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Jan Koterwa*, Hubert Kycia**,
Anna Czapkiewicz***

The relationship between the inflation rate and the unemployment rate in Poland and their long-term associations with selected macroeconomic variables

1. Introduction

Analyzing the relationship between macroeconomic and financial variables has been popular in the scientific world in recent years. Numerous works have been written in which authors have shown the existence of significant short- and long-term relationships between macroeconomic factors.

Based on empirical data from the period 1861–1957 from the United Kingdom, Philips (1958) demonstrated the existence of a negative correlation between the unemployment rate and the pace of wage growth. As a result of this study, the Phillips curve was developed, illustrating the statistical relationship between the unemployment rate and inflation. The theory was challenged by the phenomenon of stagflation, which involves the simultaneous occurrence of high unemployment and inflation rates. This phenomenon occurred in Western European countries and the USA after the first oil crisis in 1973.

Phelps (1968) illustrated that in cases where the unemployment rate is low, achieving equilibrium between unemployment and inflation rates is impossible. In the event of increased money supply, this leads to the occurrence of hyperinflation without affecting the unemployment rate.

In contrast, L.P. Rochon and S. Rossi (2018), rejecting the above theories, point out that the unemployment rate and the inflation rate are linked through the

* AGH University of Krakow, Krakow, Poland, e-mail: jankoterwa@student.agh.edu.pl
** AGH University of Krakow, Krakow, Poland, e-mail: kyciahubert@student.agh.edu.pl
*** AGH University of Krakow, Krakow, Poland, e-mail: gzrembie@cyf-kr.edu.pl

mechanism of the actions of banks' in the credit market. When commercial banks provide lines of credit for non-GDP transactions, they inflate the volume of bank deposits without primary purchasing power. This is instrumental in increasing the price of assets, and it indirectly translates into an increase in unemployment when deposit holders choose to purchase real estate or financial assets (the prices of which rise as a result of this inflationary pressure), rather than allocating their income to goods and services on the market. Such action translates into a reduction in the level of employment in many companies, which do not increase their revenues in such a situation.

The aim of this paper is to analyze the long- and short-term dependencies for selected Polish macroeconomic factors in the period 2001–2021. The analysis considers the WIG20 index, the USD/PLN exchange rate, the Brent crude oil index, the interest rate on 10-year treasury bonds, inflation, and the unemployment rate. The correlation between inflation and unemployment was analyzed thoroughly. It was also examined whether the relationship between the inflation rate and the unemployment rate in the Polish economy can be described with the use of the Phillips curve.

The authors' justification for choosing such a research topic was the current economic situation in Poland and the fact that from February 2021 to February 2023, the annual inflation rate increased from 2.4% to the level of 18.4%. This was the second-highest inflation rate in the European Union after Hungary. The inflation rate significantly affects the standard of living of Poles in the country, initiating a lively discussion about the factors influencing inflation and strategies to mitigate it.

This paper consists of the following sections: in the second part, a literature review is presented. Section three covers the methodology and the description of tools and tests used while the fourth part covers the presentation of the study results and their interpretation. The paper concludes with a brief summary and description of the conclusions.

2. Literature

There are numerous studies about the relationship between macroeconomic variables in different countries in the literature. I.O. Osamwonyi and E.I. Evbayiro-Osagie (2012) showed the existence of significant short-run and long-run relationships between the Nigerian stock market index and the inflation rate in Nigeria. E. Lawal (2016), on the other hand, in his study reported the absence of long-run relationships between the inflation rate and the Nigerian stock market index.

This implies that a study conducted for the same country's economy may lead to divergent results, which may be the effect of using data from different periods or selecting other econometric models.

Naka et al. (1998) performed a similar analysis for data describing the Indian economy. The paper shows that selected macroeconomic variables, including the inflation rate, are in a long-run relationship with the Indian stock market index. Studies focusing on the relationship between macroeconomic variables and stock market indices have also been conducted by: Gjerde and Saettem (1999) for the Norwegian economy, M. Ibrahim (1999) for the Malaysian economy, T. Barbic and I. Condic-Jurki (2011) for the economies of selected Central and Eastern European countries, Maysami et al. (2004) for the Singapore economy and many others.

Another example of an analysis of macroeconomic processes based on the VECM model is the work of Asari et al. (2011), which examined the relationships between interest rates, inflation, and exchange rate volatility in Malaysia. Andrei (2015) examined the relationship between macroeconomic variables for the Romanian economy, while Nsabimana et al. (2020) verified the relationship between sustainable investment and economic growth in China. Wojciechowski (2015) analyzed the hypothesis on the impact of international trade openness on productivity acceleration. The results of the study conducted, for the Visegrad Group, indicate that there is a long-term relationship between economic openness and labor productivity for all V4 countries, with unidirectional causality in the Granger sense running from productivity to trade openness in the case of Hungarian economy. In contrast, an article by Hülsewig et al. (2001) investigates the impact of the bank lending channel on the transmission mechanism of monetary policy in Germany. With the use of VECM model, authors obtained two cointegrating relationships interpreted as the supply and demand of long-term credit. It was observed that monetary policy has a negative impact on both the supply and demand of long-term credit. At the same time, the authors found that this impact is quite weak due to the protection that banks surround their customers when the state applies restrictive monetary policy.

