KWARTALNIK NAUK O PRZEDSIĘBIORSTWIE

4/2024

The Impact of Central Bank Reference Rates on Market Interest Rates in Poland

Wpływ stóp referencyjnych banku centralnego na poziom rynkowych stóp procentowych w Polsce

Paweł Węgrzyn PhD
Warsaw School of Economics
Department of Economic Geography
e-mail: pwegrz@sgh.waw.pl
ORCID: 0000-0001-8963-2765

dr hab. Michał Kruszka
Vistula University
Faculty of Business and International Relations
e-mail: m.kruszka@vistula.edu.pl
ORCID: 0000-0002-9138-7225

Anna Topczewska PhD
WSB Merito University in Warsaw
e-mail: anna.topczewska@wsb.warszawa.pl
ORCID: 0000-0001-8848-4609

Keywords:
Interest rate benchmark, WIBOR, ARDL model, Granger causality test

Abstract: This study aims to determine the influence of the National Bank of Poland's (NBP) reference interest rate on the 3M and 6M WIBOR levels. The research hypothesis posits that the base interest rates are a primary determinant of WIBOR levels. The article employs Granger causality tests and an ARDL model to identify which macroeconomic variable most significantly affects the WIBOR 3M and 6M rates. ARDL model results unequivocally suggest that the WIBOR level is primarily influenced by the NBP's reference interest rate, showing a positive and statistically significant impact. Conversely, Granger causality tests indicate that historical reference interest rate cannot be used to forecast the 3M and 6M WIBOR levels. This could be attributed to the possibility that expectations regarding future interest rates might influence the WIBOR level rather than historical data.

Słowa kluczowe:
referencyjna stopa procentowa, WIBOR, model ARDL, test przyczynowości Grangera

Streszczenie: Celem niniejszego opracowania jest określenie wpływu referencyjnej stopy procentowej Narodowego Banku Polskiego (NBP) na poziom wskaźników referencyjnych stopy procentowej WIBOR 3M i 6M. Hipoteza badawcza zakłada, że podstawowe stopy procentowe są główną determinantą poziomów wskaźnika referencyjnego WIBOR. W artykule zastosowano testy przyczynowości Grangera oraz model ARDL w celu określenia, która zmienna makroekonomiczna w największym stopniu wpływa na kształtowanie się wskaźnika referencyjnego WIBOR 3M i 6M. Wyniki modelu ARDL jednoznacznie sugerują, że na poziom WIBOR wpływa przede wszystkim referencyjna stopa procentowa NBP, wykazując pozytywny i statystycznie

istotny wpływ. Z kolei testy przyczynowości Grangera wskazują, że historyczna referencyjna stopa procentowa nie może być wykorzystana do prognozowania poziomów WIBOR 3M i 6M. Można to uzasadnić tym, że to nie dane historyczne, a oczekiwania dotyczące kształtowania się przyszłych stóp procentowych wpływają na poziom wskaźnika referencyjnego WIBOR.

JEL:
L21, M41, M48, O44, O13, Q51, Q53, Q56

Introduction

The analysis of central bank reference rates (policy rates) and their impact on market interest rates is a critical area of research in financial economics. Nonetheless, the fluctuations in market rates impact economic behaviour; therefore, the central bank's capacity to exert any influence hinges primarily on the relationship between official rates and market rates [Biefang-Frisancho Mariscal, Howells, 2002]. Understanding how these rates influence broader financial markets is essential for policymakers, financial institutions, and investors. As Petrevski and Bogoev [2012] indicate, the effective transmission of monetary policy actions to market interest rates enhances the efficacy of national monetary policy through the interest rate channel. The Warsaw Interbank Offered Rate (WIBOR), as a benchmark for the cost of borrowing Polish zloty between banks, plays a pivotal role in the Polish financial system. It affects various financial products, including mortgages, loans, bonds and derivative contracts. Therefore, comprehending the determinants of WIBOR levels, particularly the influence of the National Bank of Poland's (NBP) reference interest rate, is paramount.

The reference interest rate, set by central banks, is a primary tool for regulating monetary policy. It serves as a signal to financial markets about the stance of monetary policy and influences various economic activities, from consumer spending to business investments. This study specifically focuses on the NBP's reference interest rate, identified as the primary determinant of the 3-month and 6-month WIBOR levels. The research hypothesises assumes that the base interest rates exert a strong positive impact on WIBOR levels. To test this hypothesis, the study employs an Autoregressive Distributed Lag (ARDL) model and Granger causality tests to identify which macroeconomic variables most significantly affect the WIBOR 3M and 6M rates. By analysing data from January 2005 to June 2023, the study seeks to provide empirical evidence on the significant relationship between central bank reference rates and market interest rates in Poland.

The findings of this research offer valuable insights into the effectiveness of monetary policy transmission mechanisms in Poland. By confirming the hypothesis that the NBP's reference rate is a primary determinant of WIBOR levels, the study could

highlight the importance of central bank policy in shaping financial market conditions. Such insights are crucial for policymakers and market participants in understanding and anticipating the movements in interbank rates and their broader economic implications.

