European Research Studies Journal
Volume XXVII, Issue 4B, 2024

pp. 692-706

Co-variance in Action: Analyzing the Impact of EUR/USD Exchange Rate Changes on Polish Zloty (PLN) Valuation (2019–2022) as a Predictive Tool in Forex Markets

Submitted 10/10/24, 1st revision 25/10/24, 2nd revision 01/11/24, accepted 25/11/24

Jarosław Klepacki[1]

Abstract:

Purpose: *The purpose of the study is to examine the phenomenon of co-variance using the example of the impact of changes in the EUR/USD exchange rate on the value of the Polish zloty (PLN) as an element of forecasting in the foreign exchange market. The first objective of the study is to confirm the hypothesis that one of the most important external factors influencing the state of the Polish currency is the euro-dollar exchange rate. The second secondary objective is to confirm the research findings that an increase in volatility on the foreign exchange market often leads to a depreciation of the currencies of countries with a relatively higher interest rate level, i.e., mainly emerging countries, even in periods of unpredictable phenomena.*

Design/methodology/approach: *Using research based, inter alia, on the Pearson linear correlation coefficient over the period 2019 - 2022, at different time intervals for Japanese technical analysis candles, taking into account the occurrence of so-called unpredictable events.*

Findings: *The results show that, contrary to popular opinion, it is possible to speak of the occurrence of a co-variance phenomenon with respect to USD/PLN and EUR/USD. Moreover, the hypothesis of an impact of the EUR/USD exchange rate on EUR/PLN according to the principle: "an increase in the EUR/USD exchange rate favours the zloty against the euro" is also not supported by the research conducted. It can be confirmed that the sharp increase in liquidity and volatility in the area of the currency pairs studied does not allow us to confirm the assumption that they directly favour the phenomenon of co-movement.*

Practical implications*: These results provide an important practical vector for the creation of predictive models in such a complex and volatile area as the foreign exchange market.*

Originality value: *This research aims to fill the research gap in the field of exchange rate forecasting models taking into account extreme phenomena of the external environment. The implications of such a study can be applied as part of a prediction system in the corporate area.*

Keywords: *Forecasting, currency market, liquidity management, volatility, correlation*.

JEL Codes: *G32, G15, G17.*

Paper Type: *Research article.*

[1]*PhD, Assistant Professor, Faculty of Management, University of Warsaw, Poland, ORCID: 0000-0002-9601-8963, e-mail: jklepacki@wz.uw.edu.pl;*

1. Introduction

Prediction (forecasting) in the area of investment decisions of both business entities and individual investors was and is one of the key processes. However, there are areas within the boundaries of which, despite its universality, the implementation of forecasting activities is considered ineffective and sometimes even impossible. One such area is the foreign exchange market, which, being an important determinant of financial risk, plays an important role in liquidity management processes in the corporate area.

The purpose of this paper is to attempt to identify a potentially important element of the forecasting model in the area of the foreign exchange market by examining and assessing to what extent the valuation of the Polish zloty (PLN) is affected by changes in the EUR/USD exchange rate under the so-called co-movement phenomenon.

This is to fill the research gap in the field of exchange rate forecasting models taking into account extreme phenomena of the external environment. Such an analysis is aimed at confirming the hypothesis that one of the key external factors affecting the condition of the Polish currency is the Eurodollar exchange rate, (if the EUR/USD exchange rate rises the better for the PLN - the assumption of positive correlation). The implications of such a study can be applied as part of a prediction system in the corporate area (Thalassinos and Politis, 2012).

The realized side plot is to examine the formation of the valuation of the Polish zloty under the influence of changes in the EUR/USD exchange rate in a highly volatile macroeconomic environment. Thus, the study itself will be divided into periods identified as those with a moderate or normal course of volatility of macroeconomic phenomena and those diagnosed as periods with a highly volatile external environment in which, in addition, there were so-called extreme phenomena black swans.

The leading method of the study is the observational method and descriptive method based on the collected statistical data within the collected time series. The scope of observation covered the period of 2019 - 2022, with a focus on extreme points, based on daily, H4, and H1 charts. Due to the nature of the foreign exchange market and currency pairs, the main focus was on the relationship of changes between EUR/USD and EUR/PLN and EUR/USD and USD/PLN. An assumption confirmed by the literature was made that changes in the EUR/PLN exchange rate best reflect the internal (fundamental) valuation of the Polish zloty.

The study is divided into intermediate headings. Configured in this way, the analytical and research path helps in an orderly and logical way to properly interpret the collected data and identify its cause-and-effect structure in order to draw conclusions based on it.

