/USD, b) ETH/USD, (c) CNY/USD, (d) EUR/USD, (e) GBP/USD, (f) USD/RUB, (g) USD/UAH
Source: calculated and plotted by the authors based on data from [9]

The analysis of Fig. 2 allows us to conclude that in certain periods, sharp changes in the local Hurst exponent (declines/increases) are observed, indicating instability and the presence of crisis processes. For instance, in the case of the CNY/USD currency pair, such fluctuations were recorded around point 20 and point 40, corresponding to late 2018 – early 2019, as well as during the COVID-19 pandemic

(around point 70). During the period 2022–2024 (points 100–150), the dynamics of the local Hurst exponent predominantly show declines, indicating high instability for this pair. This may be attributed both to the confrontation between the United States and China and to deeper factors related to the war in Ukraine. China seeks to strengthen its global position while maintaining ties with Russia, whereas the U.S. supports Ukraine, creating additional impacts on the currency market.

For the EUR/USD and GBP/USD currency pairs, fluctuations in the local Hurst exponent during 2022–2024 are observed, which, in our opinion, are more likely driven by internal economic and political events in the U.S. and the UK.

A similar pattern is observed for cryptocurrency pairs, where we see rapid declines and increases, reflecting the characteristic cycle of crises and recoveries in this market. Notably, the war in Ukraine has had a significant impact: prior to the war, Ukraine was home to cryptocurrency mining farms due to affordable electricity and a tech-savvy population. However, with the onset of hostilities, this situation changed, and cryptocurrencies gained popularity as a tool for international transfers and financial transactions.

The USD/UAH currency pair exhibits a significant decline in the local Hurst exponent, directly linked to the consequences of the Russia-Ukraine war. However, in 2024, the values returned to pre-war levels due to international financial support. As for the Russian ruble, fluctuations are also observed in the 2022–2024 period, with several sharp declines, particularly in 2022 and early 2024, indicating an overall downward trend.

Thus, the application of the local Hurst exponent method has allowed us to identify multiple crisis periods, which, in our view, indicate that the war in Ukraine has had a widespread impact on the entire currency market.

Next, we conduct a recurrence analysis of the currency market to examine its response to the Russian-Ukrainian war. The calculation results are presented in Fig. 3. A detailed study of the recurrence plots reveals the market's fine-scale characteristics.

The recurrence diagrams for cryptocurrency pairs (Figure 3(a, b)) confirm previous findings and also demonstrate the presence of instability. The period from 2022 to 2024 is characterized by the non-stationarity of processes. However, it is rather difficult to draw a definitive conclusion regarding the impact of the Russian-Ukrainian war on the cryptocurrency market. Cryptocurrencies have their own history and crises, as this segment of the financial market is inherently more speculative.

For the EUR/USD currency pair (Figure 3(c)), the last three years of the analyzed period also exhibit an unstable state, which may indicate the influence of the war in Ukraine. Most European Union countries actively support Ukraine financially, yet the Eurozone remains dependent on Russian energy resources, and sanctions against Russia have affected national economies. Despite this, efforts to maintain the euro's stability are evident, as it is the second most significant reserve currency after the US dollar, making it a key instrument in international finance. Moreover, the euro symbolizes Europe's economic and political unity, and due to its stability, it attracts investors, contributing to geopolitical balance.

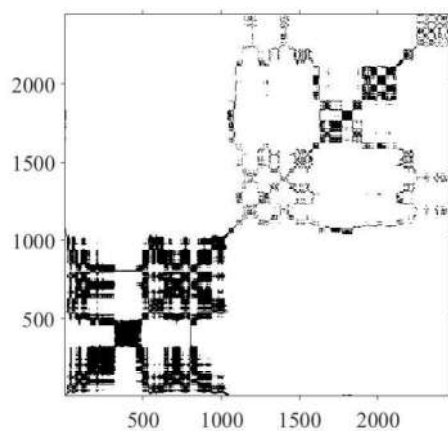
From Figure 3(d), it can be concluded that during 2022, the GBP/USD currency pair experienced significant fluctuations, reflected in the presence of individual black points on the diagram. The current situation indicates a gradual transition to a more stable state. In our opinion, the most pronounced impact of the war was observed at the very beginning of hostilities.

According to Figure 3(e), in 2022, the CNY/USD currency pair exhibited white points and regions, indicating particular market conditions. However, by 2024, a trend toward stabilization is observed, which is likely a consequence of the Russian-Ukrainian war. It is known that various components for drone and equipment production are supplied from the Chinese market, so the revitalization of this segment may contribute to the stabilization of the yuan's exchange rate.

