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### *The Causal Relationships between WIG20 and PLN*

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Zależności przyczynowe między WIG20 i PLN

**Keywords:** exchange rates; stock prices; Granger causality

**Słowa kluczowe:** kursy walut; ceny akcji; przyczynowość w sensie Grangera

**JEL code:** F31; G10; G15

#### **Introduction**

The inflow of information to financial market participants causes constant changes in the valorisation of individual instruments. Price fluctuations are the result of a reaction to the expected future changes in microeconomic and macroeconomic factors as well as behavioural factors related to the prevailing emotional sentiment among investors. The results are price changes and capital transfers between various financial assets and geographic regions. The paper attempts to investigate the relationship between price changes on the Polish capital and currency market. The aim of the analysis was to examine the causal relationship between changes in the WIG20 index, representing the stock market, and changes in the zloty exchange rate (PLN). The conducted research is of particular importance in the conditions of the progressive internationalization of the operations on the financial market. The share of foreign investors trading on the Warsaw Stock Exchange market exceeds 50%, and currency fluctuations may have a significant impact on the profitability

estimates of the investments. Therefore, the study of causality between the changes of the WIG20 and the PLN exchange rate will allow for a better analysis of the key determinants of the valuation of Polish assets.

The relationships between the stock market and the currency market have been the subject of quite extensive research. Various methods, geographic areas and a diversified range of data were used in the analyses, and the results were quite ambiguous. Jorion investigated the exposure of US corporations to currency risk and concluded a significant relationship exists between exchange rates and return rates [Jorion, 1990, pp. 331–345]. Bahmani-Oskooee and Sohrabian did not find long-term relationships between the stock market and exchange rates in the United States [Bahmani-Oskooee, Sohrabian, 1992, pp. 459–464]. Roll came to a different conclusion, identifying exchange rates as significant factors of changes in stock exchange indices in various countries [Roll, 1992, pp. 3–41]. Ajayi and Mougoue came to similar conclusions, examining markets from eight developed countries [Ajayi, Mougoue, 1996, pp. 193–207]. Abdalla and Murinde analysed the interdependencies between stock and currency markets on four Asian emerging markets. In the results, they emphasized the one-way causality between the prices of shares and exchange rates, in which the currency market was the reason [Abdalla, Murinde, 1997, pp. 25–35]. Nieh and Lee conducted a similar test for the group of G7 states and did not confirm the relationship between share prices and exchange rates [Nieh, Lee, 2001, pp. 477–490]. Relationships between the currency market and the stock market were also examined for emerging markets in South Asia. In this case, one-way causality was found from the exchange rate to share prices for India and Sri Lanka, whereas in the case of Bangladesh and Pakistan, no relationships were identified [Smyth, Nandha, 2003, pp. 699–704]. Grambovas investigated the relationship between currency volatility and the stock market for Greece, Hungary and the Czech Republic. He emphasized strong ties and for that reason recommended extreme caution in economic policy [Grambovas, 2003, pp. 24–48]. Fedorova and Saleem examined the relationship between stock and currency markets in the pre-crisis period in 2008, in Poland, Hungary, Russia, and the Czech Republic, confirming the existence of one-way relationships and the currency market as the reason for the changes. The exception was the Czech Republic, where the stock market influenced the currency market [Fedorova, Saleem, 2010, pp. 519–533]. Koseoglu and Cevik, who studied the Czech, Hungarian, Polish, and Turkish markets, came to different conclusions. They pointed to the stock market as significantly affecting the level of the mean and variance [Koseoglu, Cevik, 2013, pp. 65–86]. The interdependencies between the stock and currency market in the context of the crisis were also analysed. Wong and Li studied the relationship between the stock market and real exchange rates for 11 economies in two financial crises in 1997 and 2008. They obtained strong evidence for a stochastic relationship between the variables and the importance of exchange rate stability during a financial crisis [Wong, Li, 2010, pp. 137–150]. The countries of the south of Europe were examined in the conditions of fiscal crisis and political

