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How Much Is WIRON Better Than WIBOR?

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Abstract

Theoretical background: The transition from traditional interbank offered rates (IBORs) to more stable and reliable benchmark rates has become a focal point in the financial industry, particularly in the aftermath of the LIBOR scandal. We endeavour to apply theoretical considerations regarding proper benchmark rates within the context of WIBOR and WIRON rates on the Polish financial market. This study delves into the characteristics and effectiveness of both rates.

Purpose of the article: The purpose of this research is to evaluate WIRON against WIBOR across several key dimensions to determine which rate serves as a better benchmark for financial instruments in Poland. This comparison is pivotal, as the chosen benchmark rate significantly impacts the valuation, risk, and performance of a wide array of financial products and contracts. It is hypothesized that WIRON fulfils more criteria of ideal reference rate than WIBOR.

Research methods: Our methodology integrates a comprehensive qualitative and quantitative analysis, comparing WIBOR and WIRON against established criteria for a proper reference rate. This includes an examination of their verifiability, susceptibility to manipulation, daily calculation, independence from policy rates, resilience to market stress, avoidance of calendar effects, and representativeness of the underlying market. To delve deeper into the quantitative aspect, we will conduct numerical analysis and a comparison of quotations employing standard statistical indicators, as well as utilizing the Generalized Autoregressive Conditional Heteroskedasticity (GARCH) model.

Main findings: The findings indicate that WIRON potentially offers a more robust alternative to WIBOR, particularly for overnight (ON) tenors. WIRON demonstrates a slightly better alignment with the principles of verifiability, resilience, and representativeness, attributed to its design that leverages actual transaction data. However, both rates adequately meet the majority of the proper reference rate criteria, with unique advantages in different contexts. The study also observes that WIRON, while advantageous in specific aspects, does not decisively outperform WIBOR across all tenors and criteria. It particularly concerns the fact that WIBOR rates are an outcome of a market-based price formation process; they embed market participants' expectations about future interest rates and market conditions. This nuanced evaluation underscores the complexity of selecting a singular benchmark rate that can effectively cater to the diverse needs of the financial market.

Introduction

Reference rates, at least since the implementation of LIBOR in the 1980s, have been crucial for many segments of the financial markets, both wholesale and retail. In financial contracts, reference rates typically function as benchmarks or as interest rates against which the pricing of other financial instruments is determined. They serve as a standard for determining the interest rate or pricing of various financial products, such as loans, mortgages, derivatives, or bonds.

Following the LIBOR scandals (Ashton & Christophers, 2015), various countries have established special committees to facilitate the transition from IBOR rates to new reference rates known as risk-free rates. These rates have either already replaced the discredited ones or are slated to do so in the near future. In Poland, similar initiatives have resulted in the development of WIRON. It is calculated as a weighted average interest rate of overnight (ON) deposit transactions concluded by data contributors with other financial institutions as well as with large enterprises (GPW Benchmark, 2023d).

The objective of this paper is to evaluate whether, and in what capacity, WIRON functions as a superior and more reliable reference rate than WIBOR, which is scheduled to be replaced. To achieve this, the characteristics of a proper reference rate will be determined, and WIRON will be compared against them. Additionally, WIBOR and WIRON quotations will be examined to discern differences in terms of magnitude and volatility.

Literature review

The definition of reference rates provided by the Bank of International Settlements (Economic Consultative Committee, 2013, p. 3) states that "reference rates are widely used interest rates that connect payments in a financial agreement to standard money market interest rates". A more general definition is given by Baig and Winters (2021, p. 946): "A reference rate is a base rate used in financial contracts". Similarly, Rose (2002, p. 7) mentions that reference rates are financial benchmarks

used in pricing of financial instruments. They are also used for the calculation of the cost of capital (Błach & Łukasik, 2020, p. 26).

