Managerial Economics
2016, vol. 17, no. 1, pp. 7–20
http://dx.doi.org/10.7494/manage.2016.17.1.7

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The long-run relationship between the stock market and main macroeconomic variables in Poland

1. Introduction

In the financial literature, there are some studies concerning long-term relationships between financial markets. For example, Chen et al. (2002) investigated the dynamic interdependence of the major stock markets in Latin America. Using data from 1995 to 2000, they found that there is one cointegrating vector that appears to explain the dependencies in prices of the the stock market indices of Argentina, Brazil, Chile, Colombia, Mexico, and Venezuela. On the basis of daily data from the period 1993–2002, Voronkova (2004) showed the existence of cointegration between European developed markets and the stock markets of Czech Republic, Hungary, and Poland. Additionally, Syriopoulos (2007) indicated that the long-term linkages between emerging CEE markets (Czech Republic, Hungary, Poland, and Slovakia) and developed markets (Germany and the US) are stronger than among the CEE countries themselves.

Furthermore, researchers also studied the relationship between stock markets and exchange rates. Each of these variables play crucial roles in influencing the development of a country's economy (Nieh and Lee, 2001); therefore, this subject has drawn the attention of investors and policy makers. This relationship can be used by practitioners to predict future trends for each other. Among the macroeconomic indicators, exchange rates are able to influence stock prices through trade effect (Geske and Roll, 1983). Moore (2007) investigated the effect of the euro on stock markets for Hungary, Poland, and the UK, and also the co-movement

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of stock prices with the euro-zone using the daily stock price indices. The result reveals that the exchange rate is a more-important factor for Hungary than for Poland. The existence of long-run equilibrium relationships among stock prices, industrial production, real exchange rates, interest rates, and inflation in the United States was investigated by Kim (2003). Applying Johansen's cointegration analysis for monthly data for the period 1974–1998, they found that the S&P 500 stock price is positively related to industrial production yet negatively related to the real exchange rate, interest rate, and inflation. Analysis of the error-correction mechanism revealed that the stock price, industrial production, and inflation adjust to correct disequilibrium among the five variables, while variance decompositions indicate that the stock price is driven by innovations in the interest rate.

What is more, Rjoub (2012) studied the long-run relationship between Turkish stock prices, the exchange rates, and US stock prices to reflect world trends. He found that the floating exchange rate has a negative impact on the Turkish stock market; therefore, a decline in the value of the Turkish national currency is expected to stimulate domestic economic activity. Abdelaziz et al. (2008) used cointegration analysis to investigate the long-run dynamics among domestic stock prices, the global market index represented by the US stock market, oil prices, and the real exchange rates in four oil-exporting Middle East countries. A long-run equilibrium relationship was found among stock prices, real exchange rates, and oil prices for three countries: Egypt, Oman, and Saudi Arabia.

The issue of relationships between stock prices and some economic variables was taken into consideration by Fifield et al. (2002), Bhattacharya and Mukherjee (2006), Brahmasrene and Jiranyakul (2007), Humpe and Macmillan (2007), Mahmood and Dinniah (2009), and Barbic and Condic-Jurkic (2011), among others.

Capital markets play a vital role in achieving sustainable economic growth. Stock markets are particularly important to economic development. Traditional models of the economy suggest that a link exists between stock market performance, exchange rate behavior and the levels of export and import. Dornbusch and Fischer (1980) suggest that exchange rate fluctuations affect the competitiveness of firms, as changes in the exchange rate affect the value of the earnings. The depreciation of local currency makes exporting goods attractive and leads to an increase in stock prices, as growing foreign demand increases a firm's revenues (which positively affects its) value.

The aim of this paper is to investigate the long-run dynamics among some macroeconomic variables, the EUR/PLN exchange rate, and stock prices on the Warsaw Stock Exchange (WSE). For this purpose, a cointegration analysis has been performed using the procedure from Johansen (1988). In this paper, we search the long-term relationship between the stock market, EUR/PLN exchange rate, export volume, and rate of inflation measured by the Consumer Price Index (CPI).