The recurrence diagram for the USD/RUB pair (Figure 3(f)) has a distinctly contrasting topology, indicating sharp trend shifts. Throughout the 2022–2024 period, Russia has attempted to maintain the stability of the ruble despite significant pressure from sanctions and economic restrictions. Measures such as currency regulation adjustments, ensuring an external trade surplus, and implementing monetary policies have been employed, although sanctions have also had a substantial impact on the situation.

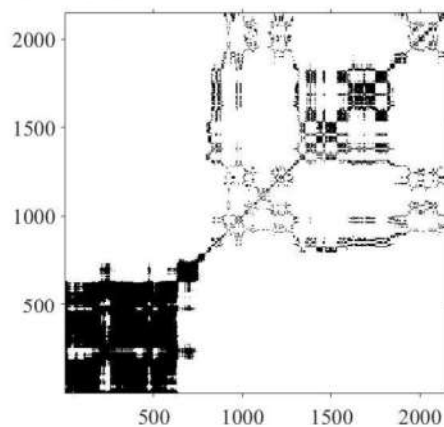
Despite these efforts, the long-term maintenance of a stable ruble exchange rate remains a challenge due to declining export revenues and the need to finance the budget deficit.

Recurrence Plot
on: 1, Delay: 1, Threshold: 0.1σ (fixed distance maximum)



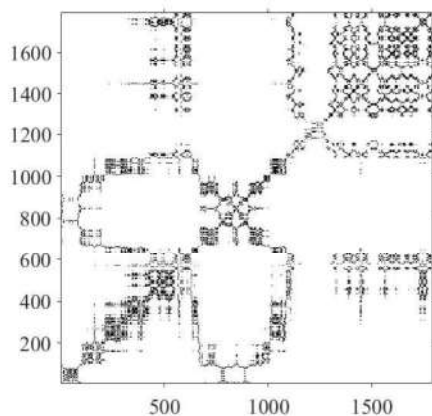
a)

Recurrence Plot
on: 1, Delay: 1, Threshold: 0.1σ (fixed distance maximum)

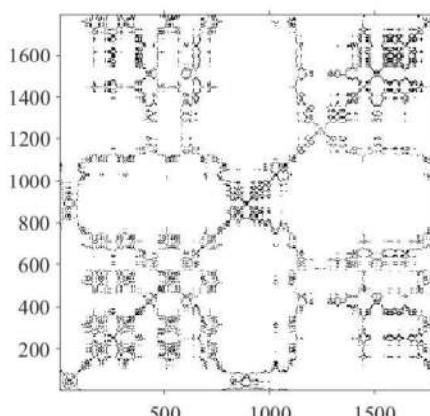


b)

Recurrence Plot
on: 1, Delay: 1, Threshold: 0.1σ (fixed distance maximum)

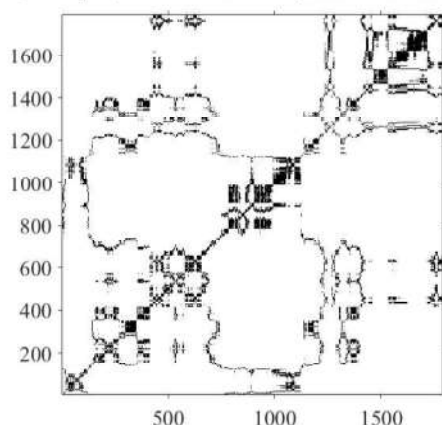


c)



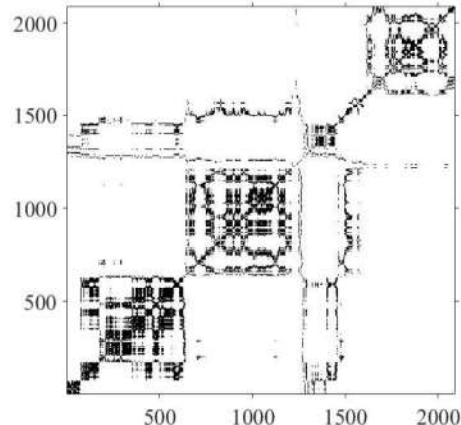
d)

Recurrence Plot
on: 1, Delay: 1, Threshold: 0.1σ (fixed distance maximum)



e)