instability, pointing to the occurrence of two-way, asymmetrical relationships [Andrikopoulos, Samitas, 2014, pp. 1261–1283]. Hajilee and Al Nasser, examining 12 emerging markets in 1980–2010, emphasized that volatility of the exchange rate has a significant impact on the stock market in both the short and long term [Hajilee, Al Nasser, 2014, pp. 163–180]. The analysis of Asian financial markets also pointed to the relationship between changes in share prices and exchange rates. The Granger causality test applied in quantiles showed that the majority of the surveyed stock and currency markets were negatively correlated and that two-way causal relationships occurred [Yang et al., 2014, pp. 1184–1201]. Recent studies also confirm the existence of a causal link between stock and currency markets in the US, Canada, and the United Kingdom. The results obtained using the asymmetric threshold model even confirm the sensitivity of relationships to short-term messages [Koulakiotisa et al., 2015, pp. 1273–1285].

Taking into account the existing research, the relationship between WIG20 and PLN and their stability in various phases of the business cycle was analysed. Therefore, we posit the research hypothesis: causal relationships exist, in the Granger sense, between WIG20 changes and exchange rate changes for PLN.

## 1. Test sample and test method

The analysis of the relationship between the stock market in Poland and the PLN exchange rate was based on data covering the period from April 12, 2000 to the end of December 2017. The beginning of the research period resulted from changes in the Polish currency system. On April 12, 2000, a floating exchange rate for PLN became effective, devastating devaluation. Limitations of exchange rate fluctuations were lifted. It was decided to conduct the analysis from the date of change in the currency regime, assuming full freedom in shaping the PLN exchange rate. For the equity market, the index describing the economic situation on the Warsaw Stock Exchange will be the WIG20 index. This is the most popular benchmark index, and it is a reference point for many institutional investors, both domestic and foreign. It is a fairly good indicator of sentiment among foreign investors and therefore is useful for comparisons with changes in the currency market. The situation on the PLN market was measured using two USD/PLN and EUR/PLN exchange rates because the US dollar and the euro were the main currencies for exchange transactions for PLN. However, the share of particular currencies in the turnover has changed. Statistics published by the Polish National Bank (NBP) indicated that in the first part of the analysed period, transactions on USD/PLN prevailed in the market turnover, and after Poland's accession to the EU, operations focused on a EUR/PLN pair [NBP].

Conducting the analysis required some changes and data transformations. First, the time series of variables were synchronized. Differences in the ranks were due to the specification of individual markets. Most often it was caused by days off work

and extraordinary events. To ensure full compatibility of the time series, adjustments were made. The lack of records was supplemented with the theoretical price, which was the arithmetic mean of the neighbouring observations. As a result, 4,601 observations corresponding to the daily rates of individual assets were obtained for the audited period.

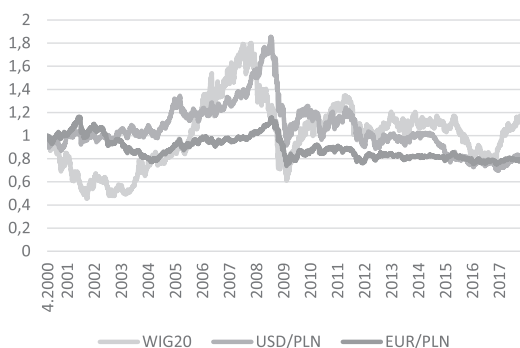


Figure 1. The value of synthetic indices in the period April 2000 – December 2017

Source: Author's own study.

To achieve comparability of assets, they were transformed by determining synthetic indexes. The value of each index, WIG20, USD/PLN and EUR/PLN, was assumed to be one on April 12, 2000, the first day of the period under examination. For the synthetic WIG20 index, it was assumed that its changes result from subsequent daily percentage changes. In the case of synthetic currency indices, a slightly different approach was followed. The changes in indices also resulted from changes in the percentage of daily currency rates, but here, the reverse was true of the equity market. The fall in the exchange rate meant a strengthening of the PLN and an increase in the synthetic currency index. The increase in the exchange rate resulted from the weakening of the PLN and was responsible for the decline in the index. Figure 1 presents the development of synthetic indices in the analysed period.