The collected data set exhibits some problems with seasonal and cyclical variations. Such variables may be seasonally adjusted by applying the various types of filtering described in Lutkepohl (2004) and Otsu (2009). Loef and Franses (2000) proved empirically that the seasonal cointegration models yield to more-accurate forecasts only for longer horizons, while the nonseasonal models outperform the other methods in shorter horizons. Lutkepohl (2005) showed that different treatments of seasonal data affect the system and change the impulse response functions.

The rest of the paper is organized as follows: in the next section, we give a short description of the methodology applied in the paper. In Section 3, we present and analyze in detail the data that we use in the empirical study. A short summary concludes the paper.

2. Methodology

Model VEC

The aim of a cointegration analysis is to determine if there are any common stochastic trends between the considered variables. If there is a common stochastic trend, the variables will share a common long-run equilibrium.

Let $Y_t = (Y_{1t}, \ldots, Y_{Kt})$ denotes a vector of K variables. After a determination, an order of integration of Y_t the Johansen's methodology (1988) is applied to investigate the cointegration between the considered time series.

When Y_t is integrated of the order $I(1)$, the VECM model is built, which has a following form:

$$\Delta Y_t = \Pi Y_{t-1} + \Gamma_1 \Delta Y_{t-1} + \ldots + \Gamma_{p-1} \Delta Y_{t-p+1} + \varepsilon_t \quad (1)$$

When **rank** $(\Pi) = r$ and $r < K$, then there are r cointegration relations, and matrix Π can be expressed as $\Pi = \alpha\beta^T$.

Each component of $\beta^T Y_{t-1}$ is stationary and defines a long-run equilibrium relationship.

Testing for the cointegration between components of Y_t is equivalent to testing the rank of matrix Π. To test for the cointegration rank, Johansen proposes two different pairs of hypotheses, which are:

$$H_0\text{: } rank\ (\Pi) = r \text{ against } H_1\text{: } r < rank\ (\Pi) \leq K \quad (2)$$

and

$$H_0\text{: } rank\ (\Pi) = r \text{ against } H_1\text{: } rank\ (\Pi) \leq r + 1 \quad (3)$$

A test statistic testing the first hypothesis is referred to as the trace statistic, whereas a test statistic used in the second hypothesis is referred as the maximum eigenvalue statistic.

Let $\lambda_1, \ldots, \lambda_s$ be eigenvalues of the Π matrix put in ascending order. The trace statistic and the maximum eigenvalue statistic have following formulas:

$$\lambda_{trace}\left(r,K\right) = -T\sum_{i=r+1}^{K}\log(1-\hat{\lambda}_i) \tag{4}$$

and

$$\lambda_{\max}\left(r,r+1\right) = -T\log(1-\hat{\lambda}_{\max}) \tag{5}$$

Both tests are performed step-by-step until the null hypothesis can no longer be rejected.

Impulse Response Function

The previous section discussed the interrelations between the variables of a system. However, knowledge about the response of one variable to an impulse of another variable seems to be more interesting. Therefore, in what follows, the impulse-response analysis is carried on. Let model VEC be presented as the following VAR model:

$$Y_t = \mu + A_1Y_{t-1} + A_2Y_{t-2} + \ldots + A_{p-1}Y_{t-p+1} + \varepsilon_t \tag{6}$$

where $A_1, \ldots, A_{p-1}$ are autoregressive parameter matrices and ε_t is a vector of residuals. It is assumed that $\varepsilon_t \sim N(0,\Sigma)$.