The most important and widespread reference rate since the 1980s was LIBOR (London Interbank Offered Rate). It was the rate at which large banks indicated that they could borrow short-term wholesale funds from one another on an unsecured basis in the interbank market (Hou & Skeie, 2014, p. 1). LIBOR was calculated through a process that involved a panel of leading banks reporting to Thomson Reuters their estimated rates at which they could borrow their designated currency in the interbank market (Bryan & Rafferty, 2016, p. 79). Each morning, these banks submitted their rate estimates for each of the 10 currencies and 15 different interest rate periods. Thomson Reuters applied then a trimmed mean methodology, eliminating outliers by deleting the top quarter and bottom quarter of measures, and calculating the average for the middle 50%. This average was then published as the quoted LIBOR rate for that day. The calculation process created the image of a coherent and orderly market with an equilibrium rate of interest. The process involved arithmetically averaging quotations provided separately by banks, whether they were actual transactions or estimated values. In facts, panel banks answered the question "At what rate could you borrow funds, were you to do so by asking for and then accepting interbank offers in a reasonable market size just prior to 11 am London time?".

The financial crisis exposed vulnerabilities in benchmark rates like LIBOR, leading to questions about their credibility and suitability as indicators of funding conditions. One significant vulnerability was the loss of liquidity in the interbank market, which dried up in 2008. As a result, the quotes used to calculate LIBOR increasingly became guesses rather than real transaction data. This loss of liquidity made it easier for banks to submit corrupted rates to LIBOR because there was no real market price to contradict them. The LIBOR scandal revealed intentional misstatements of LIBOR submissions by professionals at financial institutions. These intentional misstatements were made to understate the costs of funds during the crisis and to profit from LIBOR-linked positions over a longer period (Bryan & Rafferty, 2016, pp. 82–83; Hou & Skeie, 2014, pp. 3–15).

After the LIBOR scandal, several measures were taken to address the issues and prevent similar incidents in the future. These measures included the following:

1. Regulatory actions: In mid-2012, regulatory bodies in both the US and the UK imposed fines and enforcement orders on Barclays Bank, marking it as the initial entity implicated in the scandal. Subsequently, additional banks, including UBS and RBS, were also subjected to financial penalties.

2. Criminal and competition investigations: In addition to regulatory measures, criminal and competition investigations were launched into individuals within the banks involved, leading to subsequent lawsuits and civil claims.

3. Reform of LIBOR: In March 2012, the LIBOR scandal led to a British Government-commissioned review by Martin Wheatley of the FSA, aiming to rectify LIBOR's flaws and manipulability. The review recommended stricter oversight,

diversified oversight bodies, and expanded rate-setting contributors to bolster LIBOR's integrity and transparency (Ashton & Christophers, 2015; Bryan & Rafferty, 2016; Hou & Skeie, 2014).

As a result, IBA (ICE Benchmark Administration) adopted a new, standardized, transaction data-driven waterfall methodology for LIBOR calculations. A similar waterfall methodology is still utilized for WIBOR, as will be demonstrated later in the article.

Eventually, regulators worldwide opted to discontinue LIBOR and shift towards risk-free rate benchmarks derived from either overnight bank funding transactions or overnight repo transactions, where one party borrows against government collateral from another (Tuckman, 2023, p. 474). The paradigm shift in financial markets from Interbank Offered Rates to new sets of Risk-Free Rates (RFRs) refers to the transition from using IBOR benchmarks as the reference rates for pricing various financial contracts to utilizing new RFR benchmarks that are rooted in actual transactions and liquid markets. The change is significant as it involves moving away from the traditional poll-based methodology used for IBORs towards transaction-based rates that are considered more robust and credible (Schrimpf & Sushko, 2019, p. 29).

Already in July 2013, the International Organization of Securities Commissions (IOSCO) developed a set of principles regarding financial benchmarks (IOSCO, 2013), which have since served as the foundation for the reform and regulation of IBOR rates and other benchmark indicators.

In 2016, the European Parliament and Council adopted Regulation (EU) 2016/1011 of 8 June 2016 on indices used as benchmarks in financial instruments and financial contracts or for measuring the performance of investment funds (BMR) (Council of the European Union, 2016). The BMR aims to ensure the credibility and resilience to potential manipulation of benchmarks, as well as to minimize conflicts of interest in the processes of establishing them.

The new reference rates incorporate some (or all) of the following attributes:

– shorter tenor, usually ON, where volumes are larger than for longer-dated tenors,

– moving beyond interbank markets to add bank borrowing from a range of non-bank wholesale counterparties (cash pools/money market funds, other investment funds, insurance companies, etc.) (Schrimpf & Sushko, 2019, p. 34).

Table 1 shows the current risk-free rates used in selected jurisdictions. All of them are overnight, but they differ in respect to collateralisation. Some are secured (SOFR, SARON), some not (SONIA, TONAR, €STR).