2. Literature Review

According to the established worldview, the leading role of forecasting and, as a result, forecasts is to provide the most objective, scientifically based solutions possible for the anticipated formation of economic phenomena in the future (Zelias *et al.*, 1997). The determinant of such an interpretation is the assumption that the forecasting process is based on regularities that characterize the phenomenon being forecast or that exist between it and other phenomena. Such a relationship of existing regularities that are the result of the interrelationship of various phenomena is the ontological basis of forecasting[2].

Thus, it can be assumed that the forecasting process proves successful if the interrelationships persist constantly, systematically or at least in a predictable manner, with one of the previously identified interrelationships being a consequence of the previously identified one. The problem with which scientific forecasting is unable to cope effectively is a process in which the number of variables and the accompanying nature of the interrelationships constantly and/or very rapidly change. We can deal with such forecasting either in a highly fungible external environment (macroeconomic environment in which extreme phenomena occur) or in a highly complex market structure - the research area.

Prediction in the area of the foreign exchange market, due to the peculiarities of this market, fulfills at least one of these marks, and is therefore an extremely difficult process that science has so far been unable to cope with. The foreign exchange market is a unique area. It is an example of such complex systems that it seems very difficult to say whether a series is stochastic, deterministic, chaotic or a combination of these states.

The foreign exchange market is global, there are no set trading hours, there is no single seat overseeing trading, and it is available to virtually everyone. As a rule of thumb, it can be assumed that it has been operating more or less in its current form since 1971, when the gold standard was abolished. Since then, exchange rates have been volatile, and forecasting their changes has become an important rule in economic trading (Groen and Matsumoto *et al.*, 2004; Hakim *et al.*, 2022).

The attempt to diagnose the most likely scenario is usually carried out on the basis of technical and/or fundamental analysis. Until the mid-1980s, the prevailing view was that exchange rate changes occur as a result of changes in the value of fundamental macroeconomic variables (Dornbusch *et al.*, 1976). A significant increase in the importance and popularity of technical analysis came with the spread of the Internet (James *et al.*, 2003). Theoretically, however, the most complete picture of expected future changes is obtained by using both tools simultaneously. Technical analysis is based on the study of patterns of historical price changes,

[2] *https://mfiles.pl/pl/index.php/Predykcja*.

inscribing them with the assumption of a certain repeatability. The range of types of instruments used in this case is wide, and to this day has the character of an open set.

Fundamental analysis, on the other hand, is a method of analysis that forecasts long-term trends based on macroeconomic analysis. However, the prevailing view in the literature is that the effectiveness of these methods is debatable (Bettman, Sault, and Schultz, 2009; Bajgrowicz *et al.*, 2009; Juszczuk *et al.*, 2014). There is therefore a legitimate need to continue research in this area, resulting in a constantly updated quantity and quality of analyses and models (Rossi *et al.*, 2013).

Recent studies point to the growing importance of using the convergence of the exchange rate to purchasing power parity using the so-called Taylor rule (Byrne, Korobilis, and Ribeiro, 2016). However, the shortcoming always remains the effective lifetime of such models and their very limited versatility. The peculiarities of the foreign exchange market and currency pairs mean that the prediction models currently being developed through research and academic experience are dedicated only to specific currencies or the region of the world in which the currencies occur. Due to the above-average fluctuation of variables, there is also a need for frequent calibration.

The problem of a large and constantly changing number of variables affecting currency pricing is referred to in the literature as noise. The extent to which a deterministic process retains its properties when corrupted by noise is unclear.

Researchers basing the prediction path on chaos theory have tried to solve this problem. In one of the latest approaches, the authors propose an improved model for forecasting exchange rates that involves reconstructing the phase space from the observed time series and using support vector regression (SVR) for forecasting (Radhwan, Ahmed, Kamel, Mahmod, Dahab, Mohamed, Hassanien, and Aboul Ella, 2015).

Considering the exchange rates of a currency pair as scalar observations, the observed time series are first analyzed to verify the existence of underlying nonlinear dynamics governing its evolution over time. The time series are then embedded in a multidimensional phase space using embedding parameters. A novel method based on the Differential Evolution (DE) genetic algorithm (as a global optimization technique) was used in the selection process to find the optimal embedding parameters.

The authors compared the predictive accuracy of the proposed model with the usual use of support vector regression. Experimental results show that the proposed method, based on chaos theory and genetic algorithm, is comparable to already existing approaches (Radhwan, Ahmed, Kamel, Mahmod, Dahab, Mohamed, Hassanien, and Aboul Ella, 2015).

3. Research Methodology

The lack of conclusive results towards the development of precise prediction mechanisms prompts the search for more universal principles on which to base the models developed so far. One such principle is the issue of co-movement in financial markets.