One example of the application of multivariate models to the Polish economy is the work of M. Salamaga (2015), in which the author examines the long-run relationship between exports and the pattern of comparative advantage. Based on the VECM model constructed, the existence of a long-run equilibrium state is shown. A. Marona and B. Bieniek (2013) conducted a study describing the impact of foreign direct investment on the Polish economy. An article on a similar topic by H. Gurgul and Ł. Lach (2009) shows results indicating significant relationships between direct investment and economic growth in Poland. The existence of these relationships was confirmed in a paper by L. Wojciechowski (2016), which

also shows that the HICP inflation rate, fixed capital formation, and the nominal effective exchange rate have a significant impact on the productivity of the Polish economy. A. Geise (2015) examined how Brent oil price developments affect the inflation rate in selected EU countries. The results indicate that the inflation changes due to an oil shock are of a permanent nature, meaning that these shocks do not wear off. A. Czapkiewicz and M. Stachowicz (2016) show that variables such as the Polish inflation rate, the Polish stock market index, and the EUR/PLN exchange rate are in long-run equilibrium.

3. Methodology

3.1. VECM

The VECM model allows both short- and long-term dynamics to be analyzed. The general form of the VECM model consisting of K endogenous variables is given by equation (1) (Johansen 1995).

$$\Delta y_t = \pi y_{t-1} + \sum_{i=1}^{p} \Gamma_i \Delta y_{t-i} + u_t \tag{1}$$

where:

$\pi = \alpha\beta'$
where:
α – matrix of variable adjustment coefficient to the equilibrium state,
β – matrix of long-run coefficients of cointegrating relationships,
Γ_i – matrixes of coefficients of autoregressive successive lags (short-run dynamics),
p – lag order,
u_t – random disturbances.

The rank of π matrix is equal to the number of cointegrating relationships r. Depending on the value of r, the appropriate form of the model should be adopted:

- $r = 0$ – no cointegration, VAR model is constructed on differenced variables,
- $r = 1, \ldots, K - 1$ – cointegration exists, VECM model is constructed on differenced variables,
- $r = K$ – no cointegration, VAR model is constructed as the variables are stationary.

The verification of the number of cointegrating relationships is equivalent to determining the rank of π matrix. S. Johansen (1991, 1992) proposed two methods

to test the cointegration rank: the trace statistic (2) and the maximum eigenvalue test (3). The null hypothesis of Trace test states that $rank(\pi) \leq r_0$ and the alternative hypothesis states that $rank(\pi) > r_0$. The null hypothesis of maximum eigenvalue test states that $rank(\pi) = r_0$ and alternative hypothesis suggests that $rank(\pi) = r_0 + 1$.

$$\lambda_{tr}(r_0, K) = -T \sum_{i=r_0+1}^{K} \log(1 - \lambda_i) \tag{2}$$

$$\lambda_{\max}(r_0, r_0 + 1) = -T \log(1 - \lambda_{\max}) \tag{3}$$

where λ_i are the eigenvalues of π matrix and values are organized in ascending order. Testing begins with the null hypothesis $rank(\pi) = 0$ and is carried out iteratively until there are no grounds to reject the null hypothesis.

Both Johansen tests and VECM model require the determination of the optimal lag order. For this purpose, the values of the information criteria are used: Akaike information criterion (AIC), Hannan–Quinn information criterion (HQC), Schwartz criterion (SC), Final Prediction Error criterion (FPE).

3.2. Impulse response function

One of the key issues related to the VECM model is that it is possible to analyze the impact of a single variable on other variables, with the aim of discovering economic relationships in both the short and long term. Impulse response function can be used to perform this analysis. Its form is described by equation (4).

$$y_t = \mu + \sum_{i=0}^{\infty} \Theta_i \omega_{t-i} \tag{4}$$

where:

$\mu = E(y_t)$,
$\Theta_i = \Phi_i P$,
$\omega_t = P^{-1} u_t$,
u_t – random disturbances,
p – the lower triangular matrix obtained based on the Cholesky decomposition of the covariance matrix of random disturbances.

In practice, it is assumed that the forms of matrices Θ_i and Φ_i are not known, so they are calculated based on the obtained estimates of the VECM model parameters and the covariance matrix of errors (Lütkepohl 2005). In this case, the Φ_i matrix is described by equation (5).

$$\Phi_i = \sum_{j=1}^{i} \Phi_{i-j} A_j, \quad i = 1, 2, \ldots, \tag{5}$$

where A_j – matrices of autoregressive coefficients and $A_j = 0$ for $i > j$.