Recurrence Plot
on: 1, Delay: 1, Threshold: 0.1σ (fixed distance maximum)



f)

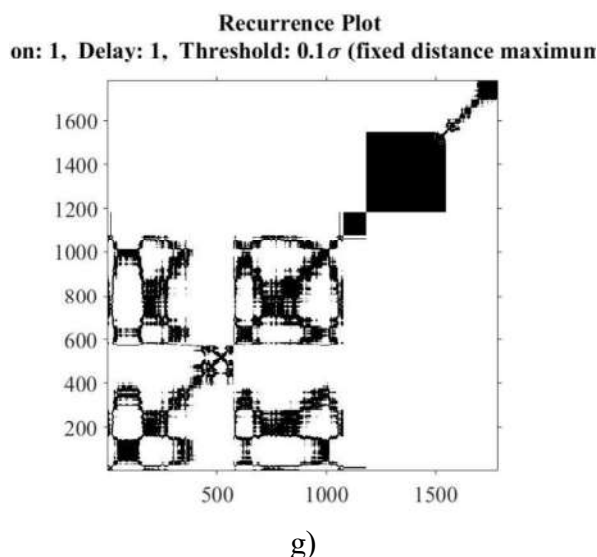


Figure 3. - Recurrence plots for: (a) BTC/USD, b) ETH/USD, (c) EUR/USD, (d) GBP/USD, (e) CNY/USD, (f) USD/RUB, (g) USD/UAH

Source: calculated and plotted by the authors based on data from [9]

The recurrence diagram for the USD/UAH currency pair (Figure 3(g)) shows various rectangular black areas, indicating a certain level of stability in the Ukrainian hryvnia due to measures taken by the National Bank of Ukraine (NBU) and other economic factors. These include the establishment of a fixed exchange rate of the hryvnia against the US dollar, which reduces market panic and supports confidence in the national currency. An important stabilization factor is international financial assistance, as substantial grants and loans from partners (IMF, EU, US) contribute to budget financing, replenishment of NBU's foreign exchange reserves, and overall economic stability. It is noteworthy that even during the war, Ukraine continues to export agricultural products and other goods, ensuring an inflow of foreign currency. The NBU also actively uses foreign exchange reserves for interventions to curb exchange rate fluctuations. As of November 2024, reserves remain at a sufficient level to cover import needs and maintain stability.

Despite these measures, the hryvnia remains under significant pressure due to economic destruction, high military expenditures, and declining production, with its stability largely dependent on continued international support and the effectiveness of economic institutions. This is also reflected in the recurrence diagram: white points near position 1500 and beyond indicate signs of stabilization, potentially influenced by socio-political events, including the US elections and changes in foreign aid policies.

Thus, recurrence analysis has made it possible to «diagnose» the states of currency pairs, obtain detailed information about their dynamics, and assess the impact of the Russia-Ukraine war on the foreign exchange market.

Conclusions and prospects for further research. Based on the conducted study, it can be concluded that fractal analysis enables the identification of large-scale patterns and self-similarity in the dynamics of exchange rates, serving as an important indicator of long-term trends and market instability. Recurrence analysis, in turn, facilitates the «diagnosis» of local market states, allowing for the identification of critical moments when currency pairs undergo abrupt behavioral changes, particularly under the influence of external geopolitical and geo-economic factors.

The analysis has demonstrated that both fractal and recurrence characteristics of the currency market change significantly under the impact of crisis events such as the Russian-Ukrainian war. These methods allow for the detection of both global and local anomalies, which is crucial for forecasting and risk management. The obtained results can be used as an additional tool for developing monetary policy strategies, optimizing foreign exchange reserves, and managing financial risks.

A deep understanding of the fractal properties of the market helps anticipate potential trend changes, while recurrence analysis enables timely responses to local crises. Future research prospects

include the integration of advanced data analysis tools and artificial intelligence to enhance the capabilities of fractal and recurrence analysis in the foreign exchange market, thereby significantly improving the accuracy of forecasts and the quality of managerial decisions.