The Determinants of Market Interest Rates

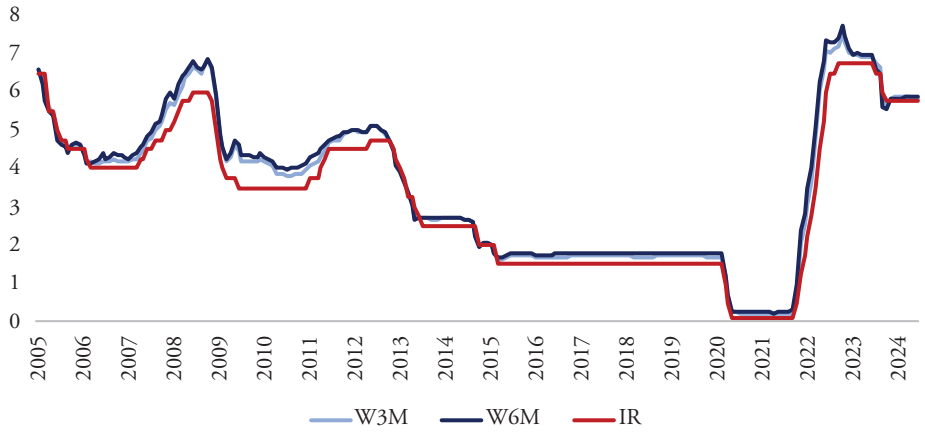
Market interest rates, also known as financial benchmarks, market indices or reference rates, serve as crucial indicators of the financial market's condition. They are instrumental in calculating the value of financial instrument flows and assessing the performance of portfolios comprising them [Ansori, Ashar, 2023]. Determining market interest rates, such as the Warsaw Interbank Offered Rate (WIBOR), involves multiple economic indicators and macroeconomic conditions. Central bank policies, particularly the reference rates, are one of them [Friedman, Kuttner, 2010]. Nevertheless, other factors, including inflation expectations, macroeconomic variables, and liquidity conditions, may substantially influence the dynamics of market interest rates.

The issue of the influence of central bank policy on the market interest rate was considered in many studies [Fedorova, Meshkova, 2021; Kliber, 2017]. The reference rates of central banks act as a primary monetary tool to guide economic policy, directly impacting interbank rates like WIBOR. For example, Williams [2020] confirms the strong links between monetary policy (including the level of interest rates) and the level of the SONIA indices. The theoretical underpinning for this relationship suggests that banks adjust their lending and deposit rates based on the central bank's cues to align with national economic policy objectives [Iddrisu, Alagidede, 2020], directly affecting WIBOR. Despite the notable relationship between central bank reference rates and interest rate benchmarks like WIBOR [Król, 2023], the literature lacks extensive studies on the strength of this connection and in-depth analyses in this area. The relation between WIBOR 3M, WIBOR 6M and policy rate is presented on Figure 1.

Figure 1 shows that both WIBOR 3M and WIBOR 6M closely follow the central bank's policy interest rate (IR) over time. Throughout the period, there is a strong alignment between the market rates and the central bank's policy rate, with minimal divergence, highlighting the significant influence of monetary policy on interbank rates.

The inflation level is another macroeconomic variable potentially impacting the market interest rate. Inflation impacts interest rates through its effects on purchasing power and the real value of money. When inflation rates rise, central banks may increase reference rates to control inflation (in line with the direct inflation target adopted), raising WIBOR as the cost of borrowing increases.

Figure 1. The level of WIBOR 3M, WIBOR 6M and policy rate for the period from 2005 to the end of the first half of 2024



Source: own elaboration based on GPW Benchmark data.

Extensive research has demonstrated a significant relationship between the pace of economic growth and market interest rates. Economic growth signals robust business activity, increased consumer spending, and healthier employment levels, collectively heightening demand for credit, thereby influencing interest rates upwards. Studies such as those by Belke and Setzer [2003] highlight that higher economic growth rates often lead to increased market interest rates, as central banks may raise rates to curb potential inflationary pressures. Similarly, Disyatat and Vongsinsirikul [2003] support this view by indicating that strong economic growth in emerging markets has historically led to tighter monetary policy and higher interest rates. On the other hand, the inverse relationship, suggesting a positive effect of lowering interest rates on economic growth through lower financing costs and stimulating the economy, is more reasonable based on academic research [Ahmed et al., 2021]. Nevertheless, due to the reliance on monthly data in this study, economic growth rates, typically reported quarterly, will not be considered as they would drastically reduce the number of observations in the model. Instead, an alternative indicator that reflects economic activity is utilized: Total industrial production sold, published monthly since 2005. This measure captures the monthly fluctuations in industrial output, providing a more frequent and timely proxy for economic performance. By incorporating this indicator into the research, the study effectively assesses the impact of economic activity on market interest rates without compromising the data's temporal granularity.

Moreover the unemployment rate may be utilised as an alternative indicator to gauge economic conditions. Rising unemployment typically reduces the demand for cred-

it. In response, banks may lower financing costs to stimulate borrowing, potentially influencing WIBOR downwards. However, empirical evidence linking unemployment rates directly to market interest rates like WIBOR is limited. There is a potential indirect channel of influence through the Phillips Curve, where increased unemployment correlates with lower inflation, leading central banks to reduce interest rates, thereby indirectly affecting market rates [Blanchard, 2016]. This relationship suggests a theoretical pathway by which unemployment might indirectly impact market interest rates through its effects on inflation and subsequent central bank actions.