Matrix Σ can be decomposed as $\Sigma = W\Sigma_eW^T$, where Σ_e is the diagonal matrix. Then, process Y_t can be written equivalently as follows:

$$Y_t = \mu^* + A_0^*Y_t + A_1^*Y_{t-1} + A_2^*Y_{t-2} + \ldots + A_{p-1}^*Y_{t-p+1} + e_t \tag{7}$$

where $A^*_i = W^{-1}A_i$
or as its moving average representation:

$$Y_t = \mu^* + \Psi_0^*e_t + \Psi_1^*e_{t-1} + \Psi_2^*e_{t-2} + \ldots \tag{8}$$

where $e_t = W^{-1}\varepsilon_t$, $\Psi^*_0 = W$ and $\Psi^*_k = \Psi_kW$ for $k = 1, 2, \ldots$

Matrices Ψ_1, Ψ_2 ... come from the moving-average representation of (6). This means that element of the matrix $\Psi^*_{ij,k}$ represents the influence of the $e_{j,t}$ disturbance on $Y_{i,t+k}$.

3. Empirical study

Data

We study the long-term relationship between the Warsaw stock market represented by the WIG20 index, EUR/PLN exchange rate, export volume, and rate of inflation (CPI). The WIG20 prices and monthly EUR/PLN exchange rates were collected from the stooq.pl database, the CPI data is collected from the Central Statistical Office of Poland (GUS), and the Export data is derived from the Eurostat base. In empirical analysis, the logarithm of monthly closing price of WIG20 is considered, the CPI was obtained by comparing the prices of the considered month to the prices of the period where the index was equal to 100. The Export data is given in million EUR and represents the value of goods exported in *t* months.

The period under study covers the time from January to December, 2015. This period contains different market phases; particularly, it covers the period of the global financial crisis in 2008, which is visible in data spikes on the times-series plots (Figure 1, Figure 2).

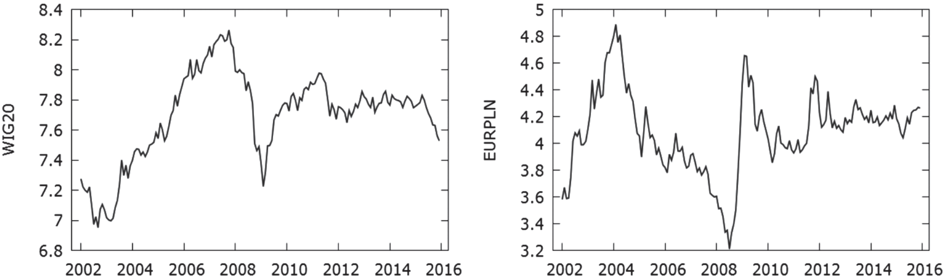

Figure 1. The plots of monthly prices of WIG20 and the monthly EUR/PLN exchange rate

Source: author's own research

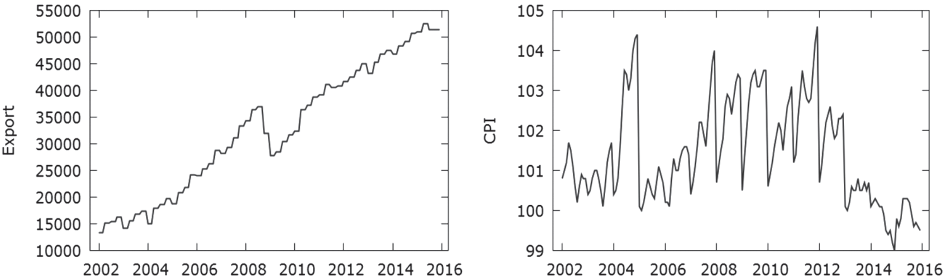

Figure 2. The plots of monthly export in million EUR and monthly Consumer Price Index

Source: author's own research

Firstly, all time series denoted as WIG20, EUR/PLN, CPI, and Export have been tested to be stationary or not. The results of an ADF test (including trend) indicate that variables WIG20, EUR/PLN, and CPI are $I(1)$, whereas Export is $I(0)$. These results are confirmed by a KPSS test. However, the vector consisting of all analyzed variables is $I(1)$ (Lutkepohl, 2005), so the one from the assumptions of possibility of the VECM building is fulfilled.