According to the prevailing view, this is a phenomenon involving strong correlations between the prices of the same or different asset classes in multiple markets. Importantly, and perfectly in line with the main theme of the phenomenon under study: academic research indicates that with the increasing integration of international financial markets, the phenomenon of co- movement is intensifying (Morana *et al.*, 2008; Kamara, Lou, and Sadka, 2008).

The source of the phenomenon of co-mingling is attributed by scientific researchers to the relationship of ties between the economic foundations of countries, as to which we can speak of cross-border flows of goods, services and capital (Rijckeghem *et al.*, 2001). Recent research results also indicate that an important element of the occurrence of co-movements in financial markets is periodic drops in liquidity, which in turn are the aftermath of violent phenomena, or turbulence (phenomena referred to as black swans) (Xu, Taylor, and Lu, 2018). It also turns out that issues directly derived from the field of behavioral finance, such as risk appetite or investor sentiment, are not insignificant (Xu, Taylor, and Lu, 2018).

When characterizing the phenomenon of co-movement in financial markets, one cannot fail to mention several important studies whose results are related to this issue. For example, a very interesting conclusion was reached in their research by Menkhoff *et al.* (2012) noting that an increase in volatility in the foreign exchange market leads to a depreciation of the currencies of countries with relatively higher interest rates, that is, primarily emerging economies (Menkhoff, Sarno, Schmeling, and Schrimpf, 2012).

Realized in the same vein, the work of Liu *et al.* (2012) not only confirmed this conclusion, but also pointed out that during periods of increased volatility there is a risk of sudden and strong weakening of the currencies of these economies (Liu, Margaritis, and Tourani-Rad, 2012). The above conclusions are worth supplementing with another one stating that the phenomenon of co-movement intensifies during periods of financial market turmoil.

The picture of co-movement in financial markets that emerges based on the research to date seems to correlate perfectly with both the currency pairs studied, EUR/USD, EUR/PLN and USD/PLN, as well as the time horizon of the research, the years 2019 - 2022. This is because it is in this period that we observe an intensity of extreme phenomena that has not been observed before 2020 - the Covid-19 pandemic; 2022 - the war in Ukraine.

According to official figures, there are currently 190 countries in the world. According to a United Nations report, this gives as many as 180 officially recognized currencies. The 180 currencies also include those currencies that do not have an independent exchange rate. After eliminating such monetary systems, 130 world currencies remain[3].

The foreign exchange market shaped by transactions involving the Polish zloty (PLN) is a regional market, importantly one of the largest and most liquid within the developing economies of Central and Eastern Europe. The Polish New Zloty (PLN) appeared in place of the zloty on January 1, 1995. Since 2000, Poland has used a floating independent exchange rate, meaning there is no official denominator (measure of value). It also means that no currency or currency unit determines the value and range of volatility of the zloty exchange rate[4].

Foreign exchange market transactions include:
spot foreign exchange transactions,
Outright forward transactions (including transactions with differential settlement),
currency swaps,
CIRS transactions,
currency options[5].

The average daily turnover in the domestic foreign exchange market in April 2022 amounted to $13,019 million, almost half that of April 2019. Compared to April 2019, the average daily value of transactions involving PLN increased by 52% and amounted to $9,618 million in April 2022[6].

Transactions involving PLN are mainly carried out in three centers: Poland, the United Kingdom and the United States. Importantly, only ¼ of transactions involving the Polish zloty are made in the domestic market. The remaining transactions are carried out in major *offshore* centers, primarily in London[7].

According to a Bank for International Settlements (BIS) report published in October 2022, the Polish zloty ranked 23rd among the most actively traded currencies with a daily turnover of 54.315 billion.

According to statistics from the BIS and the National Bank of Poland, the USD/PLN currency pair makes up more than 50 percent of turnover in the Polish zloty. The

[3]*https://www.zadluzenia.com/ile-jest-walut-na-swiecie/.*
[4]*https://www.obserwatorfinansowy.pl/bez-kategorii/rotator/rola-euro-i-dolara-w-polskiej-gospodarce/.*
[5]*https://nbp.pl/wp-content/uploads/2022/10/Polska2022.pdf, , pp. 5-7.*
[6]*Ibid.*
[7]*https://www.obserwatorfinansowy.pl/bez-kategorii/rotator/rola-euro-i-dolara-w-polskiej-gospodarce/.*

value of transactions involving the EUR/PLN pair is approx. 25 percent of the total. This structure applies to both the domestic and global markets. An analysis of NBP data on the main segments of the domestic market provides interesting information.

On the spot market (operations carried out between financial and non-financial entities), closely related to the real sphere of the economy, transactions involving the EUR/PLN pair dominate (53 percent), the share of USD/PLN is only 22 percent.