Research Methods

Data

Based on the literature review, economic variables such as the NBP reference interest rate (policy rate), the inflation index (CPI) and the unemployment rate were used to explain WIBOR levels. The study focuses on the period from January 2005 to the end of June 2024 (234 observations for each explanatory variable presented in Table 1). The starting point of 2005 is justified by significant changes in Poland's financial markets and institutions following its accession to the European Union in May 2004, which profoundly impacted economic dynamics and regulatory frameworks. Additionally, data on industrial production sold, an important indicator of economic activity utilized in this study, are available from 2005 onwards. Furthermore, considering a wide range of maturities (fixing dates) of WIBOR indices, in this article, we have chosen to use WIBOR 3M and WIBOR 6M as the dependent variable in two separate models. The rationale for this is that extensive analysis by the Polish Financial Supervision Authority confirms that in the domestic market, interest rate reference indices with a tenor of three months and six months are most commonly used [Polish Financial Supervision Authority, 2024], the exception is the leasing and factoring sector, where WIBOR 1M is used most frequently.

All variables were tested for stationarity using the Augmented Dickey-Fuller (ADF) test and Phillips-Perron Unit Root (PP) test. Based on the untransformed data, all variables – excluded industrial production sold (IPS) – were found to be non-stationary; thus, differential variables were made (d1). After transformation, the ADF test and PP test confirmed the stationarity of the first differences of all variables. The subsequent step in assessing the data quality for the model was the correlation analysis.

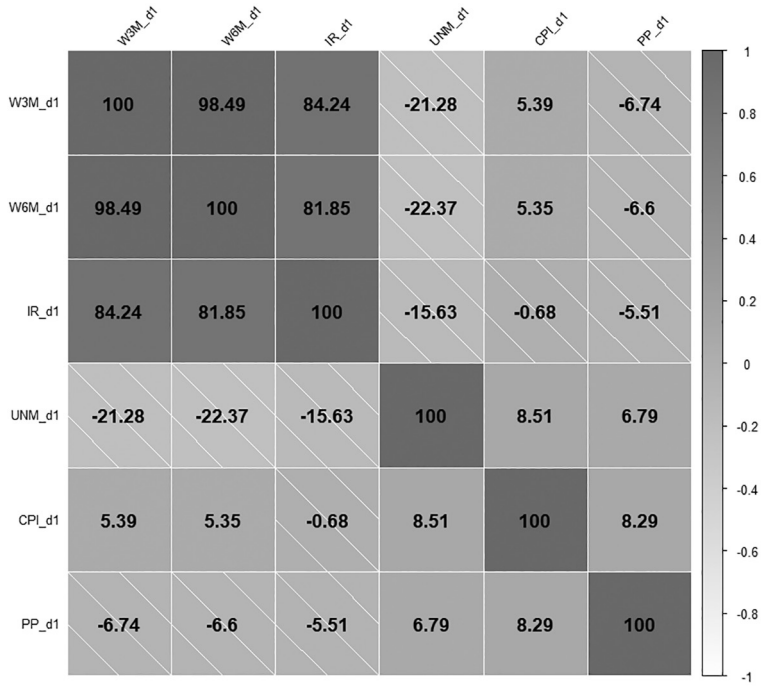
Table 1. Macroeconomic variables used in research from January 2005 to June 2023

Data	Abbreviation	Description	Source
Warsaw Interbank Offered Rate (3M)	W3M	The Warsaw Interbank Offered Rate (WIBOR) 3M and 6M are the three-month and six-month interest rates at which Polish banks lend unsecured funds to each other in the Warsaw interbank market. This benchmark rate influences various financial products in Poland, including mortgages and loans, and reflects short-term borrowing costs in the Polish banking sector.	Stooq (https://stooq.pl/q/?s=wig)
Warsaw Interbank Offered Rate (6M)	W6M		
Central Bank reference rate	IR	The Central Bank reference rate is the primary interest rate used by the NBP, Poland/s central bank, for regulating monetary policy (level at the end of the month).	NBP (https://nbp.pl/podstawowe-stopy-procentowe-archiwum/)
Consumer Prices Index (%)	CPI	The Consumer Price Index (CPI) measures monthly percentage changes in the price of a basket of consumer goods and services, calculated in relation to the previous month. It serves as a critical indicator of inflation.	GUS (https://stat.gov.pl/wskazniki-makroekonomiczne/)
Total Industrial Production Sold (%)	IPS	Index measuring the total value of goods and services produced and sold by the industrial sector. It reflects short-term industrial activity and economic performance, calculated as the percentage change in production levels from the previous month.	
Unemployment rate (%)	UNM	The number of people unemployed as a percentage of the labour force.	

Source: own elaboration.

As Figure 2s shows, significant correlations were only observed between the variables W3M and W6M (which does not affect the model quality given that both variables are dependent variables) and between the dependent variables and the policy interest rate (IR). A negative and relatively moderate correlation was observed between the unemployment rate (UNM) and the other interest rates variables (including policy rate). The level of inflation (CPI) and industrial production sold (IPS) sold showed no significant correlation with any of the other variables in the analysis.

Figure 2. Correlation matrix between first differences of explanatory variables



Source: own elaboration in R.