The data plots (Figure 1 and 2) suggest the presence of seasonality and outliers in some of the variables.

Therefore, all variables under study were tested for the existence of seasonal patterns, level shifts, or outliers. The data has been filtered by employing the X-12-ARIMA algorithm. This filter is used to detect and adjust outliers and other distorting effects. According to proper test results, seasonal moving-average filtering was applied only for the CPI variable, whereas the other variables were corrected for outliers and level-shift existence.

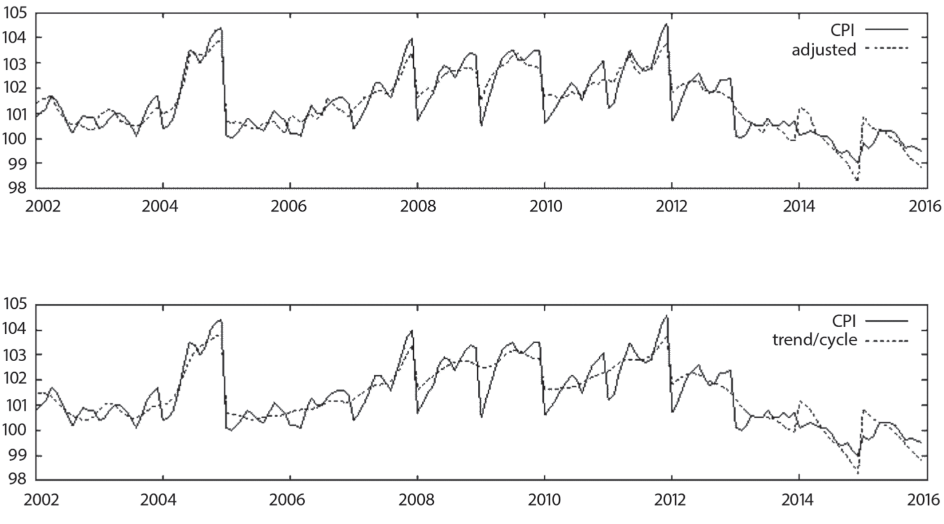

Figure 3. Filtered CPI data

Figures 3 and 4 present the seasonally adjusted series and estimated trends for the CPI and corrected EUR/PLN rate compared with the original data plots. The seasonally adjusted series also incorporate corrections for irregular fluctuations represented by sampling and non-sampling errors or strikes. We can observe significant differences between the adjusted and original series for the CPI, as this was additionally filtered in order to remove seasonality.

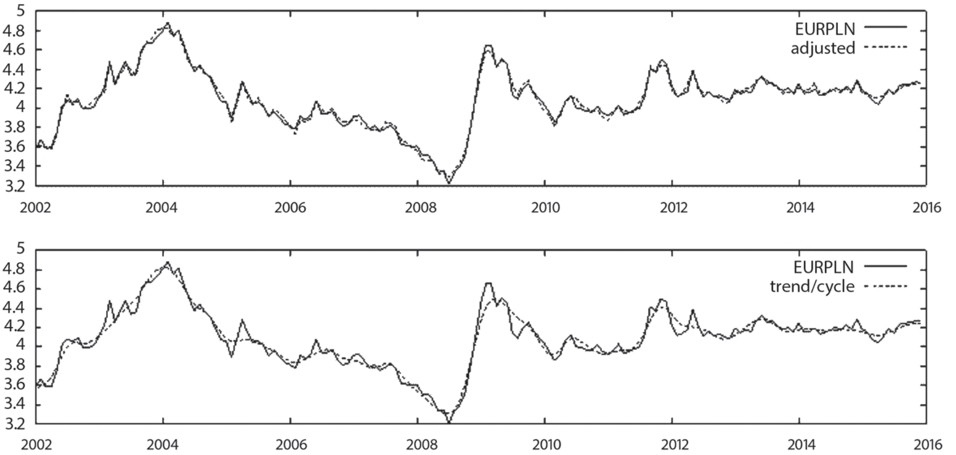

Figure 4. Filtered EUR/PLN data

Model VEC estimation

In order to choose the optimal lag length in model VEC, some information criteria have been used: Akaike information criterion (AIC), Hannan–Quinn (H-Q) information criterion (HQC), Schwartz criterion (SC), and Final Prediction Error criterion (FPE). All the information criteria prefer the model with one lag; so, taking into account the data frequency, we assume one lag length in the VEC model.