This structure of transactions reflects the proportion of trade invoicing currencies. In the largest segment of the market - forex swap transactions (59 percent of total turnover), the USD/PLN pair makes up 50 percent, the EUR/PLN 25 percent[8]. One key conclusion emerges from these data the EUR/PLN and USD/PLN pairs are key to shaping the valuation of the Polish currency.

According to the report published by the National Bank of Poland, "Results of the survey of April 2022 turnover in the foreign exchange market and the OTC derivatives market in Poland," it is the EUR/PLN pair that is considered the primary currency pair in the interbank spot market of the zloty, best informing the value of our currency.

The euro accounts for the majority of domestic imports and exports. Statistically for more than a decade, the euro exchange rate has fluctuated between PLN 4.00 and PLN 5.00. Previously, in 2008, we saw both a descent to PLN 3.20 and an approach under PLN 5 (Figure 1).

***Figure 1**. Long-term chart of the EUR/PLN pair.*

***Source:** Own elaboration.*

[8] *https://nbp.pl/wp-content/uploads/2022/10/Polska2022.pdf, pp. 5-7.*

EUR/USD determines the exchange rate between the U.S. dollar and the euro currency and is undoubtedly the most popular currency pair. The euro as a currency has been in effect since 1999 and currently operates in 19 countries. The EUR/USD currency pair is distinguished by its enormous liquidity (Figure 2).

Trading takes place 24 hours a day. Bank for International Settlements (BIS) report published in October 2022 shows that the U.S. dollar has maintained its place as the dominant currency, accounting for as much as 88 percent of all foreign exchange transactions and 44 percent of global interest rate derivatives trading[9].

The EUR, meanwhile, remained the second most actively traded currency, but reduced its share marginally from 2019 to 31 percent, while other leading currencies such as the Japanese yen and British pound maintained their shares at 17 percent and 13 percent, respectively, while the Chinese yuan saw the biggest increase to 7 percent from 4 percent, moving it up to fifth place from eighth.

Figure 2. *Long-term chart of the EUR/USD pair*

Source: *Own elaboration.*

The EUR/USD pair is thus the juxtaposition of the two most important currencies in the world, in which a penny of trade transactions are carried out, which statistically translates into the fact that it is currently the most popular instrument of the forex market. It accounts for approx. 40% of all executed trades[10].

[9]*https://www.bis.org/statistics/rpfx22_fx.pdf,*
[10]*Ibid.*

4. Research Results and Discussion

The identification of the sources of the phenomenon of co-movement in the relations of linkages between the economic foundations of countries refers to the theory of the optimal currency area formulated by Mundell. According to this theory, a common European currency can be identified with a "public good" as a necessary element to stabilize the economic situation in a regional supranational perspective confirming the progressive integration of international financial markets (Moshirian *et al.,* 2004).

Poland's trade relations with the Eurozone result in the automatic anchoring of the Polish zloty in the European currency. This effect is also reinforced by the prospect of Poland's entry into the eurozone. We can therefore talk about the phenomenon of co-movement, where the course of regional currencies depends on the exchange rate of the dominant currency - this phenomenon has been referred to as informal monetary union (Bednarz *et al.,* 2006).

The forecasting of exchange rates using the covariance phenomenon will be verified based on a three-year time interval: the years 2019 - 2022, in which extreme phenomena (black swans) were identified, Covid-19 pandemic and the war in Ukraine. According to the assumptions, these phenomena are an important element of the occurrence of co-variance in financial markets, as they are directly related to periodic drops and increases in liquidity.

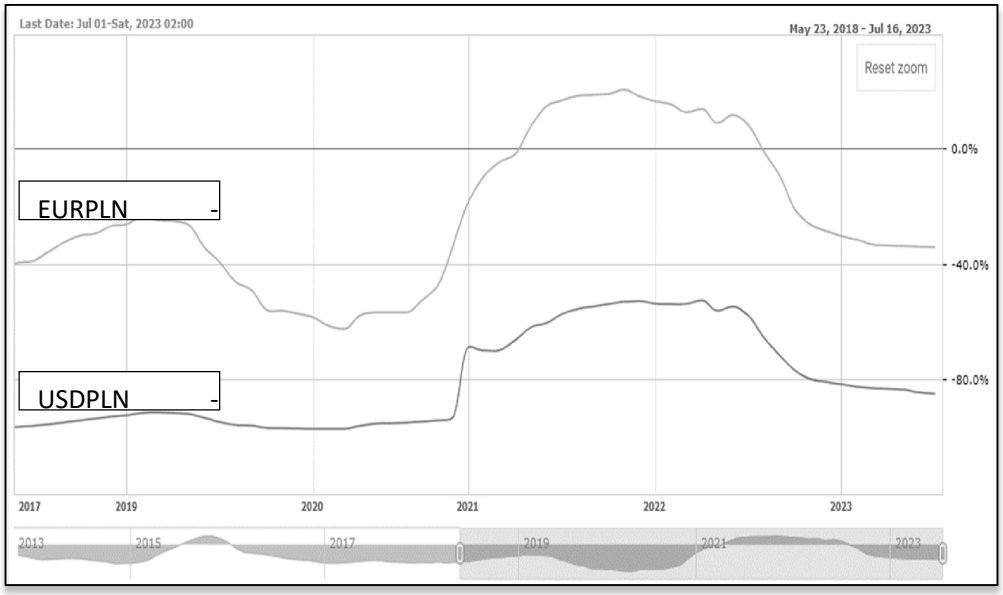
The extent and degree of co-variance in the area of the EUR/USD and USD/PLN and EUR/USD and EUR/PLN pairs markets will be verified by examining Pearson's correlation coefficient. The correlation coefficient will be calculated based on the average rates of the selected period for different time intervals.