Granger Causality Test

An additional dimension to the comprehensive analysis undertaken in this study is the application of Granger causality tests. Granger causality is not causality in the traditional philosophical sense but rather a predictive causality [Shojaie, Fox, 2022]. In mathematical terms, if variable X Granger causes variable Y, the past values of X contain information that helps predict Y:

$$Y_t = \alpha + \sum_{i=1}^{n} \beta_i Y_{t-i} + \sum_{i=1}^{n} \gamma_i X_{t-i} + \varepsilon_t, \tag{1}$$

In the context of this research, the Granger causality tests were utilised to ascertain if specific explanatory variables have predictive power over WIBOR 3M or WIBOR 6M. Granger's interpretation of the meaning of causality is essential, as it only checks whether historical levels (lagged) of variable X can be used to forecast future levels of variable Y.

ARDL Model

The Autoregressive Distributed Lag (ARDL) approach facilitates a detailed exploration of relationships across variables, capturing both their short- and long-run associations [Qamruzzaman, Wei, 2018]. Doing so ensures a comprehensive understanding of the intricate interplay between economic variables over different time horizons. The ARDL model provides a flexible framework that caters to variables integrated at different orders, eliminating the necessity for them to be cointegrated in the same order. This is an invaluable advantage when dealing with non-stationary data that might exhibit varying levels of integration [Pesaran et al., 2001]. Moreover, the model has been used in similar studies to assess the impact of determinants affecting market interest rates [Miłobędzki, 2020].

The Johansen test was used to assess the cointegration of the variables. This method identifies the number of cointegration relationships and estimates their parameters in a system of non-stationary variables. Unlike the Engle-Granger two-step approach [Beck, 1992; Enders, Siklos, 2001], limited to testing cointegration in pairs of variables, the Johansen procedure is suitable for systems with more than two variables, providing a more comprehensive analysis of cointegration in multivariate time series.

The results indicate the presence of at least one cointegrating vector, meaning that the variables in the system share a long-run equilibrium relationship. This finding supports the appropriateness of using the ARDL model, which accounts for both short-term dynamics and long-term relationships between the variables. The general equation of ARDL can be expressed as [Kong et al., 2021]:

$$\Delta Y_t = \alpha_0 + \sum_{i=1}^{p} \alpha_i \Delta Y_{t-i} + \sum_{j=1}^{q} \beta_j \Delta X_{t-i} + \gamma Y_{t-1} + \delta X_{t-1} + \varepsilon_t \qquad (2)$$

Where:

- ΔY_t and ΔX_{t-1} represent the changes in the dependent and independent variables,
- p and q are the respective lags for the dependent and independent variables,
- α_0, α_i, β_j, γ and δ are the parameters to be estimated,
- ε_t represents the error term.

Moreover, the error correction model (ECM) has been increasingly recognised for its robustness and flexibility in econometric analyses, particularly as an extension of the Autoregressive Distributed Lag (ARDL) approach [Saleem et al., 2021]. One of the main strengths of the ECM lies in its ability to disentangle the short-term dynamics from the underlying long-term equilibrium relationships, providing insights into transient shocks and enduring associations among used economic variables. Furthermore, the ECM facilitates examining how economic systems adjust and converge to equilibrium

following disturbances, shedding light on the stabilising mechanisms inherent in economies. The general formulation of ECM can be expressed as [Engle, Granger, 1987]:

$$\Delta Y_t = \gamma_0 + \sum_{i=1}^{p} \gamma_i \Delta X_{t-1} + \theta EC_{t-1} + \varepsilon_t \tag{3}$$

Where:

- ΔY_t and ΔX_{t-1} represent the changes in the dependent and independent variables,
- θ denotes the speed of adjustment back to equilibrium,
- EC_{t-1} is the error correction term derived from the long-run relationship.

Finally, the ARDL models with ECM used in our research can be expressed as:

$$\begin{aligned} \textbf{Model 1: } \Delta W3M_t = {} & \beta_0 + \sum_{i=1}^{2} \beta_1^i \Delta CPI_{t-i} + \sum_{i=1}^{3} \beta_2^i \Delta IR_{t-i} + \\ & \sum_{i=1}^{4} \beta_3^i \Delta UNM_{t-i} + \sum_{i=1}^{4} \beta_4^i \Delta IPS_{t-i} + \theta(W3M_{t-1} - \alpha_0 - \alpha_1 CPI_{t-1} - \\ & - \alpha_2 IR_{t-1} - \alpha_3 UNM_{t-4} - \alpha_4 IPS_{t-4}) + \varepsilon_t \end{aligned} \tag{4}$$

$$\begin{aligned} \textbf{Model 2: } \Delta W6M_t = {} & \beta_0 + \sum_{i=1}^{2} \beta_1^i \Delta CPI_{t-i} + \sum_{i=1}^{3} \beta_2^i \Delta IR_{t-i} + \\ & + \sum_{i=1}^{4} \beta_3^i \Delta UNM_{t-i} + \sum_{i=1}^{4} \beta_4^i \Delta IPS_{t-i} + \theta(W6M_{t-1} - \alpha_0 - \alpha_1 CPI_{t-1} - \\ & - \alpha_2 IR_{t-1} - \alpha_3 UNM_{t-4} - \alpha_4 IPS_{t-4}) + \varepsilon_t \end{aligned} \tag{5}$$

Where:

- the terms with Δ capture the short-run dynamics,
- the terms inside the parentheses (associated with θ) represent the long-run relationship and its deviation from equilibrium (error correction mechanism).