Table 1. Risk free rates proposed as alternative to LIBOR in selected jurisdictions

Jurisdiction	Working Group	Alternative Ref Rate Name	Administrator	Collateralisations	Description
United States of America	Alternative Reference Rates Committee	Secured Overnight Financing Rate (SOFR)	Federal Reserve Bank of New York	Secured	Secured rate that covers multiple overnight repo market segments
United Kingdom	Working Group on Sterling Risk-Free Reference Rates	Sterling Overnight Index Average (SONIA)	Bank of England	Unsecured	Unsecured rate that covers overnight wholesale deposit transactions
Switzerland	The National Working Group on CHF Reference Rates	Swiss Average Rate Overnight (SARON)	SIX Swiss Exchange	Secured	Secured rate that reflects interest paid on interbank overnight repo rate
Japan	Study Group on Risk-Free Reference Rates	Tokyo Overnight Average Rate (TONAR)	Bank of Japan	Unsecured	Unsecured rate that captures overnight call rate market
Euro area	Working Group on Euro Risk-Free Rates	Euro short-term rate (€STR)	European Central Bank	Unsecured	Unsecured rate that captures overnight wholesale deposit transactions

Source: (Financial Conduct Authority, 2023).

To minimize the risk of manipulation and errors in the process of determining the value of the RFR, the administrators are central banks, and in the case of Switzerland: SIX Swiss Exchange. Description of the market developments related to RFR, especially trading activity in RFR-linked derivatives and development of term RFRs, can be found in ISDA (2023).

The reference rates apply not only to transactions in the market where it is determined but goes beyond this market segment and is widely used in financial markets. Therefore, we will concentrate on benefits and especially on the requirements for the "ideal" reference rates. In 2022, the Steering Committee of the National Working Group selected WIRON as an alternative benchmark to WIBOR, which is widely used in financial contracts and financial instruments, and adopted a road map for its replacement (Emis, 2024, p. 43).

From this perspective, we will try to assess to what extent WIRON, the new reference rate in Poland, meets the requirements of a proper reference rate, especially in comparison to the still used WIBOR rate.

The purpose of reference rates is to provide a transparent and objective benchmark that reflects prevailing market conditions. They help ensure fairness and consistency in determining the pricing of financial instruments.

For loans or mortgages, reference rates like LIBOR served as the basis for calculating interest rates, with formulas such as "LIBOR + 2%" adjusting the borrower's rate according to market changes.

In derivatives, reference rates determine contract values or settlements. For example, in interest rate swaps, payments between parties are based on the difference between a fixed rate and the reference rate.

In the literature, there have also been attempts to develop term risk-free rates, meaning rates that, like the former IBOR-type rates, included a forward-looking element. However, this is challenging as it requires using quotes from liquid swap and derivative markets, which are not always readily available. There is also a mutual interaction between the markets. Traditionally, the derivative market and the cash market were distinct and operated independently. In the post-LIBOR environment, however, this interaction has become bidirectional. For example, if the SOFR swap or futures market rises by 10 basis points for no apparent economic reason – potentially due to factors like market liquidity, margin calls, or other miscellaneous effects – and the term "SOFR" is derived from these instruments, the term "SOFR" will rise accordingly. This, in turn, affects the cash products' cash flows and valuations (Bai & Liu, 2022, pp. 29–30; Financial Stability Board, 2021).

Overall, reference rates in financial contracts provide a standardized method for pricing and determining the interest rates or values of various financial instruments. They provide several benefits for the economy (Economic Consultative Committee, 2013, pp. 4–6; Maechler & Moser, 2022, pp. 3–5).

1. Reduction of complexity and standardization of financial contracts; reference rates link payoffs in financial contracts to standard money market interest rates, which reduces the complexity of financial contracts and facilitates their standardization. This leads to lower transaction costs and enhanced market liquidity.

2. Facilitation of risk reallocation; reference rates encourage active trading and increase the coordination of individual contracts, which in turn reduces the costs of reallocating risks in the financial system.

3. Maintaining predictable financing conditions; proper use of reference rates ensures that economy-wide financing conditions do not change in unpredictable and unintended ways. Using reference rates that are not reliable or robust may result in a tightening of credit conditions beyond interbank lending, affecting corporate bonds, household mortgages, or consumer loans.