If $i = j$ then $\Phi_{i-j} - \Phi_0$ and it is assumed that this matrix is the identity matrix I_k of order $k \times k$. The coefficients of Φ_i matrix are interpreted as the responses of any variable in the vector y_t to an impulse from another variable in this vector, assuming the constancy of the remaining factors (Salamaga 2015). The Θ_i matrix is defined by the following equation (6).

$$\Theta_i = \Phi_i P \tag{6}$$

where p – similarly, as in the equation (4).

3.3. Variance decomposition

The analysis of the influence of individual variables on other variables in the model can be extended based on the decomposition of the forecast error variance. The Forecast Error Variance Decomposition (FEVD) informs to what extent the variance of an endogenous variable is explained by the remaining variables in the model. The formal expression for the magnitude of the forecast error variance of variable j explained by exogenous shocks of variable k for forecast horizon h at forecast origin t is determined by the formula (7).

$$\omega_{jk,h} = \frac{\sum_{i=0}^{h-1} (e_j' \Theta_i e_k)^2}{MSE\left[y_{j,t}(h) \right]} \tag{7}$$

where e_j – j-th column of the matrix I_k, where the index jj specifies the element of this matrix.

The denominator of the fraction is the mean squared error for the h-th step forecast, for variable j. It is described by equation (8).

$$MSE\left[y_{j,t}(h) \right] = \sum_{i=0}^{h-1} (\Phi_i \Sigma_u \Phi_j')_{jj} \tag{8}$$

where:

Σ_u – the covariance matrix of the random component of the VECM model,
$\Phi_i = JA^j J', J = \left[I_k, 0, \ldots, 0 \right]$, matrix J is of order $kxkp$,
p – number of lags in the model.

4. Empirical study

4.1. Dataset description

The study was conducted for monthly data describing selected macroeconomic processes in Poland from 2001 to 2022. Six variables were chosen:

- Inflation (percentage change compared to the same month of the previous year),
- Unemployment,
- WIG20 (Polish stock market index),
- USD/PLN exchange rate,
- Long-term government bond yields (LTI),
- Brent Crude Oil Index.

The choice of the above variables is justified by the fact that the first five of them are interconnected and shape the economic situation in Poland. The Brent oil index was included in the set of variables because Geise hypothesized in his work about the existence of a relationship between oil prices and inflation, which has a transmission character. Based on the research results, the author concluded that this hypothesis is true.

Data was collected from Eurostat, as well as from databases on the stooq.pl and investing.com websites. Figure 1 depicts line charts of these variables.

Maintaining the inflation rate below 5% for nearly two decades until the beginning of 2021 is considered one of the major successes of Poland's socio-economic transformation. As of July 2000, the inflation rate was at 11.6%, while the unemployment rate, which had increased due to structural changes in the Polish economy, stood at 16%. Thanks to a restrictive monetary policy applied in 2001–2003, the inflation rate dropped to 1.6% in December 2003. However, this decline in inflation had an impact on the unemployment rate, which in the same month reached 19.8%. This means that after a period of stagflation, there was an inverse relationship between inflation and unemployment in accordance with the Phillips curve. Poland's entry into the European Union allowed the country to access new investment funds and gain new markets for Polish businesses, although they also faced new competitors. Opening up the Polish market to foreign economic entities also had positive effects, as it led to the creation of new job opportunities. Thanks to these factors, as well as favorable changes in the Labor Code introduced in 2002 and the emigration of some unemployed individuals to EU countries, the unemployment rate dropped below 10% in May 2007, for the first time since May 1998 (Bolejko et al. 2014). Due to the outbreak of the financial crisis, the unemployment rate exceeded 10% once again. However, the growth of

unemployment was curbed in 2013, and since then, there has been a consistent decline, driven by a favorable economic climate that lasted until the outbreak of the COVID-19 pandemic.

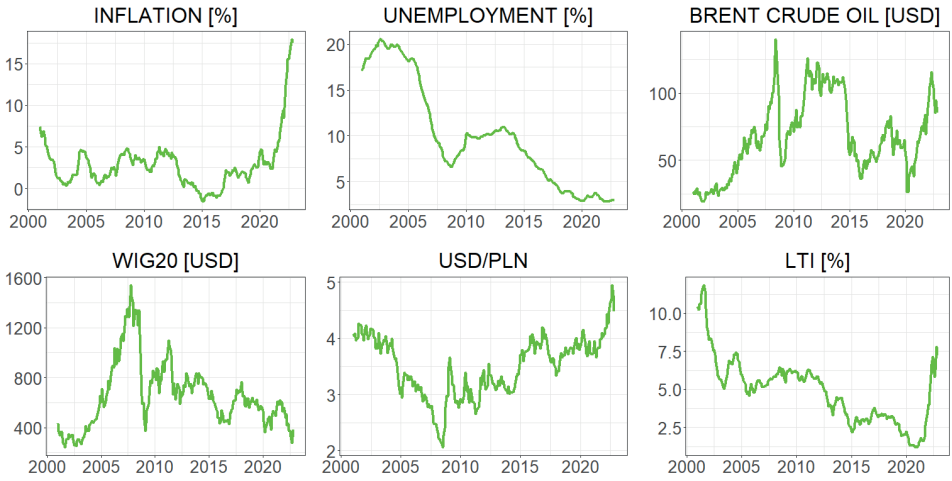

Figure 1. Line charts of the selected macroeconomic processes

The economic recession resulting from the outbreak of the COVID-19 pandemic led to an increase in the inflation rate, which reached 5% in July 2021. Since then, there has been a sharp rise in inflation. In November 2022, the inflation rate stood at 17.1%, the highest level since February 1997. Several reasons for this situation can be identified:

- The economic recession was caused by the need to impose restrictions in many areas of social and economic life. Due to lockdown measures, economic demand was limited, leading to wage reductions and job cuts. Supply, on the other hand, was hindered due to the temporary suspension of operations by some businesses, a reduction in the supply of raw materials from abroad, and increased employee absenteeism resulting from the "zero COVID" policy (Santander Bank Polska 2020).
- The National Bank of Poland's (NBP) initial reluctance to raise interest rates during the early stages of inflation growth, which contributed to further inflationary pressure.
- The government's support for Polish companies through financial aid packages in the form of anti-crisis shields.

- The rapid increase in oil prices in 2020–2021 led to a weakening of PLN against USD, along with additional cost increases for businesses in various sectors, especially in the fuel, energy, construction, and transportation industries.
- The outbreak of the war in Ukraine in February 2022 and the subsequent embargo on Russian goods, along with investor uncertainty about the geopolitical situation in the region, partially limited investments, especially in the commercial real estate market (Mirowski 2022).

The global financial crisis in 2007–2008 had a negative impact on the WIG20 index, which, after a sharp decline in value in 2008, never returned to the levels seen in 2005–2007. Currently, the values achieved by the WIG20 are similar to those recorded at the beginning of the 21st century.

The situation is somewhat different in the case of the Brent Crude Oil index. After a 70% drop caused by the financial crisis in 2007, the price of an oil barrel reached 125 USD as early as April 2011. It remained relatively stable until the autumn of 2014 when it started to decline sharply due to factors such as the oil war among OPEC countries, the appreciation of USD, the emergence of the Islamic State, and the outbreak of conflict in eastern Ukraine. The period of falling oil prices ended with the outbreak of the COVID-19 pandemic, which significantly weakened the U.S. and global economies, contributing to a rapid increase in the price of a barrel of oil. Currently, it is at a similar level as it was before 2014.

Due to the nature of fluctuations in the exchange rate of USD against PLN within the analyzed time frame, three periods can be distinguished:

- In the first period, from 2001 to 2003, the exchange rate of USD against PLN remained stable. This situation was due to the weakening of USD and a decrease in inflation in Poland.
- From 2004 to 2007, there was a continuous decline in the value of USD against PLN, driven by increased exports and foreign capital inflow after Poland's accession to the EU. This led to the appreciation of PLN against USD, in line with the Balassa-Samuelson effect.
- Since 2008, the exchange rate of USD against the PLN has shown an upward trend (Gadomski 2019).

After the inflation rate stabilized at the beginning of the 21st century, the interest rate on long-term government bonds was at a level close to the inflation rate. The increase in inflation in 2021 has also caused the LTI to rise, however this is less than the increase in the inflation rate. Interest rates need to be raised gradually so that the increase in the cost of servicing loans is less steep, hence the difference between the LTI and the inflation rate seen at the end of 2021.

4.2. VECM model estimation

The first stage of the conducted research involved testing the stationarity of the time series under consideration. The augmented Dickey-Fuller test at a significance level of 5% indicated that all variables are non-stationary. Subsequently, the ADF test was repeated for the first differences of the data series according to formula (9)

$$\Delta y_t = y_t - y_{t-1} \quad \left(t \in T_1\right), \tag{9}$$

where $T_1 = \{1, 2, \ldots, n-1\}$.

It transpired that for each analyzed variable, its first differences, based on the ADF test results, could be considered as a stationary series. Detailed results of the ADF tests are presented in Table 1.

Table 1

P-values of the ADF test for the considered time series

Variable	P-value	Conclusion
Inflation	0.99	Non-stationary
Unemployment	0.97	Non-stationary
USD/PLN	0.53	Non-stationary
Brent oil	0.58	Non-stationary
WIG20	0.62	Non-stationary
LTI	0.99	Non-stationary
Inflation	<0.01	Stationary
Unemployment	<0.01	Stationary
USD/PLN	<0.01	Stationary
Brent oil	<0.01	Stationary
WIG20	<0.01	Stationary
LTI	<0.01	Stationary

In order to construct the VECM (Vector Error Correction Model), the optimal number of lags was selected. The choice was made based on four information criteria: HQ, AIC, BIC, and FPE. Based on the selected information criterion, the optimal lag order was determined to be one.

