Analyzing the Correlation between Central Bank Interest Rates and Inflation on the Example of Poland within the European Union

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Abstract:

Purpose: The main aim of this study was to determine the relationship between inflation and interest rates of the Central Bank in Poland with the background of European integration and the COVID-19 pandemic.

Design/Methodology/Approach: The Central Bank of Poland (CBP) was the main source of data for the analysis (1998-2023). We used different methods which helped to analyze the changes in inflation and interest rates in Poland, for example Augmented Dickey Fuller test (ADF test), Autoregressive Moving Average model (ARIMA model) and the regression analysis using the Classical Method of Least Square.

Findings: The study demonstrated that inflation will decrease steadily in Poland due to relatively high interest rates. The Central Bank of Poland and government agencies should implement cohesive policies to reduce inflation. The Central Bank of Poland has increased interest rates to fight inflation, whereas the wide range of social welfare programs introduced by the government has contributed to higher inflation.

Practical implications: The results will fill in the gap concerning the financial policy of Central Bank.

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Originality/Value: *The new information about impact of interest rate on inflation and a ARiMA model was presented.*

Keywords: *Inflation, interest rates, European integration.*

JEL codes: *F10, F13, F17.*

Paper type: *Research article.*

1. Introduction

Financial institutions, politicians, and the industrial sector propose various solutions to fighting inflation. However, governments can have different policy priorities, for example inflation, unemployment, economic growth, etc. Inflation affects all consumers, in particular low-income groups (Ciborowski, 2003; Hakim and Thalassinos, 2023).

Inflation is measured with the use of the consumer price index (CPI) by analyzing changes in the prices of a basket of goods between the examined year and the reference base year. The relative increase in prices defines inflation. In turn, the producer price index (PPI) measures the change in the prices paid by domestic producers (Ciborowski, 2003; Thalassinos *et al.,* 2022).

Inflation contributes to other undesirable economic phenomena, such as unemployment. Although inflation affects prices, whereas unemployment influences the labor market, both phenomena are closely related. According to the Phillips curve, an inverse relationship exists between inflation and unemployment: inflation decreases unemployment and vice versa (Barnichon and Matthes, 2017; Wessel *et al.,* 2018).

Central banks implement measures to control inflation, whereas governments fight unemployment, which indicates that fiscal and monetary policies have contradictory aims (Kopeć, 2015). Due to the growing availability of information from diverse sources, including the Internet, television, and radio, inflation penetrates social space and affects consumer behavior (Skolik, 2015). The accurate inflation forecast has an impact on policy decisions of central banks (Eugster and Uhl, 2024).

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Inflation rises as a result of shocks and global financial crises (Globan *et al.,* 2014). The accessibility of financing is also crucial since it helps some struggling businesses avoid defaulting and therefore boosts their market's productive capacity. A downward pressure on product pricing results from this increased productive capability (Acharya *et al.,* 2020). Inflation is impacted by corruption as well. Because it takes time for corruption to manifest, its effects on inflation are mostly indirect (Piplica, 2011).

Each country's monetary policy, as well as that of the European Union, examines the significance of the exchange rate in particular and considers how the central bank functions when choosing its target rate (Nojković *et al.,* 2015). The monetary policy of the European Central Bank (ECB) aims to promote productivity growth, maintain low and stable inflation, and reduce and homogenize real effective exchange rates within the EMU. The main aim of ECB is to keep prices stable, thereby supporting economic growth and job creation (Stylianou, 2022).

The main aim of this study was to determine the relationship between inflation and interest rates of the Central Bank in Poland on the background of European integration and the COVID-19 pandemic. Various sources of data were used in the analysis, including *Statistics Poland* reports containing macroeconomic variables such as interest rates and inflation. Specific research objectives were to:

- evaluate changes in inflation and interest rates in Poland,
- evaluate the stationarity of time series with the use of the augmented Dickey-Fuller
  (ADF) test and the Autoregressive Integrated Moving Average (ARIMA) model,
- predict interest rates and inflation.