According to the general interpretation, it is assumed that if the value is in the range from -1 to 1, where values close to zero means no correlation, towards -1 - negative correlation, and towards 1 - positive correlation. A positive correlation means that an increase in the price of one pair is associated with an increase in the other, while a negative correlation is the opposite mechanism.

The scale of the correlation is reflected in a summary of the actual historical course of price changes for the analyzed currency pairs - Figure 3 below. Analyzing the above chart, it should be noted that the relevant reference point is the extreme events: the Covid-19 Pandemic, early 2020 and the start of the war in Ukraine on February 24, 2022. In terms of the study, it is these two events that directly translate into changes in the specificity of fluctuations in the correlation index.

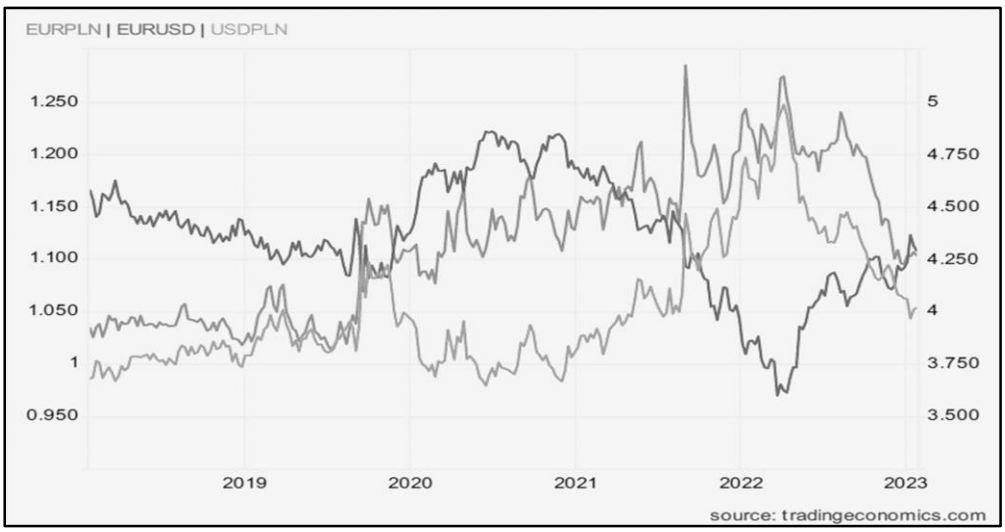
This is also perfectly illustrated in the chart below (Figure 4), which shows a summary of the correlation coefficients for the values of the historical EUR/USD - USD/PLN & EUR/USD - EUR/PLN currency pairs in monthly intervals in 2019-22.

***Figure 3**. Summary of actual historical course of rates on EUR/USD, EUR/PLN and USD/PLN pairs in 2019 - 2022*



***Source:** Author's calculations based on https://tradingeconomics.com/euro-area/currency data.*

***Figure 4.** Changes in Pearson's correlation coefficient for historical values of USD/PLN - EUR/USD and EUR/PLN - EUR/USD currency pairs in monthly intervals in 2019 - 2022*



***Source:** Author's calculations based on https://www.myfxbook.com/forex-market/correlation/EURPLN-EURUSD data.*

Table 1. *Significant values of Pearson's correlation coefficient in monthly intervals from 2019 to 2022*

Pearson correlation index		USD/PLN EUR/USD	-	EUR/PLN - EUR/USD
maximum correlation	positive	does not occur		01.11.2021 value: 0.21
maximum correlation	negative	01.01.2020 01.03.2020 value: -0,97	-	01.03.2020 value: -0,62
minimal correlation	negative	01.04.2022 value: -0,52		----------
minimum correlation	positive	does not occur		----------