Next, the Johansen trace test with linear trend and test of maximum eigenvalue with linear trend have been applied to verify the existence of a long-run relationship between the studied time series. The obtained results coming from both tests indicate the existence of one cointegrating relationship between the index of the stock market and the considered economic variables. Applying the Johansen trace test, we obtained *p-value*=0.00 for *rank*(Π)=1 and *p-value*=0.06 for *rank*(Π)=2, whereas applying the Johansen maximum eigenvalue test, we obtained *p-value*=0.05 for *rank*(Π)=1 and *p-value*=0.13 for *rank*(Π)=2. So, we obtained one long-term relationship between variables WIG20, Export, CPI, and EUR/PLN. The results are presented in Table 1.

The cointegrating equation normalized with respect to the WIG20 variable has the following form:

$$\begin{aligned} \mathrm{WIG20}_t = &-0.046867\ \mathrm{trend} - 0.57937\ \mathrm{EURPLN}_t + \\ &0.00022358\ \mathrm{Export}_t + 0{,}22022\mathrm{CPI}_t + \varepsilon_t \end{aligned} \tag{9}$$

The equation above represents the long-run equilibrium for WIG20 and the other variables.

Table 1

Parameters of cointegrating relationship

Variable	β	α
WIG20	1.00	0.04
EURPLN	0.58	−0.03
Export	−0.00	464.77
CPI	−0.22	0.12
Trend	0.05	–

Source: authors' calculations

As the β coefficient for WIG20 has been normalized to 1, the other beta parameters can be interpreted as the level of impact of the system variable related to this parameter on the stock market behavior. We can notice that the Export variable has neglected impact on the stock market, since parameter β is close to zero. According to our expectations, the CPI variable impacts positively on WIG20; however, the level of this impact is rather moderate. The EUR/PLN exchange rate has the biggest impact on WIG20 fluctuations. The results confirmed the fact that the exchange rate plays a crucial role to influence stock prices through trade effect (Geske and Roll, 1983). Since the parameter beta is negative, this implies that EUR/PLN has the opposite impact on the stock index value.

Parameter α in each equation reflects the speed of variable adjustment to the equilibrium relation. The sign of this parameter depends on the direction of the variables' disturbance from the equilibrium relation. If the variables are above the equilibrium, a negative α denotes that they get back to the equilibrium in the next time periods. When α is positive, the variables move away from the equilibrium state. A bigger α (in absolute value) is equivalent to the faster convergence of variables to the equilibrium.

From the results obtained, we can conclude, that Export (having a very low impact on WIG20) departs the equilibrium very quickly, while CPI moves away from this state in a slower phase. EUR/PLN relatively quickly adjusts itself to the equilibrium relationship. As α corresponding to WIG20 is very close to zero, the variable achieves the equilibrium relationship with a very low speed.

Table 2 presents the estimated short-term relationships between the system variables. We can conclude that the WIG20 depends on its lagged values and on the lag of the EUR/PLN interest rate. The EUR/PLN exchange rate does not depend only on the lag of CPI. The Export is being explained only by the lag of EUR/PLN, while CPI is not being explained by the lags of any of the variables creating the system.