For those models, the optimal lags (*p and q*) of each variable were selected based on the Akaike Information Criterion (AIC).

Results and Discussion

Based on the two conducted models (model 1 assessed the impact of economic variables on WIBOR 3M and model 2 on WIBOR 6M), the impact of independent variables on WIBOR rates was comparable in both models. Both models highlight the strong influence of the Central Bank reference rate on WIBOR. This influence is mainly visible in the short term. According to the model results, a 1 percentage point increase in the NBP interest rate contributes to a 1.061 percentage point increase in WIBOR

3M and a 1.073 percentage point increase in WIBOR 6M. Moreover, also in the long term, a positive relationship between IR and WIBOR is evident, where an increase in IR contributes 0.109 percentage points to the rise in WIBOR 3M and 0.08 percentage points in WIBOR 6M. Notably, the impact of inflation (CPI) was significant only for WIBOR 3M in the long term, though its influence was relatively small, and it remained insignificant in the short term. Industrial production sold (IPS) was statistically insignificant in both the short and long term for both WIBOR 3M and WIBOR 6M. Finally, the unemployment rate also showed no statistically significant impact on WIBOR in any of the models (Table 2).

Table 2. ARDL models' estimated coefficients and significant

Variable	Model 1 (W3M)		Model 2 (W6M)	
	coefficients	p-value	coefficients	p-value
l.1. W3M (EC)	–0.1116	0.0021**	-	-
l.1. W6M (EC)	-	-	–0.0866	0.0076**
d.1. IR	1.0605	<0.001***	1.0730	<0.001***
d.1. CPI	0.0243	0.0896.	0.0246	0.1163
d.1. IPS	–0.0001	0.8621	–0.0001	0.9263
d.1. UNM	–0.0119	0.6920	–0.0254	0.4396
l.1. IR	0.1087	0.0041**	0.0797	0.0196*
l.1. CPI	0.0024	0.0303*	0.0024	0.0525
l.1. IPS	0.0020	0.0665.	–0.0019	0.1053
l.4. UNM	–0.0001	0.9748	0.0009	0.6728
Multiple R-squared	0.778		0.748	
Adjusted R-squared	0.769		0.738	

Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: own elaboration in R.

The good quality of the model confirms these results fit. In the case of explaining WIBOR 3M, the model's fitted R2 level is 76.9%, while for WIBOR 6M it is 73.8%. The error correction (EC) coefficient is also negative and statistically significant in the two considered models. This suggests a convergence towards long-term equilibrium, wherein deviations from the equilibrium relationship are corrected over time. Furthermore, we conducted a series of diagnostic tests for the model to assess its robustness and reliability. The results of these tests are presented in Table 4.

Table 3. ARDL models' diagnostics tests (p-value) and AIC & BIC values

Tests	Model 1 (W3M)	Model 2 (M6M)
Model F-statistic	<0.0001***	<0.0001***
Breusch-Godfrey LM test (autocorrelation)	0.12561	0.1476
Shapiro-Wilk test (normality)	0.000	0.000
AIC criterium	–344.602	–302.244
BIC criterium	–310.221	–267.863

Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: own elaboration in R.

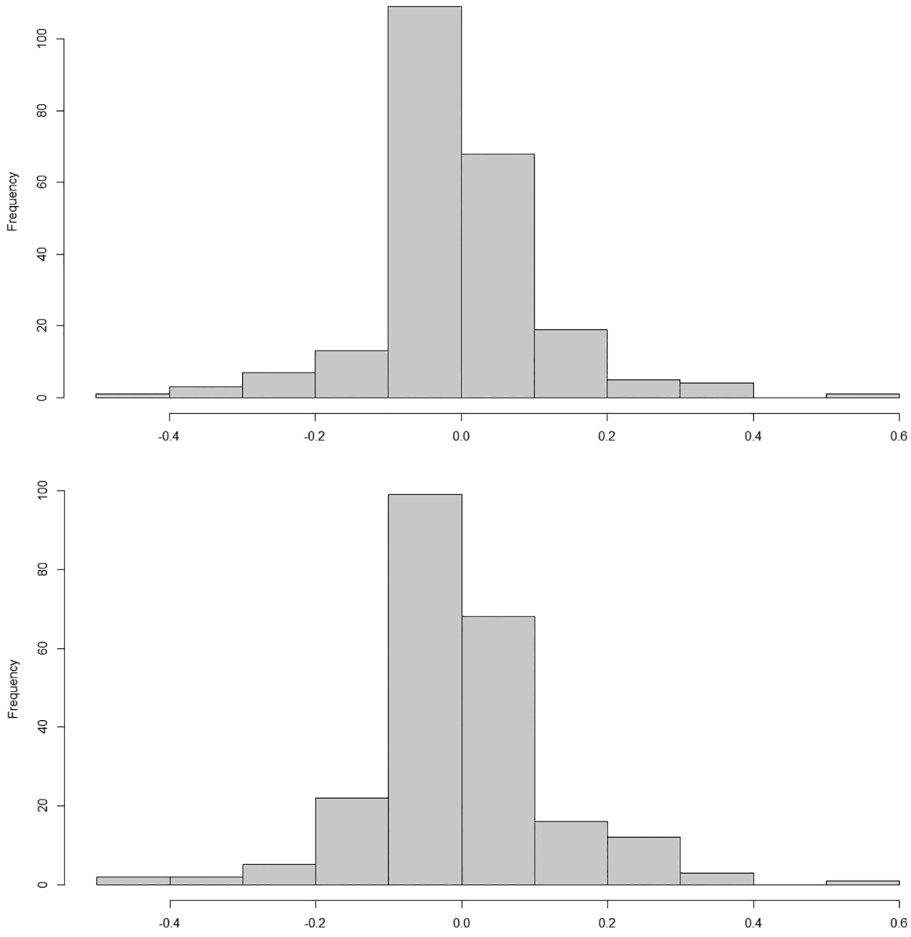
The diagnostic tests presented in Table 3 highlighting significant Model F-statistics for both models ($p < 0.0001$) strongly validate the overall fitness of the models, indicating that the explanatory variables collectively have a significant impact on the WIBOR 3M and 6M rates. The Breusch-Godfrey LM test results, with p-values of 0.126 for Model 1 (W3M) and 0.148 for Model 2 (M6M), suggest that there is no autocorrelation at the 1% or even 5% levels of significance. This is crucial as autocorrelation could have undermined the validity of the model estimations and inferences. The absence of autocorrelation in the residuals confirms that the models are well-specified and that the error terms are independent across observations. However, the Shapiro-Wilk test results indicate a departure from normality in the distribution of residuals for both models ($p = 0.000$). Despite this, the non-normality of residuals does not necessarily invalidate the model, particularly in large samples where the Central Limit Theorem ensures the robustness of regression estimates [Li, Ding, 2017].