The increase in energy prices is the main cause of inflation. The COVID-19 pandemic and the Russian invasion of Ukraine prompted the EU countries to search for other, more expensive sources of energy. Understanding the features of inflation is crucial to macroeconomics since it comes at a significant cost to individuals, businesses, and the economy as a whole (Danielaa *et al.,* 2014).

The scientific gap for this paper is examining the relationships between inflation and interest rates. It is known from the economic literature that interest rates have an impact on inflation. Low interest rates increase inflation and high interest rates pull the inflation down. This is only one side of the relationship between inflation rate and interest rate. The cost theory of inflation has an opposite impact (higher interest or cost of credit, higher production cost, higher prices, higher inflation rate). This is why pursuing monetary policy in times of inflation is difficult.

2. Materials and Methods

An analysis of the price index relative to the previous year = 100 revealed that the price index was highest in 1990 (685.8%) and 1989 (351.1%). During this period,

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Poland was transitioning from a centrally planned (communist) economy to a market economy. The third and fourth highest values of the price index were noted in 1982 (200.8%) and 1991 (170.3%).

Poland has experienced a dramatic decline in inflation from the early transition period (Figure 1)**.** The yearly average rate of inflation rapidly decreased from 150 percent in the early 1990s to single digit levels by 2001. Quantitatively, globalization appears to have lowered Polish prices by ½ to 1 percentage point annually since 1995, substantially more than in advanced economies (Allard, 2023).

The labor and external sectors dominated the determination of Polish inflation during the era, according to Byung-Yeon's findings, but their influences on inflation altered in the mid-1990s (Byung-Yeon, 2008). If mild shocks are considered and inflation is near to a 4% inflation steady state response of inflation to the monetary policy shock.

Figure 1. *CPI in Poland in 1950-2022, previous year=100.*
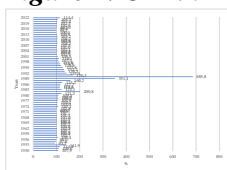
Source: Own elaboration based on Statistics Poland (2023).

The economy is a system of interconnected variables (factors) that influence other variables and induce changes in their values. Some of these variables are leading business cycle indicators, whereas others are influenced by the changes in economic factors. Leading indicators are economic factors**.** Economic ones affect non-economic ones and vice versa.

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The reference rate is the benchmark interest rate that is used by the National Bank of Poland to conduct open market operations. The reference rate is set by the Monetary Policy Council (Act of 29 August, 1997). The reference rate denotes the minimal price at which the central bank conducts open market operations on the interbank market. During open market operations, the central bank buys or sells short-term bonds to restore market equilibrium.

The Lombard rate is the maximum interest rate on loans that are granted by the central bank to commercial banks against a pledge of marketable assets such as shares, bonds, or investments (Lombard loans).

The deposit interest rate is the interest rate on overnight deposits made by commercial banks in the central bank. The deposit interest rate denotes the minimum interest rate on the market. The deposit interest rate accounted for 0% from 1998-2001. Then it started to fluctuate similarly to other rates.

Discount rate on treasury bills accounted 0% from 1998 to 2015. Only in 2010 it was 4%. From 2020 the discount rate on treasury bills was similar to other rates. The price at which the central bank purchases bills from commercial banks is known as the rediscount rate. Commercial banks had previously purchased these notes from their customers (Kazimierczak, 2013).

Figure 2. *Key interest rates in 1998-2022.*
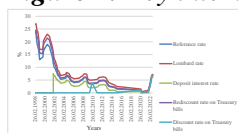
Source: *Own elaboration based on Statistic Poland (Statistics Poland 2023).*

The study was performed to check the relationship between inflation (measured by the CPI) and interest rates was examined in correlation and regression analyses. The

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rate of inflation was calculated. We subtracted 100 from the CPI to get the inflation rate.

We also conducted the statistics. First, we conducted descriptive statistics. Next, we did the Augmented Dickey Fuller Test (ADF) and Autoregressive Moving Average Model (ARIMA) to check the stationarity, Finally, we prepared the prognosis of inflation and interest rates in Poland.