Table 2

Coefficients of short-term relation

	Δ**Wig20**$_t$	Δ**CPI**$_t$	Δ**EURPLN**$_t$	Δ**Export**$_t$
Δ**Wig20**$_{t-1}$	−0.24**	−0.69	0.29*	−1796.53
Δ**CPI**$_{t-1}$	−0.00	0.01	0.01	101.53
Δ**EURPLN**$_{t-1}$	−0.10**	0.10	0.22**	−1651.32*
Δ**Export**$_{t-1}$	0.00***	0.00	−0.00***	464.77

Source: authors' calculations

Impulse response function

Figure 5 presents the results of the responses of each variable to one standard deviation shock coming from other variable. We observe that shocks have a permanent impact on each considered variable. In each case, the impulse in one variable causes an immediate increase or decrease in the value of another variable. The effect of shock disappears after some time, and a new level of equilibrium is established. Firstly, let us consider the WIG20 response to a shock coming from other variables. A one-standard-deviation shock to WIG20 causes that, in the beginning, it decreases slightly; later, it stabilizes at a new level of equilibrium lower than the initial state.

WIG20 responds to a one-standard-deviation shock coming from the EUR/PLN exchange rate in a different manner. In the beginning, it decreases a little; later, it grows to reach maximum; and finally, it also decreases and stabilizes at a new level of equilibrium higher than the initial state.

The WIG20 responds to a one-standard-deviation shock coming from Export or CPI quite differently than in the previous two cases. When an impulse comes from the Export variable, the stock index price increases a little in the beginning; later, it decreases to reach a new level of equilibrium lower than the initial state. But when the impulse comes from CPI variable, the stock index price decreases to reach a new level of equilibrium that is also lower than the initial state.

The rest of the analysis cases of impulse response of a given variable to a shock coming from other variables are also presented in Figure 2. We can notice that EUR/PLN response to a shock coming from WIG20 first rapidly increases and finally stabilizes at a new level of equilibrium higher than the initial state. The EUR/PLN variable responds to a one-standard-deviation shock coming from EUR/PLN quite differently: soon after the appearance of the shock, it rapidly increases, then decreases, and finally stabilizes at a new level of equilibrium much lower than the initial state. The EUR/PLN variable after a one-standard-deviation shock coming from CPI increases and stabilizes at a new level of equilibrium much higher than the initial state.