Upon examination of the histogram representing the distribution of the residuals from the ARDL models (Figure 3), we observe characteristics that, while divergent from a perfect normal distribution, do not necessarily compromise the model's validity. The concentration of residuals around zero is more pronounced than expected under a normal distribution; it has a higher peak around the mean. This clustering near the central value suggests that the model's predictions are pretty accurate for most cases, as errors tend not to be significant. Although the residuals do not conform to a normal distribution, they resemble a Student's t-distribution, often used in statistics as a robust alternative to the normal distribution.

The Granger causality test was used in the empirical study's final step. The use of this method is justified given that while the ARDL model captures long-term equilibrium relationships, encompassing both short and long-run dynamics, the Granger causality is more attuned to detecting the predictive capacity of a variable based on its specific lagged values. Taking that into account, the conducted analysis assesses whether the historical levels of independent variables, such as IR, CPI and UNM, can be used to

forecast the dependent variables, i.e. W3M and W6M. In addition, an inverse relationship was tested, i.e. whether the past levels of W3M and W6M can be used to forecast the independent variables. The results of the tests in relation to the W3M and W6M variables are presented in Table 4 and Table 5, respectively.

Figure 3. Histograms from ARDL models' residuals (model 1 on left, model on 2 right)



Source: own elaboration in R.

A paramount observation from the Granger causality tests is the unidirectional solid causality from the Interest Rate (IR) to W3M and W6M. Counterintuitively, results show that W3M and W6M can be used to predict further central bank interest rates. Also, Linzert and Schmidt [2011] emphasise that monetary policy expectations are

an essential determinant of interbank interest rates. This relationship could be attributed to financial market participants (including Fixing Members) already discounting information about expected interest rates at the WIBOR level. Nevertheless, there was no inverse relationship, so results show that central bank interest rates cannot be used to predict W3M or W6M levels. This phenomenon reflects the anticipatory behaviour of the financial markets, which are ahead in the interest rates curve, factoring in the potential moves in the central bank interest rates.

Table 4. Testing Granger Causality for W3M (1) and independent variables

Variable	Variables cause W3M		W3M causes variables	
	t-value (F)	p.value	t-value (F)	p.value
IR(1)	0.64	0.42	58.3	<0.001***
CPI(1)	5.28	0.022*	2.31	0.13
IPS(4)	1.91	0.11	3.45	0.009*
UNM(4)	1.41	0.23	1.11	0.45

Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: own elaboration in R.

Table 5. Testing Granger Causality for W6M (1) and independent variables

Variable	Variables cause W6M		W6M causes variables	
	t-value (F)	p.value	t-value (F)	p.value
IR(1)	1.01	0.32	53.4	<0.001***
CPI(1)	6.15	0.014*	3.90	0.050.
IPS(4)	1.99	0.097.	3.63	0.0069**
UNM4)	1.11	0.35	1.18	0.32

Signif. codes: '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Source: own elaboration in R.

Considering the relationship between the Consumer Price Index (CPI) and the WIBOR 3M or WIBOR 6M rate, the Granger causality tests reveal a direct influence of inflation on market expectations regarding WIBOR reference rates. As inflation escalates, investors and financial institutions often anticipate that the central bank will hike interest rates to rein in the rising prices. This expected response by the monetary authority translates into higher interbank rates mirrored in the WIBOR 3M and WIBOR 6M. Such an inference aligns with the established economic theory, which posits that rising inflation pressures typically culminate in increased market interest rates.