References

1. Honak, I.M. (2022). Mozhlyvosti investuvannya u kryptovalyuty v umovakh aktyvnoyi fazy pandemiyi COVID-19 u 2020–2021 rr. ta konventsijnoyi rosijsko-ukrayinskoyi vijny 2022 r. [Investment opportunities in cryptocurrencies during the active phase of the COVID-19 pandemic in 2020–2021 and the conventional Russian-Ukrainian war in 2022]. *Naukovi zapysky Natsional'noho universytetu "Ostroz'ka akademiya". Seriya "Ekonomika"*, 25(53), 67–77.
2. Burtnyak, I.V., Suduk, N.V., & Kashevskiy, R.M. (2024). R/S-analiz valyutnoho rynku [R/S analysis of the currency market]. *Aktual'ni problemy rozvytku ekonomiky rehionu*, 2(20), 245–251. <https://doi.org/10.15330/apred.2.20.245-251>
3. Martyanov, D., Viklyuk, Y., & Fleichuk, M. (2023). Modelyuvannya dynamiky rynku kryptovalyut z vykorystanniam instrumentiv mashynnoho navchannya [Modeling the dynamics of the cryptocurrency market using machine learning tools]. *System Research and Information Technologies*, (4), 54–68.
4. Derbentsev, V.D., Bezkorovainyi, V.S., & Ovcharenko, A.A. (2020). Modelyuvannya korotkostrokovoyi dynamiky valyutnykh kursiv z vykorystanniam hlybokykh nejronnykh merezh [Modeling the short-term dynamics of exchange rates using deep neural networks]. *Naukovyi visnyk Odes'koho natsional'noho ekonomichnoho universytetu*, (3-4), 153–163.
5. Hossain, A.T., Masum, A.-A., & Saadi, S. (2024). The impact of geopolitical risks on foreign exchange markets: Evidence from the Russia-Ukraine war. *Finance Research Letters*, 59, 104750. URL : <https://doi.org/10.1016/j.frl.2023.104750> (Accessed: 15.12.2024).
6. Aliu, F., Apanovych, Y., Bajra, U., & Nuhui, A. (2024). Assessing the impact of the Russia-Ukraine war and COVID-19 on selected European currencies and key commodities. *Journal of Business Economics and Management*, 25(5), 1097–1119. <https://doi.org/10.3846/jbem.2024.22518>
7. Danylchuk, H., Kibalnyk, L., Kovtun, O., Kiv, A., Pursky, O., & Berezhna, G. (2020). Modelling of cryptocurrency market using fractal and entropy analysis in COVID-19. *CEUR Workshop Proceedings*. URL : <https://ceur-ws.org/Vol-2713/paper40.pdf> (Accessed: 15.12.2024).
8. Danylchuk, H.B., Kibalnyk, L.O., Kovtun, O.A., Pursky, O.I., Kyryliuk, Y.M., & Kravchenko, O.O. (2023). The impact of the war in Ukraine on globalization processes and world financial markets: A wavelet entropy analysis. *CEUR Workshop Proceedings*. URL : <https://ceur-ws.org/Vol-3465/paper20.pdf> (Accessed: 15.12.2024).
9. Statystyka indeksiv svitovoho valyutnoho rynku [Statistics of world currency market indices]. (n.d.). URL : <http://finance.yahoo.com> (Accessed: 15.12.2024).
10. Hurst, H.E. (1951). Long-term storage capacity of reservoirs. *Transactions of the American Society of Civil Engineers*, 116(1), 770–799.
11. Weron, R. (2002). Estimating long-range dependence: Finite sample properties and confidence intervals. *Physica A: Statistical Mechanics and its Applications*, 312(1–2), 285–299.
12. Eckmann, J.-P., Kamphorst, S.O., & Ruelle, D. (1987). Recurrence plots of dynamical systems. *Europhysics Letters*.
13. Marwan, N., et al. (2007). A recurrence plot-based method for characterizing time series. *Physics Reports*.

List of sources in language original

1. Гонак І. М. Можливості інвестування у криптовалюту в умовах активної фази пандемії COVID-19 у 2020–2021 рр. та конвенційної російсько-української війни 2022 р. *Наукові записки Національного університету «Острозька академія». Серія «Економіка»*. 2022. № 25(53). С. 67–77.
2. Буртняк І. В., Судук Н. В., Кашевський Р. М. R/S-аналіз валютного ринку. *Актуальні проблеми розвитку економіки регіону*. 2024. №2 (20). С. 245-251.
3. Мартьянов Д., Вיקлюк Я., Флейчук М. Моделирование динамики рынка криптовалют с использованием инструментов машинного обучения. *System Research and Information Technologies*. 2023. № 4. С. 54–68.
4. Дербенцев В. Д., Безкоровайний В. С., Овчаренко А. А. Моделирование короткостроковой динамики валютных курсов с использованием глубоких нейронных сетей. *Науковий вісник Одеського національного економічного університету*. 2020. № 3-4. С. 153–163.