The existence of cointegrating relationships was verified with the use of the Johansen trace test (1988). One cointegrating relationship was detected, described by equation (10).

$$Inflation_t + 1.667 \cdot Unempl_t + 0.035 \cdot WIG20_t + \\ - 0.756 \cdot USDPLN_t - 0.175 \cdot Brent_t - 5.159 \cdot LTI_t = \varepsilon_t \quad (10)$$

The above equation represents a long-term equilibrium between the inflation rate and the other variables. This equilibrium is a system of interrelated variables that adjust to each other in such a way that there is no predominant tendency to change the state of the system in the model they form. Since all the series composing the variables are $I(1)$, this equilibrium is a static equilibrium, implying the stationarity of all the variables constituting the system (Welfe 2020).

The coefficients of the variables in equation (10) form a cointegrating vector, defining the long-term relationship between the variables. The reference point is the variable describing inflation, for which the coefficient β takes the value of 1. An increase in the unemployment rate by one percentage point is associated with a increase in the inflation rate by more than one percentage point. This long-term interdependence between inflation and unemployment aligns with current economic theory. An increase in the WIG20 index is associated with an increase in inflation, while the growth of the USD/PLN, Brent, and LTI variables is correlated with a decrease in inflation.

Table 2 shows the estimated parameters of the individual equations of the VECM model, the number of individual equations corresponds to the order of variables in the cointegrating vector. The parameter α appearing in all equations is interpreted as the rate of adjustment of the variable to the equilibrium state. If the variable has a positive sign at β in the long – run relationship, then a negative value of α indicates that the variable returns to equilibrium in subsequent periods. If α is positive, then the variable moves away from equilibrium in subsequent periods. It follows that unemployment returns to equilibrium at a slow rate, while the interest rate on long-term government bonds moves away from equilibrium at a slow rate. The other parameters of α are not significant.

Table 2

Coefficients of VECM model parameters

Equation	α_i	$\Delta y_{1,t-1}$	$\Delta y_{2,t-1}$	$\Delta y_{3,t-1}$	$\Delta y_{4,t-1}$	$\Delta y_{5,t-1}$	$\Delta y_{6,t-1}$
I	−0.004	0.335**	−0.303	0.000	0.902**	0.021**	0.049
II	−0.005**	−0.026	0.601**	−0.000	−0.059	0.000	−0.000
III	−0.311	−24.07*	−32.96	0.007	−19.10	1.113	24.93
IV	0.001	0.040*	0.063	−0.000	−0.074	−0.001	−0.071*
V	0.076	−1.378	1.652	0.017	5.712	0.237**	1.922
VI	0.005*	0.155**	0.183	0.000	0.591**	0.009**	0.269**

Remark: ** symbol indicates results for significance level 0.05, * for 0.1

4.3. Impulse response function

An analysis of the response to shocks for each variable was conducted. Variable shock is defined as an increase in its value by one standard deviation. It should be emphasized that the order of variables in the vector is significant in the analysis of response to shocks. In the study, the vector consists of the following variables in sequence: inflation, unemployment, WIG20 index, USD/PLN exchange rate, Brent crude oil, and LTI.

The response function to shocks is depicted in Figures 2 and 3. It can be observed that imposing a shock on individual variables leads to immediate responses from the reacting variables. The curves commence from the period *Month* = 1, as the response of variables to the shock of inflation and unemployment is examined in subsequent periods. In most cases, the variable either increases or decreases and then stabilizes at a different level. Special attention was paid to the response of inflation and unemployment to shocks applied to each of the considered variables: inflation rate, unemployment rate, WIG20 index, USD/PLN exchange rate, Brent crude oil index, and ten-year government bond yield. The confidence intervals are limited by red lines.