The ARIMA model is a very good tool to analyze the stationarity of inflation and interest rates. The model fits the data and can be used to elaborate prognosis. The ARIMA procedure allows to create an autoregressive integrated moving average (ARIMA) model that allows for accurate modeling of time series. ARIMA models offer more sophisticated methods for modeling trend and seasonality components than exponential smoothing models and have the additional advantage of being able to include predictor variables in the mode.

An Auto Regressive (AR only) model can be calculated where Yt depends only on its own lags. That is, Yt is a function of the 'lags of Yt' (Choi, 1992; Routa *et al.,* 2014; de Jonga and Penzerg, 2004; Erdem and Shi, 2011):

$$y_t = \varphi_0 + \varphi_1 y_{t-1} + \varphi_2 y_{t-2} + ... + \varphi_p y_{t-p} + e_t,$$ (1)

where:

$y_t, y_{t-1}, y_{t-2}, ..., y_{t-p}$ - the value of the forecast variable at the time or period $t, t-1, t-2, ..., t-p$;

$\varphi_0, \varphi_1, ..., \varphi_{t-p}$ - model parameters.

e_t - error (rest) of the model for the moment or period $t;$ *and*

p - delay operator.

Another model is the moving average MA model:

$$y_t = \theta_0 + e_t - \theta_1 e_{t-1} - \theta_2 e_{t-2} - ... - \theta_q e_{t-q}$$ (2)

where:

y_t - is the value of the forecast variable in period $t;$

$e_t, e_{t-1}, ..., e_{t-q}$ -errors (residuals) in periods $t, ..., t-q;$

$\theta_0, \theta_1, ..., \theta_q$ - model parameters, and

q - delay operator.

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In the final step of analysis we conducted the regression analysis.

The multivariable regression function can be written as follows (Bórawski *et al.,* 2021; Bevans 2023):

$$Y = \alpha_0 + \alpha_1 X_1 + \alpha_2 X_2 + \ldots + \alpha_k X_k + \xi \tag{3}$$

Where:
Y—dependent variable;
X_i—explanatory variables (i = 1, 2, …, k);
ξ—random component; α_0—intercept of regression function;
α_i—structural parameters of the model (i = 1, 2, …, k).

The second method used in the paper was Pearson correlation and regression analysis. We used two models. The first was classical regression model. The second was regression using Classical Method of Least Square. The Y – inflation rate (CPI) was the dependent variable. The following monetary policy instruments are implemented by the Central Bank of Poland and they were independent variables:

X_1 – reference rate,
X_2 – Lombard rate,
X_3 – deposit interest rate,
X_4 – rediscount rate on Treasury bills,
X_5 – discount rate on Treasury bills.

3. Results and Discussion

The inflation rate is diversified in the European Union (EU) countries. The highest inflation rate was in Estonia (19.4%), Lithuania (18.9%), Hungary (15.3%), Czechia (14.8) and Poland (13.2%) in 2022. The most important reasons for inflation growth in these countries was the invasion of Russia on Ukraine and Covid-19 pandemic. These countries relied on Russian energy supply of coal, gas, and petrol in large extend, what caused the increase of prices.

The lowest inflation rate in 2022 was observed in France (5.9%), Malta (6.1%), Finland (7.2%) and Sweden, Portugal, Cyprus, Malta (8.1%). Reasons for this are numerous. These countries did not rely on energy supply from Russia. France for example relies on nuclear energy and do not import Russian natural resources. The Covid-19 crises affected the economies and many countries have resorted to aggressive fiscal and monetary stimulus (Conlon *et al.,* 2021).

The European Union's inflation is influenced by a wide range of factors. Interest rates and the status of the economy are the two most crucial. The employment rate, the economy's openness, and the GDP are other crucial variables. These control

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variables have received theoretical and empirical support as well as applications in recent literature (Thalassinos *et al.,* 2012).