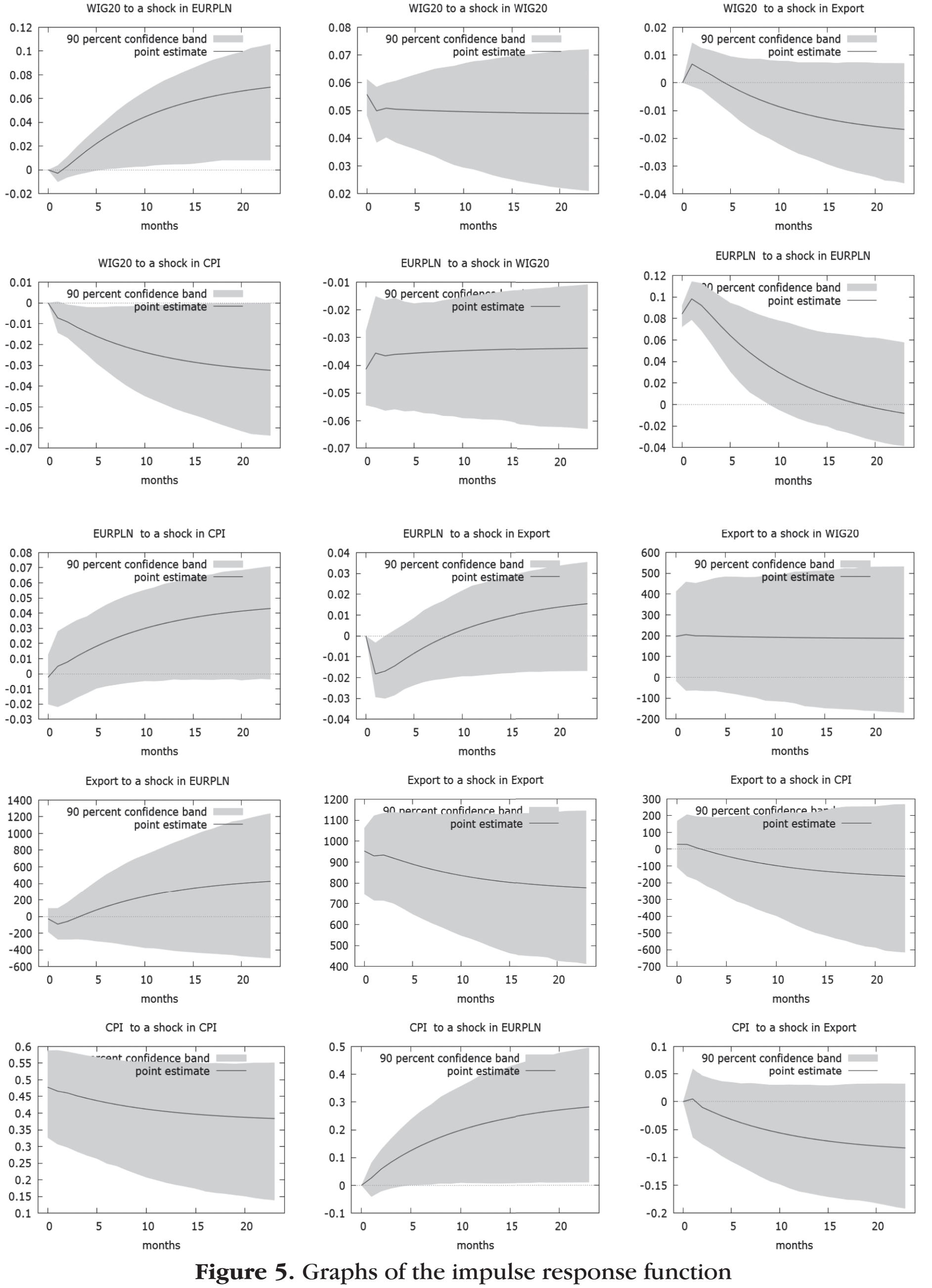

Figure 5. Graphs of the impulse response function

Source: authors' own research

After a one-standard-deviation shock coming from Export, EUR/PLN rapidly decreases, then increases, and finally stabilizes at a new level of equilibrium also much higher than the initial state.

The Export variable reaction is not noticeable after a shock coming from WIG20. But after a shock coming from EUR/PLN, it increases to new level of equilibrium higher than the initial state, whereas after a shock coming from Export or CPI, it stabilizes at a new level of equilibrium a little lower than the initial state.

The CPI variable behaves similarly to the Export variable after a shock coming from other variables. When the shock comes from EUR/PLN (similar to WIG20), its reaction stabilizes at a new level of equilibrium higher than the initial state, whereas when a shock comes from Export or CPI variables, its reaction stabilizes at a level of equilibrium lower than the initial state.