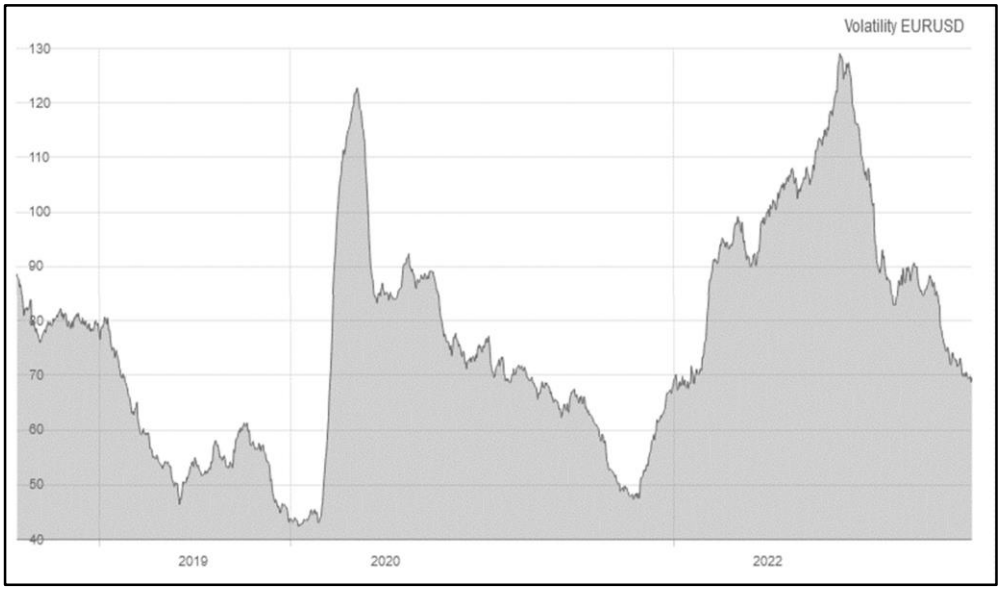
Source: *Own elaboration.*

Analyzing the above data, it can be seen that the EUR/USD and USD/PLN pairs had the highest correlation coefficient with the EUR/USD market in late 2019 and early 2020. In both cases it was a negative correlation, of which significant magnitudes (correlation >0.7) took place only in the USD/PLN relationship. It is in the case of the USD/PLN pair that we can talk about the persistence of a significant correlation volume - a value below 0.7, which persisted from the beginning of the period under study, i.e., from 2019 to the end of 2021. Thus, one can speak of a clear trend in this case.

The above data also clearly indicate that with the beginning of 2020, i.e., the start of the Covid-19 pandemic, there was a deterioration of both indicators, the situation began to normalize - the correlation indicators began to fall significantly below zero only at the end of 2022. From the perspective of the collected data, it is not possible to speak of any disequilibrium in correlations due to the outbreak of war in Ukraine (February 24, 2022).

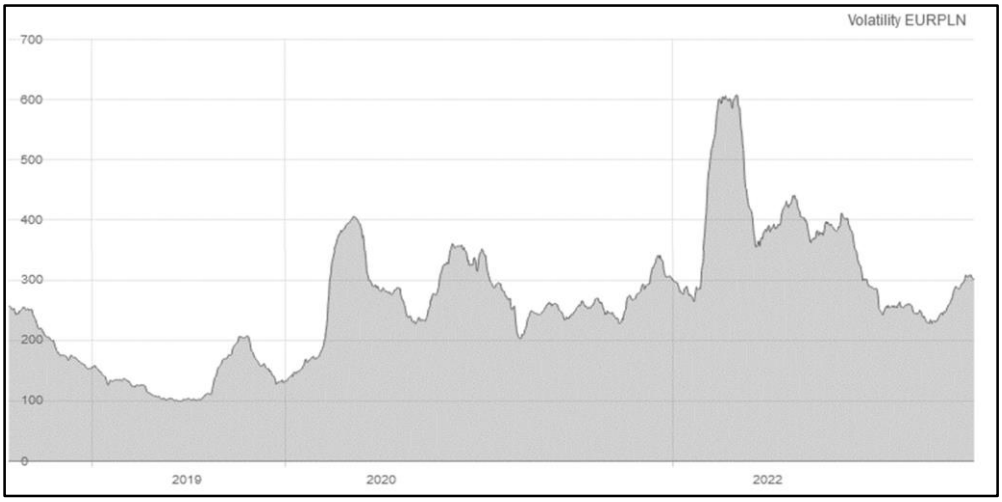
Referring to the results of previous studies, the volatility index was also adopted as relevant for studying the degree of co-movement. The volatility index was verified for the most liquid market, which is the market of the EUR/USD pair.