Table 1. *Annual average inflation rates in the EU countries in 2013-2022 (%)*

EU countries	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022
Belgium	1.2	0.5	0.6	1.8	2.2	2.3	1.2	0.4	3.2	10.3
Bulgaria	0.4	-1.6	-1.1	-1.3	1.2	2.6	2.5	1.2	2.8	13.0
Czechia	1.4	0.4	0.3	0.6	2.4	2.0	2.6	3.3	3.3	14.8
Denmark	0.5	0.4	0.2	0.0	1.1	0.7	0.7	0.3	1.9	8.5
Germany	1.6	0.8	0.7	0.4	1.7	1.9	1.4	0.4	3.2	8.7
Estonia	3.2	0.5	0.1	0.8	3.7	3.4	2.3	-0.6	4.5	19.4
Ireland	0.5	0.3	0.0	-0.2	0.3	0.7	0.9	-0.5	2.4	8.1
Greece	-0.9	-1.4	-1.1	0.0	1.1	0.8	0.5	-1.3	0.6	9.3
Spain	1.5	-0.2	-0.6	-0.3	2.0	1.7	0.8	-0.3	3.0	8.3
France	1.0	0.6	0.1	0.3	1.2	2.1	1.3	0.5	2.1	5.9
Croatia	2.3	0.2	-0.3	-0.6	1.3	1.6	0.8	0.0	2.7	10.7
Italy	1.2	0.2	0.1	-0.1	1.3	1.2	0.6	-0.1	1.9	8.7
Cyprus	0.4	-0.3	-1.5	-1.2	0.7	0.8	0.5	-1.1	2.3	8.1
Latvia	0.0	0.7	0.2	0.1	2.9	2.6	2.7	0.1	3.2	17.2
Lithuania	1.2	0.2	-0.7	0.7	3.7	2.5	2.2	1.1	4.6	18.9
Luxembourg	1.7	0.7	0.1	0.0	2.1	2.0	1.6	0.0	3.5	8.2
Hungary	1.7	0.0	0.1	0.4	2.4	2.9	3.4	3.4	5.2	15.3
Malta	1.0	0.8	1.2	0.9	1.3	1.7	1.5	0.8	0.7	6.1
Netherlands	2.6	0.3	0.2	0.1	1.3	1.6	2.7	1.1	2.8	11.6
Austria	2.1	1.5	0.8	1.0	2.2	2.1	1.5	1.4	2.8	8.6
Poland	0.8	0.1	-0.7	-0.2	1.6	1.2	2.1	3.7	5.2	13.2
Portugal	0.4	-0.2	0.5	0.6	1.6	1.2	0.3	-0.1	0.9	8.1
Romania	3.2	1.4	-0.4	-1.1	1.1	4.1	3.9	2.3	4.1	12.0
Slovenia	1.9	0.4	-0.8	-0.2	1.6	1.9	1.7	-0.3	2.0	9.3
Slovakia	1.5	-0.1	-0.3	-0.5	1.4	2.5	2.8	2.0	2.8	12.1
Finland	2.2	1.2	-0.2	0.4	0.8	1.2	1.1	0.4	2.1	7.2
Sweden	0.4	0.2	0.7	1.1	1.9	2.0	1.7	0.7	2.7	8.1

Source: *Own elaborations based on Eurostat (2023).*

The research showed that before the financial crisis of 2009, interest rates had been substantially higher than inflation since 1998. Between 2009 and 2019, the rate of inflation (CPI) was close to the rate of interest. As of 2019, inflation began to outpace interest rates, which shows that the central bank's monetary policy tools were ineffectively deployed to combat inflation.

Money supply, currency rate, interest rate, inflation anticipation, imported inflation, and Gross Domestic Product (GDP) are the factors that scholars have consistently used to explain inflation (Lim and Sek, 2015).

The domestic output gap, especially in the Eurozone panel, is the determinant of inflation (Budová *et al.,* 2023). The global output gap controls inflation in the European Union panel and its periphery economies. Several Central Banks in Europe introduced negative interest rate policies to help economies recover after the

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2008 financial crises (Liñares-Zegarra and Willesson, 2021). Moreover, the COVID-19 pandemic resulted in a remarkable surge of inflation rising to 4.6% in 2020-2022 (Equiza-Goñi, 2023).