In the next stage of analysis, on the basis of synthetic WIG20, USD/PLN and EUR/PLN indices, daily logarithmic rates of return  $r_t$  were determined.

$$r_t = \ln\left(\frac{y_t}{y_{t-1}}\right)$$

where:

$y_t$  – the value of the index on day  $t$ , and

$y_{t-1}$  – the value of the index on day  $t-1$ .

The rates of return were calculated based on data on the value of indices at the end of day  $t$  and on the day preceding  $t-1$ . As a result, three time series of logarithmic

daily returns of synthetic WIG20, USD/PLN and EUR/PLN indexes were obtained, which were subject to further analysis.

The study of dependencies was carried out in five periods. One covered the range from April 12, 2000 to the end of December 2017. Then four sub-periods were identified to examine the durability of the relationships between the variables. The first, until the end of April 2004, covered the period before Poland's accession to the EU. The second, from May 2004 to the end of October 2007, corresponded to the period from the accession to the boom of the global financial markets. The third, from November 2007 to the end of March 2009, covered the period of the financial crisis. The last sub-period, from April 2009 to the end of December 2017, corresponded to the post-crisis years.

First, stationary time series analysis was performed using the ADF unit element test and the KPSS test. Equally in the cases of both tests, the hypothesis about the lack of stationarity of variables in the five analysed periods could be rejected. Therefore, the logarithmic daily turnover rates of synthetic WIG20, USD/PLN and EUR/PLN indices are assumed to be stationary.

Table 1. Results of stationary tests

| Variable                   | ADF test               |        | KPSS test   |
|----------------------------|------------------------|--------|---|
|                            | The level of variables |        | Critical value<br>( $\alpha=0.05$ ) 0.462;<br>( $\alpha=0.01$ ) 0.741 |
|                            | Test statistic         | p      | Test statistic  |
| April 2000 – December 2017 |                        |        |   |
| WIG20                      | -48.0532               | 0.0000 | 0.0918  |
| USD/PLN                    | -18.1937               | 0.0000 | 0.1374  |
| EUR/PLN                    | -13.9203               | 0.0000 | 0.0402  |
| April 2000 – April 2004    |                        |        |   |
| WIG20                      | -31.0085               | 0.0000 | 0.4164  |
| USD/PLN                    | -29.8084               | 0.0000 | 0.0368  |
| EUR/PLN                    | -15.4218               | 0.0000 | 0.1901  |
| May 2004 – October 2007    |                        |        |   |
| WIG20                      | -29.2729               | 0.0000 | 0.0338  |
| USD/PLN                    | -28.9700               | 0.0000 | 0.1252  |
| EUR/PLN                    | -30.2642               | 0.0000 | 0.1989  |
| November 2007 – March 2009 |                        |        |   |
| WIG20                      | -18.1495               | 0.0000 | 0.0390  |
| USD/PLN                    | -6.6729                | 0.0000 | 0.4934  |
| EUR/PLN                    | -8.4357                | 0.0000 | 0.6196  |
| April 2009 – December 2017 |                        |        |   |
| WIG20                      | -17.6715               | 0.0000 | 0.2365  |
| USD/PLN                    | -14.7826               | 0.0000 | 0.0890  |
| EUR/PLN                    | -13.9990               | 0.0000 | 0.0902  |

Source: Author's own study.