4. Alignment with monetary policy; the use of reference rates affects the relationship between monetary policy and the key reference rate(s) used in the domestic economy. For example, reference rates may not reflect market conditions in other time zones, potentially delaying and limiting the impact of policy action by central banks.

5. Fostering liquidity and market efficiency; reference rates contribute to market liquidity and efficiency by providing a benchmark for valuing financial instruments, managing risk, and measuring performance. Market participants rely on discounting cash flows using yield curves based on reference rates, making them integral to various financial activities.

According to BIS (Economic Consultative Committee, 2013, p. 7) and Baig and Winters (2021, pp. 946–950), a proper reference rate should be based on market-de-

termined interest rates, such as interbank lending rates or government bond yields, and fulfil the following criteria:

1. It is easily verifiable, which means, it must not be "costly" to verify by participants. However, it is noteworthy, albeit unacknowledged by the authors, that market participants should also possess the capacity to comprehend the methodology employed in rate calculation, or ideally, be empowered to conduct such calculations independently, contingent upon access to the requisite input data sourced from the underlying market.

2. It is not prone to influence by the counterparties in the contract; good reference rate should have proper governance and administration to safeguard against manipulation or error.

3. It is calculated daily; since new financial instruments are created on business days, it is crucial for reference rates to be updated accordingly. If the reference rate does not reflect the current market conditions, parties involved in a financial contract may hesitate to enter into the agreement.

4. It is not a policy rate. Policy rates and rates to implement monetary policy are tools used in conducting monetary policy. Setting of key interest rates by a central bank, e.g. for open market operations or lending facilities, is currently the main instrument of conducting monetary policy. Taking into account that reference rates should rather reflect what is happening on the financial market, it seems that they should not be arbitrarily set policy rates.

5. It is resilient to market failure or stress; good reference rate should have clear rules for reference rate production, including transparent and well-known fallbacks in periods of no underlying transactions or market stress.

6. It is not prone to calendar regularities, e.g. change in a specific way by the end of every month.

7. It is representative; reference rates should be drawn from a representative sample of the market quotations in question, to ensure correct pricing.

Before comparing WIRON and WIBOR, we will outline key rules for their determination, focusing on main regulations without excessive detail and highlighting guiding principles for quality assessment.

The market measured by **WIBOR** is the interbank money market on which transactions are concluded in cash deposited in central bank current accounts of entities active on that market. WIBOR measures the prices of deposits in PLN placed by fixing participants or entities which meet the criteria of fixing participants. WIBOR has been recognised as a critical benchmark under Article 20(1)(c) of the BMR.

GPW Benchmark (the administrator) determines the WIBOR Reference Rate within a fixing based on quotes contributed by fixing participants (currently 10). The Reference Rates are determined for fixing tenors (ON, TN, 1W, 2W, 1M, 3M, 6M, 1Y). The minimum number of quotes necessary for a fixing for a given fixing tenor is 6. If fixing participants submit 5 or fewer quotes for a given fixing tenor to the administrator, the administrator does not determine the reference rates for such fixing tenor.

For fixing tenor ON and TN transaction data from the fixing day until 4:30 pm are taken, and for others: from the business day preceding the fixing day (t–1).

The administrator determines the average of the quotes contributed by fixing participants for a given fixing tenor at each fixing day as follows:

a) rejecting four extreme quotes, i.e. the two lowest quotes and the two highest quotes if at least 10 quotes are contributed,

b) rejecting the lowest quote and the highest quote if 8 or 9 quotes are contributed,

c) not rejecting any quotes if 6 or 7 quotes are contributed.

The reference rates are determined according to the ACT/365-day count convention, with a precision of two decimal places (GPW Benchmark, 2023b).

The administrator uses the waterfall methodology as the input data preparation method which fixing participants are required to follow in order to meet the requirements of the BMR. Every fixing participant calculates the transaction factor at level 1 of the waterfall method, based on eligible fixing tenor transactions of this fixing participant on the underlying market[1] on day t–1. It is calculated as an average of interest rates of conducted transactions, weighted by volume of the transactions. The minimum number of transactions is currently 1.