Shocks in energy prices have a significant impact on the current economy. When considering circumstances, the projected impacts of increases in the cost of several major inputs, particularly energy, on various economic sectors and the overall economy are particularly considerable (Keček, 2023).

There are a wide range of variables that can affect the price of oil and its volatility, but it also generates an oil/gasoline supply chain map that can show the weak links in the chain that are susceptible to interruptions (Min, 2022).

The level of uncertainty in the economy and in business has significantly grown because of the war in Ukraine. Additionally, it led to significant issues with the rise in energy prices (Prohorovs, 2022). In any economy, energy expenditures make up a significant portion of total costs. Effective inflation in the nations is influenced by current energy price trends (Bednář *et al.,* 2022).

The stationarity of time series was analyzed with the use of the ADF test which revealed that interest rates were stationary in the examined period (no changes in mean values or variation over time). In contrast, the inflation rate (CPI) was non-stationary. Therefore, the differences were calculated in the following step of the analysis (Table 2).

Table 2. *Augmented Dickey-Fuller test (ADF test) for inflation and interest rates*

ADF test	p-value	
	without a trend toward significance	with a trend toward significance
Inflation (CPI)	0.407	0.976
Reference rate	0.000	0.000
Lombard rate	0.000	0.000
Deposit interest rate	0.119	0.000
Rediscount rate on Treasury bills	0.000	0.000
Discount rate on Treasury bills	0.000	0.000

Source: *Own elaboration based on Statistics Poland data.*

The data presented in Table 3 indicates that inflation and interest rates were stationary. It means that the time series of inflation and interest rates do not depend on previous values. Their values are rather caused by unpredictable shock which apper in the economy of Poland. The p-value was low, only inflation had high p-value.

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Table 3. *ARIMA model for inflation and interest rates in Poland*

Variable	AR				MA			
	Coefficient	Standard error	Z	p-value	Coefficient	Standard error	Z	p-value
Inflation (CPI)	0.292	0.305	0.959	0.337	0.628	0.395	1.590	0.112
Reference rate	0.938	0.069	13.48	0.000	0.126	0.306	0.412	0.680
Lombard rate	0.935	0.075	12.47	0.000	0.275	0.438	0.628	0.529
Deposit interest rate	0.419	0.334	1.254	0.210	0.204	0.379	0.539	0.589
Rediscount rate on Treasury bills	0.924	0.088	1.052	0.000	0.354	0.557	0.636	0.525
Discount rate on Treasury bills	0.896	0.124	0.721	0.000	0.466	0.311	1.501	0.133

Source: *Own elaboration based on Statistics Poland data.*

Inflation and interest rate predictions are presented in Table 4. The analysis revealed that inflation will decrease in 2023-2027. To decrease inflation, the central bank should not decrease interest rates, particularly the reference rate, the Lombard rate, and the deposit interest rate. The deposit interest rate and the discount rate on Treasury bills are not critical parameters, and they are expected to decrease.

Table 4. *Forecast and standard error*

Variable	Forecast									
	2023	Standard error	2024	Standard error	2025	Standard error	2026	Standard error	2027	Standard error
Inflation (CPI)	12.6	2.58	6.2	3.51	4.3	3.58	3.8	3.58	3.6	3.58
Reference rate	5.37	2.23	5.63	3.26	5.87	3.94	6.10	4.47	6.31	4.88
Lombard rate	6.38	2.54	6.75	3.99	7.10	4.20	7.43	5.61	7.73	6.15
Deposit interest rate	3.61	1.63	2.81	1.93	2.48	1.98	2.34	1.98	2.28	1.99
Rediscount rate on Treasury bills	6.13	2.42	6.48	3.92	6.80	4.85	7.10	5.53	7.37	6.04
Discount rate on Treasury bills	6.02	0.70	5.55	1.18	5.13	1.46	4.75	1.65	4.42	1.79

Source: *Own elaboration based on Statistics Poland data.*

According to Łyziak (2016), integrating both sorts of information is the best method to make use of survey data on inflation expectations rather than employing them separately as alternative forward-looking information to macroeconomic models. Szafranek (2019) emphasized that the major focus of the central bank's operations is inflation forecasting. This is a very important issue because accurate inflation forecast may help in proper policy decisions.