Figure 5. *Volatility of historical values of the EUR/USD pair from 2019 to 2022 measured in pips*



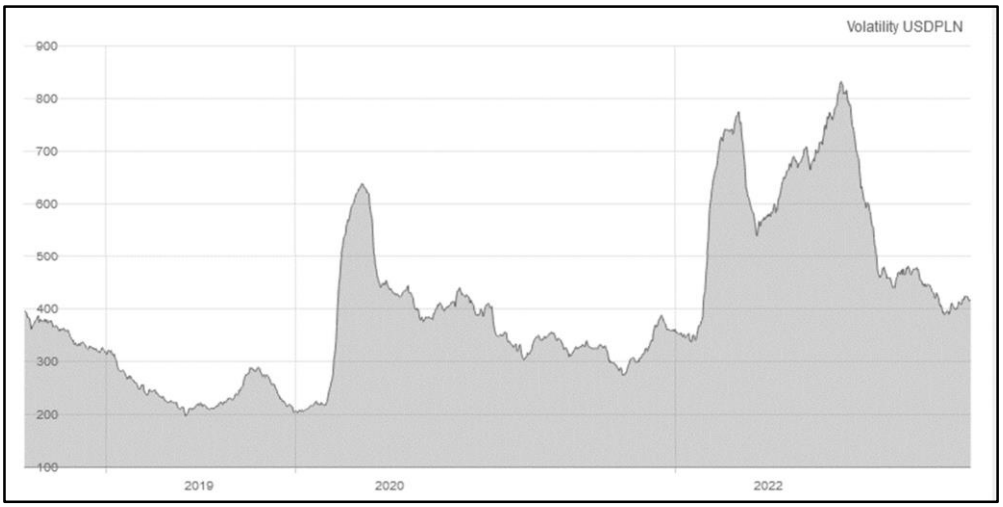
Source: *Author's calculations based on https://www.mataf.net/pl/forex/tools/volatility data*

Figure 6. *Volatility of historical values of the EUR/PLN pair in 2019-2022 measured in pips*



Source: *Author's calculations based on https://www.mataf.net/pl/forex/tools/volatility data.*

Figure 7. *Volatility of historical values of the USD/PLN pair in 2019-2022 measured in pips*



Source: *Author's calculations based on https://www.mataf.net/pl/forex/tools/volatility data.*

The above comparison of the course of volatility for the EUR/USD; USD/PLN and EUR/PLN pairs allows us to indicate that shortly before the Covid-19 pandemic and before the start of the war in Ukraine, we can talk about a clearly limited volatility. Its sharp increase occurs after the occurrence of extreme phenomena. Of which, in the case of the EUR/USD pair, we can say that a much greater increase in volatility was caused by the start of the Covid-19 pandemic than the outbreak of war in Ukraine. Exactly the opposite of the USD/PLN and EUR/PLN pairs. This is explained by Poland's near-front location.

5. Conclusions, Proposals, Recommendations

In the area of the examined historical courses of changes in the exchange rates of currency pairs, it is possible to speak of the occurrence of the phenomenon of co-variance with regard to USD/PLN and EUR/USD. The phenomenon of co-variance with regard to EUR/PLN and EUR/USD does not occur in the examined time range in a continuous manner, moreover, the hypothesis of an influence of the EUR/USD rate on EUR/PLN according to the principle "an increase in the EUR/USD rate favors the quotation of the zloty against the euro" is also not confirmed by the conducted research.

The clear anchoring of the Polish zloty to the European currency, indicated by the value of the correlation coefficient, if it is visible, is only in short time intervals, which were not the subject of the conducted research. In fundamental terms, it is certainly possible to speak of a relationship between the Polish zloty and the euro.

The study of the relationship between the USD/PLN and EUR/USD pairs based on Pearson's linear correlation coefficient confirms previous scientific views that an important element in the occurrence of co-movement in financial markets is periodic drops in liquidity, which in turn are often a prelude or aftermath of violent phenomena or turbulence.

Thus, it can be confirmed that sharp increases in liquidity and volatility in the area of the currency pairs under study do not allow confirmation of the assumption that they directly promote the occurrence of co-movement. Within the framework of prediction in the area of the foreign exchange market, the influence of EUR/USD on USD/PLN quotes is important from the point of view of modeling, with particular significance in periods of limited liquidity and volatility. We can only talk about the phenomenon of co- movement in the unidirectional aspect, i.e. as shown: the EUR/USD exchange rate has an impact on USD/PLN quotes, but changes on USD/PLN (e.g., being a reaction to internal - domestic factors) do not affect the EUR/USD exchange rate.

It is also worth pointing out at this point (as has been proven) that extreme phenomena (the Covid-19 pandemic; the war in Ukraine) occurring in the markets despite their seemingly global significance - within the framework of the research conducted - can have a differentiated impact. The conducted research allows us to accept the conclusion that co-movement phenomena do not intensify during periods of financial market turmoil, on the contrary, co-movement indicators decrease.