If the calculation according to level 1 (transaction-based) is not possible due to missing or not eligible data, fixing participant moves to level 2 (transaction-derived). This level is intended to find transaction factor through interpolation of model quotations reported at level 1 on day *t*, taking into account the spread adjustment factor. Alternatively, transaction factors are calculated based on non-fixing qualified transactions from the base market on day t–1. If it is not possible, level 3 procedures apply and extrapolation of prices from related markets are used, based on eligible fixing-tenor and non-fixing tenor transactions from the financial institutions and other financial institutions segment dated t–1.

At level 4 (expert judgement), committed quotes are considered when the waterfall method's levels 1 to 3 do not yield results. A committed quote is a binding offer to make a deposit at a specified rate for certain tenors. Participants agree to transact at these rates upon demand within a 15-minute window after quotes are published, with deposits capped between PLN 5 to 30 million, varying by tenor (GPW Benchmark, 2023c).

Despite the implementation of the waterfall quotation method, WIBOR rates largely lack a market-driven character and have been suspected of manipulation, with banks allegedly inflating quotations to gain financial benefits (Gradoń, 2014, pp. 64–65). This is confirmed by the low "transactionality" level, defined as the percentage share of model quotes, i.e. prepared on the basis of transactional data under the waterfall method, contributed by the fixing participants, in the total number of quotes in a given month. For example, the "transactionality" level in September 2023

[1] Underlying market for WIBOR are the deposit transactions in the PLN concluded between the fixing participants as well as concluded by the fixing participants with entities which are not fixing participants but meet the fixing participant criteria.

was only 7% for WIBOR 1Y, 5% for 6M, 9% for T/N and 21% for 3M. However, it was quite high for 2W and 1M (above 50%) and very high for ON (98%) (GPW Benchmark, 2023e).

WIRON is calculated from deposit transactions data, representing the weighted average interest rate of ON maturity deposits, based on transactions by 9 contributing banks. Only unsecured deposits over PLN 1 million with banks, financial institutions, and large enterprises are included. WIRON aims to reflect the wholesale money market dynamics, covering inter-bank and broader financial transactions.

Transactions reported by data contributors are cross-checked to ensure that the same transaction reported by two parties is not counted twice.

Transactions exceeding a specified nominal value are adjusted to prevent distortion in WIRON's value due to overly large transactions (current threshold: PLN 2.3 billion). Transactions above this threshold have their volume reduced to the maximum acceptable level.

Transactions with unusually low or high interest rates in relation to the median on a given day, i.e. outliers, are excluded and not considered. As a result, a distortion of the WIRON value by atypical transactions is avoided.

After preparing the pool of eligible transactions, three conditions must be met: the share of transactions from any single data contributor must not exceed 75% of the pool's total volume, at least three entities must contribute data on a given day, and the pool's total volume must be at least PLN 1 billion.

If the above conditions are not met, WIRON is determined using the fallback procedure. Once they are fulfilled, next steps are taken, which consist in examining the level of concentration, making the main adjustment and applying the formula.

Concentration levels are assessed both by market segment (financial institutions and large enterprises) and individually within each segment. Should one segment's contribution to the total transaction volume exceed 50%, the administrator checks for any entity exceeding a 50% share within that segment, adjusting their transaction value down to prevent large, temporary liquidity demands from unduly influencing WIRON's value.

The main adjustment narrows down the transaction set for calculating the volume-weighted average to those rates close to the day's average, symmetrically excluding atypical observations (both high and low) from the daily interest rate distribution.

The WIRON value is determined using the middle fifty percent of the day's volume-weighted interest rate distribution after the main adjustment, resulting in a volume-weighted average interest rate rounded to three decimal places. This method mirrors the calculation approach of €STR (European Central Bank, 2018).

WIRON is primarily calculated from transaction data. During stress periods, a fallback procedure is used, considering the NBP reference rate plus the average difference from WIRON in the past five business days, adjusting for the NBP rate's day count convention. This fallback has no usage time limit. It is also applied if one entity's transactions exceed 75% of the pool, fewer than three contributors are present,

or the pool's volume does not reach PLN 1 billion. No other stress period procedures are provided (GPW Benchmark, 2023b).

Currently (first quarter of 2024), WIRON is not yet significantly used by financial market operators, which means that it is not a benchmark from the perspective of BMR.