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Moreover, reliable predictors for inflations are of most importance for central banks all over the world to help to achieve price stability (Eugster and Uhl, 2024). To combat either inflationary or deflationary forces, policymakers must make choices in advance since monetary policy has a significant lag in its effects on the economy.

The results proved that the most important variables were the reference rate, the deposit interest rate, and the discount rate on Treasury bills. The R-squared determination coefficient was 0,911672 meaning that the model is well fitted (Table 5).

Table 5. *Results of the multiple regression analysis using Classical Method of Least Square*

Variables	Regression coefficient	STD. error	t-Student	P value
const	0,748008	1,24724	0,5997	0,5558
Reference rate	3,51722	1,69937	2,070	0,0524
Lombard rate	−0,473233	1,74138	−0,2718	0,7887
Deposit interest rate	−0,298671	0,136120	−2,194	0,0409
Rediscount rate on Treasury bills	−2,13145	1,36697	−1,559	0,1354
Discount rate on Treasury bills	2,36446	0,449342	5,262	0,0001

Arithmetic means of the dependent variable	3,720000	Standard deviation of dependent change	3,733743
Sum of squares of residuals	29,55277	Standard error of residuals	1,247160
R-squared determination coefficient	0,911672	Corrected R-square	0,888428
F(9, 197)	39,22149	The *p*-value for the F-test	0,000
Likelihood logarithm	−37,56473	Critical Information Akaike criterion	87,12947
Critical Bayesian Schwarz criterion	94,44272	Critical Hannan–Quinn criterion	89,15785
Autocorrel.residual - rho1	0,430403	Durbin-Watson Statistics	1,138181

Source: *Own elaboration based on Statistics Poland data.*

4. Conclusions

European integration influenced the rate of inflation and interest rates in Poland. After Poland joined the European Union (EU), inflation and interest rates generally decreased, which reduced the difference between the analyzed variables. European integration improved the market outlook in Poland.

The COVID-19 pandemic and the implemented lockdowns initially reduced inflation. However, inflation increased when COVID-19 restrictions were relaxed,

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and attempts were made to restart and rebuild the economy. The Russian invasion of Ukraine was the main reason for the steep rise in inflation. Due to increased internet shopping during the COVID-19 pandemic, online pricing may more precisely represent price trends than those gathered from conventional stores (Jaworski, 2021). Information about the market and consumer expectations both affect inflation. Consumers purchase goods if they anticipate an increase in price (Łyziak, 2003).

In Poland, the rate of inflation has been higher than interest rates since 2017, which implies that interest rates have not been used effectively as a monetary policy instrument to fight inflation. Inflation expectations are key factors in implementing monetary policy (Łyziak, 2006). The monetary policy has a crucial role. The policy response to shocks should also be of a temporary nature, and it appears that national governments have taken this approach (Caporale *et al.,* 2022).

The government should attempt to reduce the main production costs, namely the prices of fossil fuels and transport fuels. An increase in fuel prices automatically raises the prices of consumer goods and services. Poland has undertaken different actions to minimalize the inflation, First, the government found new sources of natural resources mainly hard coal and natural gas. Now these fuels are imported by Poland from various parts of the world. Second the Central Bank increased the interest rates to stop rise of inflation.

The Central Bank of Poland and the Polish government should develop and implement cohesive financial policies. The Central Bank of Poland has increased interest rates to fight inflation, while simultaneously introducing a wide range of governmental social welfare programs which has contributed to even higher inflation.

The Polish government should also strive to minimize the negative impact of major economic shocks. Both the EU economy and the global economy are experiencing constant fluctuations due to market shocks. European integration, the financial crisis of 2009, the COVID-19 pandemic, and the Russian invasion of Ukraine were the main economic shocks for Poland.

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