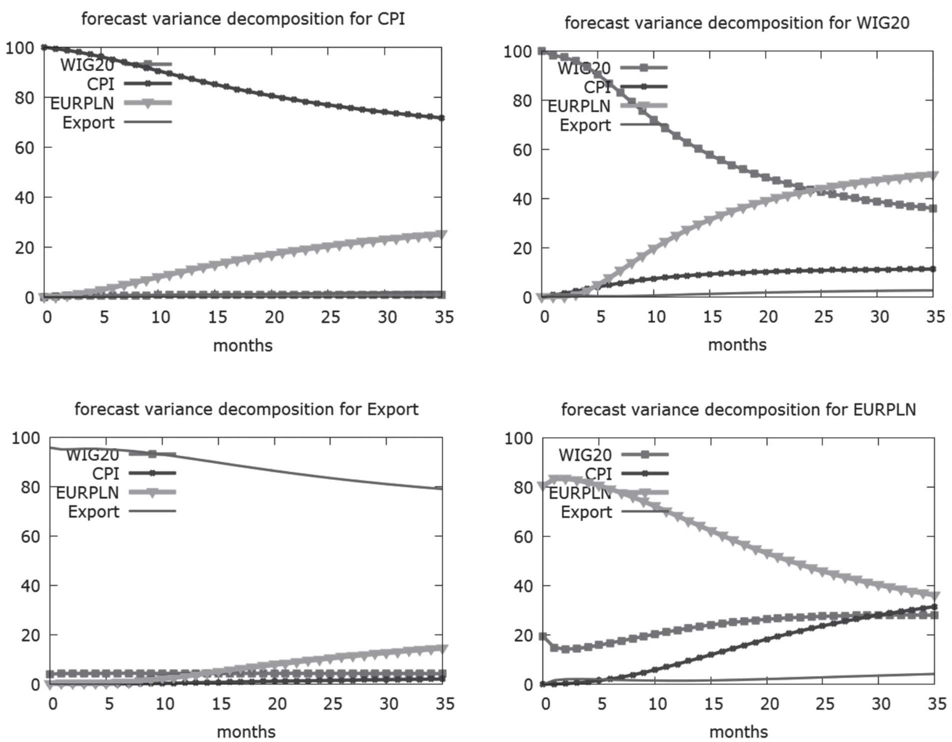

Figure 6. The variance decompositions for WIG20 (left upper panel) and the variance decomposition for Export (right upper panel) for EUR/PLN (left lower panel) and CPI (right lower panel)

Source: authors' own research

Variance decomposition

The forecast error variance decompositions show which shocks are most important in explaining the variance of a given variable through time. They measure the fraction of the forecast error variance of an endogenous variable that can be attributed to orthogonalized shocks to itself or to another endogenous variable.

In Figure 6, the decompositions have been plotted for each variable over a 36-month horizon. The behavior of WIG20 is mainly explained by the shock in the WIG20 value itself (the impact decays from around 100% to 40% after 23 months) and impulses from EUR/PLN in approximately 40% after 20 months, while the rest of its variability is explained by impulses from CPI. In the case of Export, we observe that most of its variability comes from Export itself as well as low impact from EUR/PLN that increases to almost 20% after 30 months.

The variability of the EUR/PLN exchange rate is explained by EUR/PLN shocks in EUR/PLN mainly, but WIG20 and CPI impulses contribute to its variability significantly: each explains almost 20% of the variance. The main drivers for CPI volatility are CPI (around 80%) and EUR/ PLN. The shocks coming from two other variables have a minor impact on CPIs levels.

4. Conclusion

In this paper, we studied the long-term relations between the WIG20 price, EUR/PLN exchange rate, export volume, and rate of inflation CPI. For these purposes, the VEC model was applied. The cointegration analysis has been performed using the Johansen procedure.

The results indicated the existence of one cointegrating relationship between the WIG20 price, EUR/PLN exchange rate, export volume, and rate of inflation CPI. However, the export variable had a neglected impact on the stock market in the long-term relationship. The biggest impact on the stock market had the EUR/PLN exchange rate. The impact of CPI on the stock market is rather moderate. We also concluded that CPI moves away from the equilibrium state with a rather-slow rate, whereas the EUR/PLN comes to the equilibrium state at a similar pace.

Additionally, the impulse response functions obtained from considered VEC model give us a picture of how shock coming from one variable impacts the other variables.

The analysis of the impulse-response function revealed that shocks have a permanent impact on each of the variables considered. In each case, an impulse in one variable causes an immediate increase or decrease in the value of another variable. The effect of shock disappears after some time, and a new level of equilibrium is established. For each variable, the effect of shock decreases after approximately 12 to 15 months.

Taking into account the results obtained from the variance decompositions, we can indicate which shocks are most important in explaining the variability of variables through time. This analysis confirmed the fact that the stock market responds most strongly to the impulse coming from the EUR/PLN rate. However, the behavior of WIG20 is explained mainly by a shock in the WIG20 value itself, while only the rest of its variability is mostly explained by impulses from the EUR/PLN rate.

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