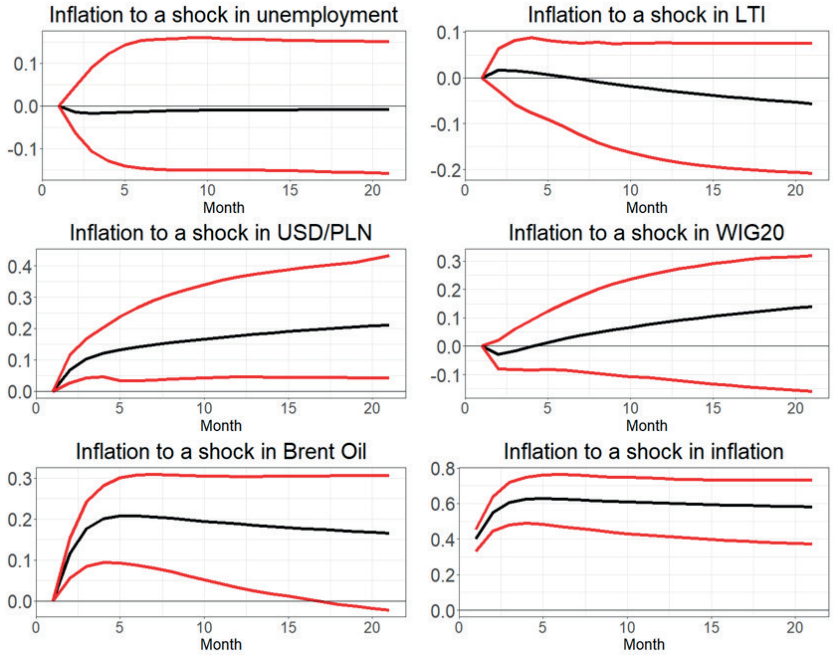

Figure 2. Impulse response function – inflation response

The reaction of the inflation rate to a shock from the unemployment rate, which can be observed in the top left graph of Figure 2, indicates that an increase in the unemployment rate by one standard deviation leads to a slight decrease in unemployment over a quarterly period. This suggests a trade-off between unemployment and inflation in accordance with the Phillips curve theory. In the subsequent months, there is a very slight decrease in unemployment, which stabilizes after a ten-month period. This means that in the observed period, there was a short-term negative relationship between unemployment and inflation in Poland. Milton Friedman already observed short-term trade-offs between inflation and unemployment in the late 1970s. He concluded that the decline in unemployment resulting from expansionary economic policies is short-lived because workers quickly realize that despite a nominal increase in their wages, they are unable to purchase more goods and services due to simultaneous price increases. As a result, some workers quit their jobs, reducing the labor force supply. Unemployment then returns to its natural level, while prices remain at a higher level (Grabia 2016).

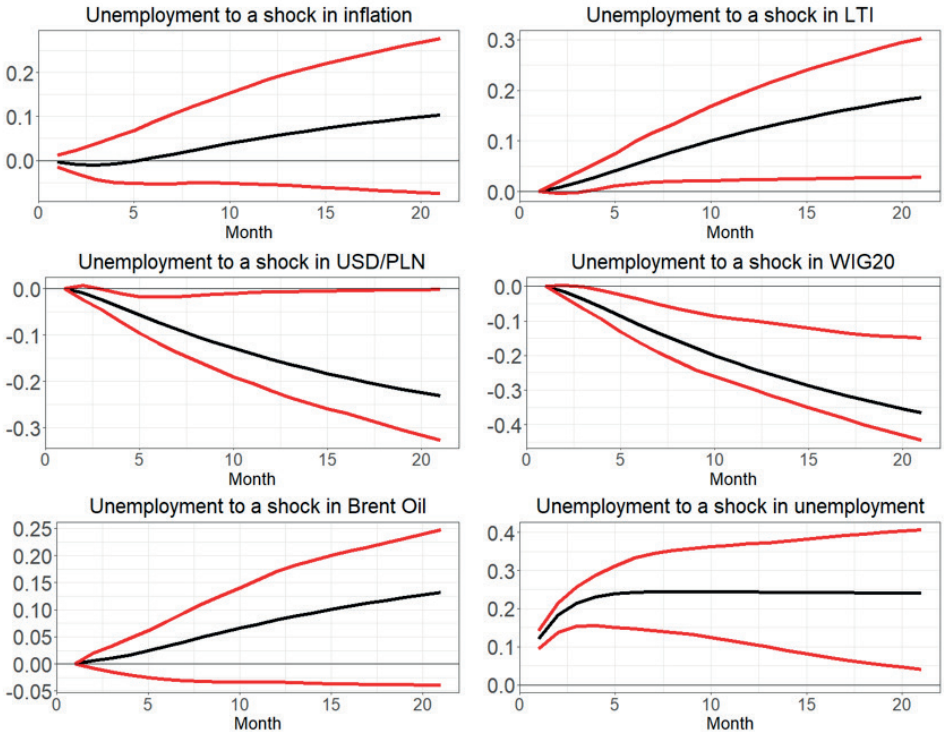

Figure 3. Impulse response function – unemployment response

An increase in the interest rates of 10-year government bonds by one standard deviation results in a slight increase in inflation over the first two months following the shock. In the subsequent months, there is a noticeable decrease in inflation, indicating that raising interest rates by the central bank does not lead to an immediate decrease in inflation. However, it is necessary to explain how the central bank influences long-term government bond interest rates.

Modern monetary policy, whose primary goal is to maintain inflation at the target level, primarily revolves around interest rate policies aimed at stabilizing market interest rates. This stabilization includes, among other things, reducing transaction costs and safeguarding the financial market by minimizing fluctuations in the prices of financial assets. Central bank decisions regarding interest rates have a tangible impact on the economy through the transmission mechanism, which represents the causal relationships between central bank actions and the reactions of economic entities and institutions to a given stimulus. Considering that the effects of implementing a specific monetary policy become evident with some delay, it is crucial for the central bank to make decisions regarding changes in interest rates with appropriate foresight (Przybylska-Kapuścińska 2008).