In the next stage, interdependencies between synthetic indexes were investigated. Causality in the Granger sense was analysed using the autoregressive vector (VAR)

model. The time series of variables were stationary, which is why the studied relationships were presented with the VAR model in the following form:

$$SP_t = a_{SP0} + \sum_{i=1}^p a_{SP1i} SP_{t-i} + \sum_{i=1}^p a_{SP2i} FX_{t-i} + \varepsilon_{SPt}$$

$$FX_t = a_{FX0} + \sum_{i=1}^p a_{FX1i} FX_{t-i} + \sum_{i=1}^p a_{FX2i} SP_{t-i} + \varepsilon_{FXt}$$

where:

$SP_t$  – logarithmic daily rate of return of the synthetic equity index;

$FX_t$  – logarithmic daily rate of return of the synthetic currency index;

$a_{SP0}$ ,  $a_{FX0}$  – free words;

$p$  – delay order for variables  $SP_t$  and  $FX_t$ ; and

$a_{SP1i}$ ,  $a_{SP2i}$ ,  $a_{FX1i}$ ,  $a_{FX2i}$  – coefficients defining short-term dependencies.

Granger's linear causality tests were carried out using the VAR model for WIG20, USD/PLN and WIG20, EUR/PLN.

## 2. Test results

While analysing the interdependencies between changes in the economic situation on the Warsaw Stock Exchange and changes in the PLN exchange rate on the currency market, research was conducted in five periods. For each period, causality in the Granger sense was analysed between the indices.

Based on causality tests for VAR models, eight one-way relationships and one bi-directional relationship were recorded between indices. For all one-way relationships, changes in currency indices were the reason for changes in the equity index. Throughout the research period, from April 2000 to December 2017, three significant causal relationships were identified. Changes in USD/PLN and EUR/PLN were the reason for WIG20 changes, but also WIG20 changes were the reason for changes in the EUR/PLN exchange rate.

In the sub-periods, there was a clear stability of one-way causal relationships. Only in the first pre-accession period to the EU was there one causal relationship, while in the remaining periods, two one-way relationships were found that were caused by the change in the USD/PLN and EUR/PLN indices. The result was the change in the equity index. The dependence occurred in a fairly wide time range and with very diverse business conditions, both in the second sub-period, after accession to the EU, which corresponded to the global economic summit, and in the third sub-period, which included a serious financial crisis in 2007–2009. One-way

Table 2. Results of causality tests for VAR models

| Cause → Effect             | Test value             | Value <i>p</i> |
|----------------------------|------------------------|----------------|
| April 2000 – December 2017 |                        |                |
| WIG20 → USD/PLN            | $F(2; 4593) = 0.1778$  | (0.8371)       |
| USD/PLN → WIG20            | $F(2; 4593) = 17.3990$ | (0.0000)       |
| WIG20 → EUR/PLN            | $F(4; 4587) = 2.3801$  | (0.0495)       |
| EUR/PLN → WIG20            | $F(4; 4587) = 12.2310$ | (0.0000)       |
| April 2000 – April 2004    |                        |                |
| WIG20 → USD/PLN            | $F(1; 1070) = 0.2146$  | (0.6433)       |
| USD/PLN → WIG20            | $F(1; 1070) = 4.2295$  | (0.0400)       |
| WIG20 → EUR/PLN            | $F(1; 1070) = 0.4795$  | (0.4888)       |
| EUR/PLN → WIG20            | $F(1; 1070) = 1.5399$  | (0.2149)       |
| May 2004 – October 2007    |                        |                |
| WIG20 → USD/PLN            | $F(1; 907) = 0.0004$   | (0.9825)       |
| USD/PLN → WIG20            | $F(1; 907) = 10.9330$  | (0.0010)       |
| WIG20 → EUR/PLN            | $F(1; 907) = 0.0542$   | (0.8160)       |
| EUR/PLN → WIG20            | $F(1; 907) = 6.5709$   | (0.0105)       |
| November 2007 – March 2009 |                        |                |
| WIG20 → USD/PLN            | $F(8; 341) = 0.9088$   | (0.5092)       |
| USD/PLN → WIG20            | $F(8; 341) = 3.3925$   | (0.0009)       |
| WIG20 → EUR/PLN            | $F(5; 350) = 0.3362$   | (0.8909)       |
| EUR/PLN → WIG20            | $F(5; 350) = 3.7260$   | (0.0027)       |
| April 2009 – December 2017 |                        |                |
| WIG20 → USD/PLN            | $F(2; 2263) = 0.0323$  | (0.9682)       |
| USD/PLN → WIG20            | $F(2; 2263) = 7.3260$  | (0.0007)       |
| WIG20 → EUR/PLN            | $F(5; 2254) = 1.4759$  | (0.1944)       |
| EUR/PLN → WIG20            | $F(5; 2254) = 4.5031$  | (0.0004)       |