5. Ashrafee T. Hossain, Abdullah-Al Masum, Samir Saadi. The impact of geopolitical risks on foreign exchange markets: Evidence from the Russia-Ukraine war. *Finance Research Letters*. 2024. Vol. 59. 104750. ISSN 1544-6123. URL: <https://www.sciencedirect.com/science/article/pii/S1544612323011224>. <https://doi.org/10.1016/j.frl.2023.104750>.
6. Aliu F., Apanovych Y., Bajra U., Nuhui A. Assessing the impact of the Russia-Ukraine war and COVID-19 on selected European currencies and key commodities. *Journal of Business Economics and Management*. 2024. Vol. 25(5). P. 1097–1119.
7. Danylchuk H., Kibalnyk L., Kovtun O., Kiv A., Pursky O., Berezhna G. Modelling of cryptocurrency market using fractal and entropy analysis in COVID-19. *CEUR Workshop Proceedings*. 2020. URL: <https://ceur-ws.org/Vol-2713/paper40.pdf>
8. Danylchuk H. B., Kibalnyk L. O., Kovtun O. A., Pursky O. I., Kyryliuk Y. M., Kravchenko O. O. The impact of the war in Ukraine on globalization processes and world financial markets: a wavelet entropy analysis. *CEUR Workshop Proceedings*. 2023. URL: <https://ceur-ws.org/Vol-3465/paper20.pdf>.
9. Статистика індексів світового валютного ринку URL: <http://finance.yahoo.com>
10. Hurst H. E. Long-term storage capacity of reservoirs. *Transactions of the American Society of Civil Engineers*. 1951. Vol. 116(1). P. 770–799.
11. Weron R. Estimating long-range dependence: finite sample properties and confidence intervals. *Physica A: Statistical Mechanics and its Applications*. 2002. Vol. 312(1–2). P. 285–299.
12. Eckmann J.-P., Kamphorst S. O., Ruelle D. Recurrence Plots of Dynamical Systems. *Europhysics Letters*. 1987.
13. Marwan N. et al. A Recurrence Plot-Based Method for Characterizing Time Series. *Physics Reports*. 2007.

КІБАЛЬНИК Любов Олександрівна

доктор економічних наук, професор,
Черкаський національний університет імені
Богдана Хмельницького,
м. Черкаси, Україна

ДАНИЛЬЧУК Ганна Борисівна

кандидат економічних наук, доцент, Черкаський
національний університет імені Богдана
Хмельницького
м. Черкаси, Україна

КІБАЛЬНИК Володимир Миколайович

Навчально-науковий випробувальний полігон
високотехнологічного озброєння та військової
техніки
м. Черкаси, Україна

СЕРЕДА Данило Андрійович

здобувач другого (магістерського) рівня вищої
освіти, Черкаський національний університет
імені Богдана Хмельницького, м. Черкаси,
Україна

МОДЕЛЮВАННЯ ВПЛИВУ РОСІЙСЬКО-УКРАЇНСЬКОЇ ВІЙНИ НА ВАЛЮТНИЙ РИНОК

Актуальність. Російсько-українська війна перетворилася на глобальний виклик, який суттєво вплинув не лише на економіку України, а й на світову валютну систему. Одним із ключових наслідків війни стало різке зростання світових цін на енергоносії, що по-різному вплинуло на валютні ринки країн-експортерів та імпортерів енергії. Перерозподіл торговельних потоків, зміни в русі капіталу та міжнародна фінансова підтримка України стали додатковими факторами нестабільності валютного ринку. Водночас зросла увага до альтернативних фінансових інструментів, зокрема криптовалют, які розглядаються як засіб хеджування ризиків в умовах економічної турбулентності. Проблема полягає в тому, що традиційні моделі аналізу валютного ринку часто не враховують фактори, пов'язані з війною, які суттєво змінюють поведінку економічних агентів. Відсутність системного аналізу глобального впливу російсько-української війни на валютний ринок ускладнює прогнозування майбутніх тенденцій та розробку ефективних політик для забезпечення фінансової стабільності. Тому моделювання цих процесів є критично важливим для розуміння динаміки світового валютного ринку в умовах геополітичних конфліктів.