The graph of the response function of the inflation rate to a shock from the WIG20 index indicates that within one month, a sudden change in its value results in a slight decrease in inflation. Over the long term, an increase in the value of the WIG20 index leads to a continuous increase in the inflation rate. It turns out that high inflation can be a determinant of profit for the stock market. The reasons for this phenomenon appear to be as follows:

- In the case of significant inflation growth, individuals with savings seek higher returns to protect their capital from the devaluation of money to a greater extent than bank deposits.
- Savers typically react to inflationary events with a delay and tend to overestimate their duration.
- The relatively slow pace of interest rate increases by the National Bank of Poland (NBP) in the last two years has led to a significant gap between real interest rates and the inflation rate, further discouraging savers from investing their capital in bank deposits (Przasnyski 2020).

It implies that high inflation, which is a clear sign of weak economic conditions, may not necessarily have a negative impact on stock indices.

As a result of a sudden change in the exchange rate of USD, the inflation rate consistently increases over the studied period. An increase in USD exchange rate means that PLN loses value, leading to inflation and economic slowdown. However, after six months, this growth slows down. The reason for this slowdown

is the impact of restrictive monetary policy instruments such as raising reserve requirements or increasing interest rates.

The influence of an oil shock on the inflation rate in Poland has a similar nature to that observed for the USD exchange rate. In the first five months, there is an increase in inflation, followed by its stabilization. An increase in oil prices leads to increased inflationary pressure, although the intensity of this pressure may vary depending on the level of development of the economy (Geise 2015).

The response of the inflation rate to a shock in itself indicates the presence of a moderate inflationary spiral phenomenon over a period of five months from its occurrence. The inflationary spiral phenomenon involves the occurrence of an inflationary impulse, such as an increase in energy commodity prices or rising import costs, leading to increased production costs and subsequently higher prices. As a result of price increases, workers demand higher nominal wages. If this increase occurs at a faster rate than the growth rate of labor productivity, it leads to an increase in unit labor costs. If businesses do not decide to reduce their profit margins, another round of price increases occurs, considering the increase in employee wages (Belka 1985). The graph shows that the inflationary spiral has a relatively strong but short-lived nature, as inflation stabilizes after five months.

The graph of the unemployment rate's response to an inflationary shock indicates that in the first quarter, the increase in the inflation rate caused a slight decrease in the unemployment rate, confirming earlier observations suggesting a short-term trade-off between unemployment and inflation, as per the Phillips curve theory. Over a longer period of time, there is a simultaneous increase in both the unemployment rate and the inflation rate, leading to the phenomenon of stagflation. This occurs because as price levels rise, the demand for goods decreases, while the quantity of real production supplied to the market increases with rising price levels. Increasing prices lead to a decrease in the real value of money, an increase in loan interest rates, and a reduction in consumer spending. All these factors contribute to a decrease in global demand. Meanwhile, rising prices lead to a decrease in the real wage rate, defined as the ratio of nominal wages to prices. This, in turn, results in increased production levels and employment for profit-maximizing firms. With continued price increases, it becomes impossible to maintain a constant level of real wages in a tight labor market. This means that simultaneous increases in prices and wages prevent further reductions in real wages, and production and employment will no longer respond to price level increases. Employers are then forced to reduce operating costs through workforce reduction (Joint Economic Committee 1980).

The response of the unemployment rate to an increase in long-term bond interest rates indicates that rising interest rates led to a sustained increase in the unemployment rate. As a result of higher interest rates, the costs of servicing loans

increase, reducing demand in the economy, which contributes to a decrease in inflation. A decrease in demand leads to companies reducing production, and the rising interest expenses force them to seek savings through workforce reduction. This suggests the possibility of describing the relationship between unemployment and inflation using the Phillips curve in the short term.

The graph of the unemployment rate's response to a stock market index shock shows a decrease in the unemployment rate in response to the growth of the WIG20 index. The inflation rate increased due to the stock market shock, providing further evidence of the negative relationship between unemployment and inflation in Poland. This is also confirmed by the reactions of the inflation rate to shocks from the USD exchange rate. An increase in the USD exchange rate leads to an increase in inflation while simultaneously reducing unemployment.

Examining the response of unemployment to an oil shock, one can observe its consistency with the response of inflation to a similar stimulus. The difference lies in the strength of the impact of the stimulus, as unemployment does not stabilize over a longer period of time. The constant increase in production and transportation costs forces companies to lay off employees to reduce costs in a situation where demand in the economy is constrained by rising inflation.

The response of the unemployment rate to its shock is similar to the response of the inflation rate to an inflationary shock. In the initial period, weak economic conditions drive a dynamic increase in the unemployment rate, which stabilizes after half a year with changes in macroeconomic policy (Przybylska-Kapuścińska 2008).

4.4. Variance decomposition

Variance decomposition was carried out to identify the variables whose shocks play the most significant role in explaining the variance of individual variables. Figure 4 illustrates the decomposition of each variable over 24 consecutive periods, which corresponds to the next two years. The darkest color corresponds to the inflation variable, and the brightest color represents the LTI variable.