The Granger causality tests reveal that WIBOR 3M and WIBOR 6M significantly impact Industry Production Sold (IPS). This finding aligns with economic theory, which suggests that lower financing costs, reflected in lower interbank rates, can stimulate investment and industrial production, thereby accelerating industrial sales and contributing to economic growth. As borrowing becomes more affordable, companies are more likely to invest in expansion, increase production, and drive overall industrial activity. As expected, the tests did not indicate any reverse relationship – IPS does not influence WIBOR 3M or WIBOR 6M. This lack of reciprocal causality suggests that while interbank rates can influence the industrial sector, industrial production levels do not directly affect the determination of WIBOR rates.

Moreover, the Granger causality tests also indicate a lack of predictability between the Unemployment Rate (UNM) and WIBOR 3M and WIBOR 6M, aligning with expectations. This suggests that the labour market dynamics encapsulated by the unemployment rate do not have a short-term predictive influence on the WIBOR rates, nor do the WIBOR rates provide foresight into labour market conditions. In both cases, no statistically significant relationships were found, reinforcing the view that unemployment and interbank rates operate independently in the short term.

Conclusion

The study's main findings reveal the significant influence of the National Bank of Poland's (NBP) reference interest rate on the Warsaw Interbank Offered Rate (WIBOR) determinants. This influence was investigated through a robust analysis using the Autoregressive Distributed Lag (ARDL) model and Granger causality tests, providing a comprehensive view of the interactions between central bank reference rates and WIBOR.

The findings indicate that the policy rates significantly influence WIBOR levels. However, the relationship between these rates and the actual market rates, such as WIBOR, is complex. Notably, the Granger causality tests underscore a critical aspect of the financial markets: the inability to straightforwardly forecast WIBOR levels based solely on the central bank's past reference rate adjustments. This phenomenon can be attributed to the market's anticipation of potential changes, suggesting that WIBOR adjustments are often influenced by expectations of future policy adjustments rather than immediate past rate changes. The evidence suggests that WIBOR rates reflect the current economic climate and embody collective market anticipations of future monetary policy directions. This preemptive adjustment by the market underscores the importance of effective communication and predictability of central bank decisions. It highlights that the behaviour of market interest rates like WIBOR is influenced not just by actual policy changes by the Monetary Policy Council (RPP), a key decision-making

body within the NBP, but, more significantly, by the market's expectations ahead of these changes. This anticipatory dynamic within the financial markets emphasises the need for central banks to maintain clear and consistent communication strategies to ensure that market expectations align closely with policy objectives. In addition, the research found that other macroeconomic variables, including unemployment rates, industrial production sold and inflation, do not play a significant role in shaping WIBOR. Nevertheless, the Granger causality test suggests that inflation (CPI) has a more remarkable ability to predict the future level of WIBOR than the central bank's benchmark interest rate. This is due to the direct inflation target adopted in Poland.

In summary, this study confirms the NBP's reference rates' significant impact on WIBOR and highlights the sophisticated interplay of market expectations and other economic variables in determining market interest rates. The findings suggest that while central bank policies are crucial, the actual movement in market rates like WIBOR is also heavily dependent on the economic environment and market sentiment. These insights have significant implications for central bank policies, emphasising the need for clear and consistent communication strategies to align market expectations with policy objectives and for market dynamics, highlighting the importance of understanding the complex relationship between central bank reference rates and market interest rates.

Despite the robust findings, this study has certain limitations. First, it focuses exclusively on the Polish market, which may limit the generalizability of the results to other economies with different monetary policy frameworks or market structures. Future research could extend the analysis to other countries or regions to explore how varying institutional contexts affect the relationship between central bank reference rates and interbank rates. Additionally, while this study considered key macroeconomic variables such as inflation, unemployment, and industrial production, there may be other influential factors – such as global financial market conditions or political uncertainties – that were not included in the model. While inflation is accounted for, the study did not incorporate inflation projections, which could provide valuable insights into market expectations. A limitation in this regard is the quarterly publication of inflation projections in Poland, similar to GDP data. This justifies conducting future studies with a lower frequency of data – such as quarterly data – which would allow the inclusion of such variables in the analysis. On the other hand, it would also be valuable to conduct research using higher-frequency data, such as daily observations, to better capture the immediate reactions of market interest rates to policy changes. This approach would allow a deeper focus on short-term dynamics and the rapid adjustments in market sentiment following central bank decisions. These avenues for future research would provide a more comprehensive understanding of the mechanisms through which central bank policies influence financial markets.

References

Ahmed Z., Zhang B., Cary M. [2021], *Linking economic globalization, economic growth, financial development, and ecological footprint: Evidence from symmetric and asymmetric ARDL*, "Ecological Indicators", vol. 121, 107060, https://doi.org/10.1016/j.ecolind.2020.107060.

Ansori M.F., Ashar N.Y. [2023], *Analysis of loan benchmark interest rate in banking loan dynamics: Bifurcation and sensitivity analysis*, "Journal of Mathematics and Modeling in Finance", vol. 3(1), https://doi.org/10.22054/jmmf.2023.74976.1098.

Beck N. [1992], *The Methodology of Cointegration*, "Political Analysis", no. 4, pp. 237–247, https://doi.org/10.1093/pan/4.1.237.

Belke A., Setzer R. [2003], *Costs of Exchange Rate Volatility for Labour Markets – Empirical Evidence from the CEE Economies*, "The Economic and Social Review", vol. 34, pp. 267–292.