The WIRON compound index extends the overnight WIRON rate to longer terms like 1, 3, and 6 months using compound interest, thereby generating risk-free rates for financial market use. This involves backward-looking calculations of compounded daily WIRON rates over selected periods, producing Compound Rates reflective of historical WIRON market behaviour. Detailed methodology is available on the GPW Benchmark website (GPW Benchmark, 2023a).

A limited number of articles comparing WIBOR and WIRON have been published. Król (2023) evaluated these reference rates from 2019–2022 from the borrower's viewpoint, finding WIRON consistently more favourable each quarter. Kozińska (2023) examined their compliance with international standards and the calculation rules' impact on financial system stability, providing insights into their respective benefits and adherence to global financial norms. Kagan et al. (2024) assessed the economic effects of replacing the WIBOR with the WIRON for preferential loans in Polish agriculture.

Research methods

Considering the characteristics of optimal reference rates, a qualitative and quantitative assessment will be conducted of both Polish reference rates: the old WIBOR and the new WIRON. We will endeavour to evaluate the degree to which WIBOR and WIRON satisfy the criteria for an appropriate reference rate through qualitative analysis.

Furthermore, numerical analysis and a comparison of quotations will be conducted, employing standard statistical indicators.

In addition, the month-end effects in WIBOR and WIRON rates will also be scrutinized using dummy variables. A GARCH(1,1) model will be utilized for analysing end-of-month irregularities.

It is hypothesized that WIRON rates may more closely align with the established criteria for reference rates than WIBOR. While the WIRON ON rate, in terms of its calculation method and distribution, is expected to closely resemble the WIBOR ON rate, for longer tenors, such as 3M and 6M, variations in the distributions may arise due to WIRON's reliance on overnight quotes and its backward-looking nature. Calculations encompass periods commencing on January 2, 2019, for NBP key rates and all WIBOR and WIRON ON rates, from April 1, 2019, for WIRON 3M, and from July 1, 2019, for WIRON 6M, concluding on January 31, 2024. This approach enables a comprehensive analysis across different durations and market conditions, facilitating a thorough comparison between the WIBOR and WIRON rates.

Results

First, we will compare WIBOR and WIBOR in terms of whether these rates meet the criteria of appropriate reference rates. It will be advisable – where justified – to compare indicators for overnight and longer-term rates separately.

1. It looks like both rates, WIBOR and WIRON, are easily verifiable. Current and historical overnight quotations are available on www.gpwbenchmark.pl. WIBOR quotations for all tenors are available for download since 2000, although the file format (pdf) does not facilitate time series analyses. For WIRON the starting year is 2019, because it was developed recently, and csv format makes calculations easier.

2. Generally, it appears that WIBOR and WIRON are currently not susceptible to manipulation due to compliance with BMR. However, WIBOR is not always based on strictly transactional data. As mentioned, the transactionality level indicator for WIBOR is high, significantly above 90%, but only for the ON term. For 3M, it is around 20% or less, and for 6M and 1Y, it generally does not exceed 10% (GPW Benchmark, 2023e). This means that the quotations submitted to the administrator are committed quotes, hence they have a lesser transactional value. WIRON primarily relies on actual overnight (ON) transactions in a highly active market, thus seldom requiring fallback procedures. Differences between WIBOR and WIRON should not be interpreted as WIBOR being more prone to manipulation, but rather reflect WIBOR's less market-driven approach, especially given the thin transaction market for longer tenors like 6M or 1Y. WIRON's methodology includes various mechanisms aimed not at countering manipulation – which is nearly impractical – but at avoiding statistical distortions, such as ensuring no single large transaction unduly affects the overall rate.

3. Both overnight (ON) rates are calculated daily, and WIBOR – for all remaining tenors too, as described earlier. In the case of WIRON, interest rates for various terms, e.g. 1M or 3M, can be calculated based on daily quotations (ON) from the past. In this sense, WIRON is available every business day for any term, but concerns the past, while WIBOR – only for fixed tenors and refers to the future.

4. Neither WIBOR nor WIRON are policy rates. However, for various reasons, they are highly, but a little bit different, correlated with National Bank of Poland (NBP) policy rates. Table 2 presents the correlation matrix for periods of data availability mentioned in "Research methods".