On the other hand, the conclusions of earlier scientific studies indicating that an increase in volatility in the foreign exchange market often leads to depreciation of the currencies of countries with relatively higher interest rates, that is, primarily emerging economies, are confirmed. This conclusion becomes particularly relevant in the current macroeconomic environment, when the interest rates of developed countries (the US, the UK) are approaching the cost of money in developing economies (Poland).

The creation of the valuation of the Polish zloty is influenced by both internal, local, regional and international factors. However, on the basis of the analysis carried out, it is impossible to say which of them have a stronger and more long-term impact. Based on the research carried out, as well as the dominant view in the literature, it should be assumed that the volatility of the Polish zloty exchange rate for years has helped stabilize the real effective exchange rate (adjusted for inflation and taking into account the structure of exports), and thus our cost competitiveness.

The area for further scientific research in this area therefore remains open and as practically justified as possible. No study can cover all aspects, thus is not without limitations, and this is also the case here. The complexity of the prediction model for the foreign exchange market directly affects its effectiveness, especially in the area of outliers.

References:

Bajgrowicz, P., Scaillet, O. 2012. Technical trading revisited: False discoveries, persistence tests, and transaction costs, Journal of Financial Economics. vol 106, 473-491.

Bednarz, J., Gędek, S. 2006. Analysis of exchange rate interdependence in the Polish foreign exchange market, Zeszyty Naukowe Szkoły Główna Gospodarstwa Wiejskiego. Ekonomika i Organizacja Gospodarki Żywnościowej.

Bettman, J., Sault ,S., Schultz, E. 2009. Fundamental and technical analysis: substitutes or complements? Accounting and Finance. vol. 49, 21-36.

Byrne, J., Korobilis, D., Ribeiro, P. 2016. Exchange rate predictability in a changing world, Journal of International Money and Finance, vol. 62, 1-24.

Dornbusch, R. 1976. Expectations and exchange rate dynamics. Journal of Political Economy, vol. 84.

Groen, J., Matsumoto, A. 2004. Real exchange rate persistence and systematic monetary policy behavior, Bank of Englad Working Papers, 231, Bank of England.

Hakim, A., Hachicha, N., Thalassinos, E. 2022. The International Spillover Among Sectors and the Interconnectedness to the Global Inflation Cycle. Available at SSRN 4058031.

James, J. 2003. Simple trend-following strategies in currency trading. Quantitative Finance, vol. 3.

Juszczuk, P. 2014, The impact of fundamental analysis on the effectiveness of investment decision support systems. Acta Universitatis Nicolai Copernici. Economics. vol. 45, No. 2,147-159.

Kamara, A., Lou, X., Sadka, R. 2008. The Divergence of Liquidity Commonality in the Cross- Section, Journal of Financial Economics, vol. 89(3), 444-466.

Liu, M., Margaritis, D., Tourani-Rad, A. 2012. Risk Appetite Carry Trade and Exchange Rates, Global Finance Journal, vol. 23, 48-63.

Menkhoff, L., Sarno, L., Schmeling, M., Schrimpf, A. 2012. Carry Trades and Global Foreign Exchange Volatility, The Journal of Finance, vol. 67(2), 681-718.

Morana, C., Beltratti, A. 2008. Comovements in International Stock Markets, Journal of International Financial Markets Institutions and Money, vol. 18, 31-45.

Moshirian, F. 2004. Elements of global financial stability. Journal of Multinational Financial Management, vol.14.

Park, Ch., Irwin, S.H. 2004. The Profitability of Technical Analysis: A Review, AgMAS Project Research Report 2004-04.

Radhwan, A., Kamel, M, Dahab, M, H, Aboul E. 2015. Forecasting Exchange Rates: A Chaos-Based Regression Approach, 38 International Journal of Rough Sets and Data Analysis, 2(1), 38-57.

Rijckeghem, C. van, Weder B. 2001. Sources of Contagion: Is It Finance or Trade? Journal of International Economics, vol. 54(2), 293-308.

Rossi, B. 2013. Exchange rate predictability, Journal of Economic Literature, 51(4), 1063-1119.

Thalassinos, E.I., Politis, E. 2012. The evaluation of the USD currency and the oil prices: A VAR Analysis. European Research Studies Journal, 15(2).

Xu, Y., Taylor, N., Lu, W. 2018. Illiquidity and Volatility Spillover Effects in Equity Markets during and after the Global Financial Crisis: An MEM Approach, International Review of Financial Analysis, vol. 56, 208-220.

Zelias, A. 1997. Theory of Forecasting, Polskie Wydawnictwo Ekonomiczne, Warsaw.