It can be observed that the behavior of all variables is primarily explained by their own shocks, especially in the initial periods. Initially, inflation explains 100% of the variability in its variance, but this influence decreases over time, stabilizing at around 80% after 12 months. Unemployment is primarily explained by unemployment shocks, but this influence quickly diminishes, stabilizing at a level of 40% after 24 months. Over time, the impact of the WIG20 index increases, exceeding 40% after two years. The variance of the WIG20 index is explained by the WIG20 variable in almost 100% throughout all subsequent periods. For the USD/PLN exchange rate, the shock of this rate explains 50% of the variance

initially, gradually waning and stabilizing at 20%. The shock of the WIG20 index has a greater impact, with its influence increasing from 50% to almost 80% after 24 months. Brent crude oil explains 80% of the variance in its own shocks, but this value slowly decreases, while the influence of the WIG20 index rises to approximately 30% after two years. The 10-year government bond interest rate explains 80% of the variance in its own shocks, but this influence rapidly decreases to 40%. Inflation and the USD/PLN exchange rate have a similar impact, accounting for 20% of the variance.

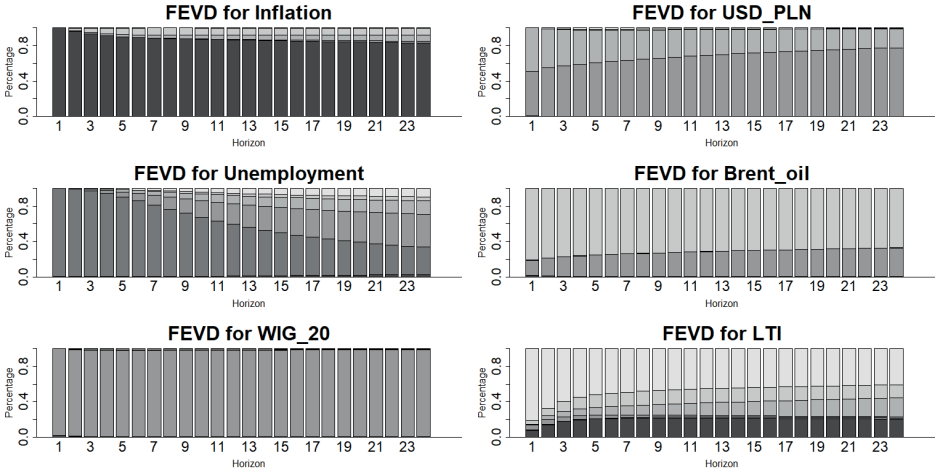

Figure 4. Variance decomposition

5. Conclusion

The study conducted an analysis of the relationship between the inflation rate and the unemployment rate in Poland and their long-term relationships with selected macroeconomic variables: WIG20 index, USD/PLN exchange rate, Brent crude oil prices, and LTI, which represents the interest rate on 10-year government bonds. The analysis was conducted with the use of VECM (Vector Error Correction Model).

The results obtained indicate the existence of one cointegrating relationship among the variables. Variables describing unemployment, inflation, and WIG20 return to the long-term equilibrium state. However, for the remaining variables – USD/PLN exchange rate, Brent crude oil, and LTI – they move away from the long-term equilibrium state in subsequent periods. Analyzing the autoregression

coefficients of the VECM model, it can be observed that in the short term, inflation is significantly influenced by the lagged values of three variables: inflation, exchange rate, and Brent crude oil.

The analysis of impulse response functions provided insights into the response of a given process to a shock in another variable. Special attention was paid to the response of inflation and unemployment to shocks from the variables examined in the study. According to the Phillips curve theory, these variables exhibit a negative correlation in the short term, whereas in the long term, there is a positive relationship leading to the occurrence of stagflation.

The variance decomposition analysis helped identify the variables whose shocks best explain the variability of other variables over time. For inflation and WIG20, these variables respond most strongly to their own shocks. The variability of the inflation rate is explained by an inflation index by more than 80%. Unemployment is strongly influenced by the impulse of the WIG20 index. In the case of the 10-year government bond interest rate, significant influences come from the impulses of inflation and the USD/PLN exchange rate.

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Summary

The purpose of this paper is to examine the relationship between the inflation and unemployment rates in Poland and to analyze their long-term relationships with selected macroeconomic variables: the WIG20 index, consisting of the 20 largest Polish companies noted on Warsaw Stock Exchange, the USD/PLN exchange rate, the Brent crude oil index, and the interest rate on 10-year government bond yields. The main objective of the study is to determine the relationship between inflation and unemployment. In this study, a vector error correction model (VECM) was used to study long-run dependence. The impulse response function and forecast error variance decomposition were also used to examine the interactions between variables. There is one long-run relationship between the factors studied. Both the values of the VECM model parameters and the results of the impulse response function indicate that there is a negative relationship between inflation and unemployment in the short term. In the long term, there is a positive relationship, resulting in the stagflation phenomenon.

JEL codes: C32, C51, E31

Keywords: *VECM, inflation, unemployment, impulse response function, variance decomposition, cointegration*