Biefang-Frisancho Mariscal I., Howells P. [2002], *Central Banks and Market Interest Rates*, "Journal of Post Keynesian Economics", vol. 24(4), pp. 569–585, https://doi.org/10.1080/01603477.2002.11490344.

Blanchard O. [2016], *The Phillips Curve: Back to the '60 s?* "American Economic Review", vol. 106(5), pp. 31–34.

Disyatat P., Vongsinsirikul P. [2003], *Monetary policy and the transmission mechanism in Thailand*, "Journal of Asian Economics", vol. 14(3), pp. 389–418, https://doi.org/10.1016/S1049-0078(03)00034-4.

Enders W., Siklos P.L. [2001], *Cointegration and Threshold Adjustment*, "Journal of Business & Economic Statistics", vol. 19(2), pp. 166–176, https://doi.org/10.1198/073500101316970395.

Engle R.F., Granger C.W.J. [1987], *Co-Integration and Error Correction: Representation, Estimation, and Testing*, "Econometrica", vol. 55(2), pp. 251, https://doi.org/10.2307/1913236.

Fedorova E., Meshkova E. [2021], *Monetary policy and market interest rates: Literature review using text analysis*, "International Journal of Development Issues", vol. 20(3), pp. 358–373, https://doi.org/10.1108/IJDI-02-2021–0049.

Friedman B.M., Kuttner K.N. [2010], *Implementation of Monetary Policy*, "Handbook of Monetary Economics", vol. 3, pp. 1345–1438, Elsevier, https://doi.org/10.1016/B978-0-444-53454-5.00012-8.

Iddrisu A.-A., Alagidede I.P. [2020], *Revisiting interest rate and lending channels of monetary policy transmission in the light of theoretical prescriptions*, "Central Bank Review", vol. 20(4), pp. 183–192, https://doi.org/10.1016/j.cbrev.2020.09.002.

Kliber P. [2017], *Determinants of the Spread Between POLONIA Rate and the Reference Rate: Dynamic Model Averaging Approach*, In: Jajuga K., Orlowski L.T., Staehr K. (Eds.), *Contemporary Trends and Challenges in Finance*, Springer International Publishing, pp. 25–33, https://doi.org/10.1007/978-3-319-54885-2_3.

Kong Q., Peng D., Ni Y., Jiang X., Wang Z. [2021], *Trade openness and economic growth quality of China: Empirical analysis using ARDL model*, "Finance Research Letters", vol. 38, 101488, https://doi.org/10.1016/j.frl.2020.101488.

Król P. [2023], *WIBOR, WIRON, WIBID, POLONIA as reference rates for bank loans*, "Economic and Regional Studies / Studia Ekonomiczne i Regionalne", vol. 16(3), pp. 412–421, https://doi.org/10.2478/ers-2023-0026.

Li X., Ding P. [2017], *General Forms of Finite Population Central Limit Theorems with Applications to Causal Inference*, "Journal of the American Statistical Association", vol. 112(520), pp. 1759–1769, https://doi.org/10.1080/01621459.2017.1295865.

Linzert T., Schmidt S. [2011], *What explains the spread between the Euro overnight rate and the ECB's policy rate?* "International Journal of Finance & Economics", vol. 16(3), pp. 275–289, https://doi.org/10.1002/ijfe.430.

Miłobędzki P. [2020], *Czy stawkę Polonia można prognozować, wykorzystując WIBOR O/N?* "Prace Naukowe Uniwersytetu Ekonomicznego We Wrocławiu", vol. 64(12), pp. 47–55.

Pesaran M.H., Shin Y., Smith R.J. [2001], *Bounds testing approaches to the analysis of level relationships*, "Journal of Applied Econometrics", vol. 16(3), pp. 289–326, https://doi.org/10.1002/jae.616.

Petrevski G., Bogoev J. [2012], *Interest rate pass-through in South East Europe: An empirical analysis*, "Economic Systems", vol. 36(4), pp. 571–593, https://doi.org/10.1016/j.ecosys.2012.03.001.

Polish Financial Supervision Authority [2024], *Economic data on the scale of use of benchmarks in the domestic financial market*, https://www.knf.gov.pl/ (accessed: 19.06.2024).

Qamruzzaman Md., Wei J. [2018], *Financial Innovation, Stock Market Development, and Economic Growth: An Application of ARDL Model*, "International Journal of Financial Studies", vol. 6(3), p. 69, https://doi.org/10.3390/ijfs6030069.

Saleem A., Sági J., Setiawan B. [2021], *Islamic Financial Depth, Financial Intermediation, and Sustainable Economic Growth: ARDL Approach*, "Economies", vol. 9(2), p. 49, https://doi.org/10.3390/economies9020049.

Shojaie A., Fox E.B. [2022], *Granger Causality: A Review and Recent Advances*, "Annual Review of Statistics and Its Application", vol. 9(1), pp. 289–319, https://doi.org/10.1146/annurev-statistics-040120-010930.

Williams T. [2020], *From LIBOR to SONIA and what you need to know*, https://www.bankofengland.co.uk/-/media/boe/files/markets/benchmarks/rfr/rfrwg-libor-to-sonia-what-is-libor-slides.pdf (accessed: 21.06.2024).