Source: Author's own study.

relationships in which the reasons for changes on the stock market were changes on the currency market also occurred in the last sub-period, post-crisis, corresponding to the economy after the collapse in 2008. It seems that the only lack of impact of the EUR/PLN index on the equity market in the first research sub-period can be explained by the level of development of the domestic foreign exchange market at that time. In the pre-accession period, USD/PLN was the main currency pair for the zloty, and the euro was the margin of trading on the currency market and hence the most likely lack of influence on the stock index [NBP]. This meant that changes in the currency market were ahead of changes in the equity market. Strengthening the PLN and declines in USD/PLN and EUR/PLN rates may have promised WIG20 increases, and the weakening of the PLN could have caused a drop in the equity market.

Attention was also paid to one bi-directional relationship, between EUR/PLN and WIG20, for the period from April 2000 to December 2017. It would mean a dependence in which both the currency market influences the stock market and the stock market influences the exchange rate changes. However, such conclusions should be approached with caution because the relationship has not been confirmed in any of the sub-periods examined. This issue requires further and more thorough research.

## Summary

Research on the relationship between the stock market on the Warsaw Stock Exchange and changes in the PLN exchange rate indicated the existence of some significant relationships. The survey covered the period from April 2000 to December 2017, which in one of the analyses is divided into four sub-periods based on changes in the market situation.

In the analysis covering the entire research period, however, the results were slightly different. A causal relationship did exist in which changes in the exchange rate were the reasons for changes in the equity market, both for the USD/PLN and EUR/PLN index. However, a two-way relationship was found between EUR/PLN and WIG20, which would indicate mutual causal relationships. The result was treated with great caution because it was not confirmed in any of the sub-periods examined. A two-way relationship requires further, more accurate research for better specified models. At this stage of the research, however, it is possible to confirm causal relationships, occurring stably, despite fluctuations in the economic situation, in which changes in the PLN exchange rate are the reasons for changes in the WIG20 index. This could indicate a situation in which the sentiment of foreign investors in Polish assets is most visible in the PLN exchange rate and then gradually begins to transfer to the stock market. As a result, the strengthening PLN exchange rate would mean an inflow of capital to Poland, which would cause increases in exchange rates over the course of time. *Vice versa*, weakening the PLN would mean foreign capital outflow, which would lead to deterioration of investors' moods and declines in share prices.

The research confirmed the occurrence of causal relationships, in the Granger sense, between the currency market and shares. The findings showed that changes in the equity index are caused by changes in currency indices. The results were obtained from the scientific discussion of the problems of interdependence between the stock market and the foreign exchange market and confirm the observed relationships in part of the research.

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### Zależności przyczynowe między WIG20 i PLN

W artykule przedstawiono wyniki badania interakcji między cenami akcji a kursami walut na polskim rynku finansowym. Wykorzystano dwuwymiarowy model wektorowej autogresji i zastosowano dzienne dane o indeksie giełdowym i indeksie kursów walut dla okresu od kwietnia 2000 r. do grudnia 2017 r. Wyniki empiryczne wskazały na jednokierunkową przyczynowość od kursów walutowych do cen akcji.

### The Causal Relationships between WIG20 and PLN

The article examines the interaction between share prices and exchange rates on the Polish financial market. A two-dimensional model of vector autoregression was used and daily data on the stock exchange index and exchange rate index for the period from April 2000 to December 2017 were used. The empirical results indicated a one-way causality from exchange rates to share prices.