Дослідження впливу війни на валютний ринок залишається надзвичайно актуальним, оскільки тривале збройне протистояння продовжує трансформувати глобальну економіку. Аналіз наукових праць свідчить про наявність прогалин у вивченні цього питання. Зокрема, потребують подальшого дослідження такі аспекти, як прямий вплив військових дій на динаміку основних валют (долара США, євро, української гривні), механізми, що визначають ці коливання, а також роль санкцій у зміні міжнародних фінансових потоків і їхній вплив на валютні ринки країн-учасниць санкційних режимів.

Метою статті є моделювання впливу повномасштабного вторгнення Росії в Україну на валютний ринок із використанням методів нелінійної динаміки, а також визначення ключових факторів, що зумовлюють його волатильність.

Результати дослідження. У статті застосовано методи розрахунку коефіцієнта Херста, локального коефіцієнта Херста та рекурентний аналіз для дослідження валютних пар BTC/USD, ETH/USD, EUR/USD, GBP/USD, CNY/USD, USD/RUB, USD/UAH. Результати моделювання свідчать, що в період з 2022 року по листопад 2024 року в динаміці цих валютних пар відбулися суттєві зміни. За допомогою коефіцієнта Херста оцінено ступінь персистентності валютних курсів, а локальний коефіцієнт Херста дозволив уточнити характер ринкових змін у різні моменти досліджуваного періоду. Рекурентний аналіз дав змогу детальніше оцінити вплив кризових явищ на валютний ринок.

Отримані результати підтвердили, що всі досліджувані валютні пари зазнали негативного впливу внаслідок повномасштабного вторгнення Росії в Україну. Зокрема, коливання валютної пари EUR/USD пояснюються залежністю країн Європейського Союзу від російських енергоресурсів. Важливим чинником впливу стали економічні та політичні санкції проти Росії, які обмежили доступ до міжнародних фінансових ринків, скоротили обсяги іноземних інвестицій і торговельних операцій, що призвело до зниження ліквідності та зростання волатильності рубля. Санкції також посилили невизначеність серед інвесторів, порушили глобальні ланцюги постачання та змусили Росію шукати альтернативні фінансові й економічні зв'язки, що ускладнило стабільність валютного ринку.

Очікувано, що війна значно вплинула на валютні пари USD/UAH та USD/RUB, оскільки гривня та рубль є національними валютами безпосередніх учасників конфлікту. Цікавим є результат моделювання для валютної пари CNY/USD, який свідчить про вплив війни в Україні на цю пару. Китай, зберігаючи економічні відносини з Росією, прагне посилити свої позиції на міжнародній арені, тоді як США активно підтримують Україну. Це відбувається на тлі загострення геополітичного суперництва між Китаєм і США, що додатково впливає на валютний ринок.

Для криптовалютних пар вплив подій в Україні виявився менш вираженим, що пояснюється більшою автономністю цього сегмента фінансового ринку.

Результати дослідження підтвердили ефективність фрактального та рекурентного аналізу для оцінки валютної динаміки. Використання цих методів відкриває нові можливості для поглибленого аналізу ринку та розробки адаптивних стратегій управління економічними ризиками, що є особливо актуальним в умовах глобальної нестабільності.

Наукова новизна. Новизна дослідження полягає у застосуванні комплексу сучасних міждисциплінарних методів моделювання для аналізу впливу російсько-української війни на валютний ринок. Завдяки поєднанню цих методів відбувається комплексне дослідження з урахуванням економічних, політичних та соціальних факторів, їх взаємозв'язку та динаміки розвитку.

Висновки. Дослідження показало, що фрактальний аналіз дозволяє виявляти масштабні закономірності та самоподібність у динаміці валютних курсів, що є важливим для прогнозування довгострокових тенденцій та оцінки нестабільності ринку. Рекурентний аналіз, у свою чергу, допоміг ідентифікувати критичні моменти, коли валютні пари зазнавали різких змін під впливом зовнішніх факторів, таких як геополітичні та геоekonomічні події. Обидва методи виявили значні зміни у характеристиках валютного ринку під впливом російсько-української війни. Результати дослідження можуть бути використані для розробки монетарної політики, управління валютними резервами та оцінки фінансових ризиків. Подальші дослідження можуть включати використання сучасних інструментів аналізу даних і штучного інтелекту для підвищення точності прогнозування та якості управлінських рішень.

Ключові слова: валютний ринок; валютні пари; криптовалютні пари; волатильність; коефіцієнт Херста; локальний коефіцієнт Херста; рекурентний аналіз; російсько-українська війна.

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