Table 2. Correlation matrix of reference rate, lombard rate, WIBOR and WIRON

	Reference rate	Lombard rate	WIBOR ON	WIBOR 3M	WIBOR 6M	WIRON ON	WIRON 3M	WIRON 6M
Reference rate	1	0.9963	0.9984	0.9943	0.9899	0.9952	0.9838	0.9535
Lombard rate		1	0.9959	0.9905	0.9861	0.9908	0.9807	0.9513
WIBOR ON			1	0.9927	0.9879	**0.9969**	0.9843	0.9533
WIBOR 3M				1	0.9991	0.9900	**0.9638**	0.9207
WIBOR 6M					1	0.9853	0.9536	**0.9057**

	Reference rate	Lombard rate	WIBOR ON	WIBOR 3M	WIBOR 6M	WIRON ON	WIRON 3M	WIRON 6M
WIRON ON						1	0.9819	0.9471
WIRON 3M							1	0.9870
WIRON 6M								1

Source: Author's own study.

All WIBOR rates are highly correlated with NBP key interest rates. NBP reference rate determines the yield obtainable on the main open market absorbing operations, usually for 7 days, affecting at the same time, the level of short-term market interest rates. NBP Lombard (lending facility) rate determines the costs of funding obtainable from the NBP overnight. It sets the ceiling for the overnight market rate. It appears that banks set their WIBOR quotations, including both model (transaction-based) rates and committed (more subjective) rates, in alignment with monetary policy rates, particularly for shorter tenors. All correlation coefficients have values above 0.99 for ON and 3M and above 0.98 for 6M.

WIRON rates, more transaction oriented than WIBOR for 3M and 6M, show lower correlation with NBP key rates: over 0.99 for ON, above 0.98 for 3M, and over 0.95 for 6M. The correlation between WIBOR and WIRON (highlighted in bold in Table 2) decreases as the time horizon extends, with ON at 0.9969, dropping to 0.9638 for 3M, and further to 0.9057 for 6M. This suggests a divergence between WIRON and WIBOR rates over time, attributed, among other factors, to the backward-looking nature of WIRON as opposed to the forward-looking approach of WIBOR, which has a lesser impact on overnight transactions.

Subsequently, the WIBOR and WIRON rates were subject to a numerical analysis and comparison using the statistical software, Gretl. Table 3 presents the summary statistics for both the WIBOR and WIRON rates.

Table 3. Summary statistics of WIBOR and WIRON

	WIBOR ON	WIRON ON	WIBOR 3M	WIRON 3M	WIBOR 6M	WIRON 6M
No. of observations	1,279	1,279	1,216	1,216	1,156	1,156
Mean	2.82 / 2.81	2.442	3.22 / 3.01	2.417	3.38 /2.93	2.388
Median	1.58 / 1.58	1.256	1.72 / 1.72	1.219	1.79 / 1.79	1.197
Standard deviation	2.65 / 2.65	2.47	2.82 / 2.77	2.49	2.89 / 2.78	2.49
Minimum	0.07 / 0.07	-0.055	0.21 / 0.21	0.002	0.24 / 0.24	0.006
Maximum	7.02 / 7.02	6.612	7.61 / 7.61	6.314	7.82 / 7.82	6.235
Skewness	0.46 / 0.47	0.52	0.33 / 0.52	0.54	0.24 / 0.65	0.56
Kurtosis	-1.51 / -1.51	-1.48	-1.45 / -1.49	-1.49	-1.69 / -1.27	-1.47

* WIBOR and WIRON published on the same day are analysed. ** WIBOR shifted forward by 1 day (for ON), 3 months (for 3M) and 6 months (for 6M) are analysed.

Source: Author's own study.

The first number for WIBOR, before the slash, indicates statistics for the same calendar day as WIRON. We may also compare WIBOR rates with realised WIRON rates, shifting the WIBOR ON forward by one day. Then, both WIBOR and WIRON refer to the same period (the second number for WIRON, after the slash). Similarly, we shifted the 3M and 6M WIBOR quotations by 3 and 6 months, respectively. In this manner, we can compare the WIBOR 3M rate, for example, on 1 June, with the actual ON rates observed during that 3-month period until the end of August (as indicated by WIRON 3M). Thus, we juxtapose the "projected" rate for the next 3 months (WIBOR 3M) with the realised WIRON 3M rate, although it is important to note that we utilised overnight rates for its calculation. For obvious reasons, the differences between ON figures are negligible but may be noticeable for longer periods. Further considerations will concern the situation in which WIBOR was moved forward.

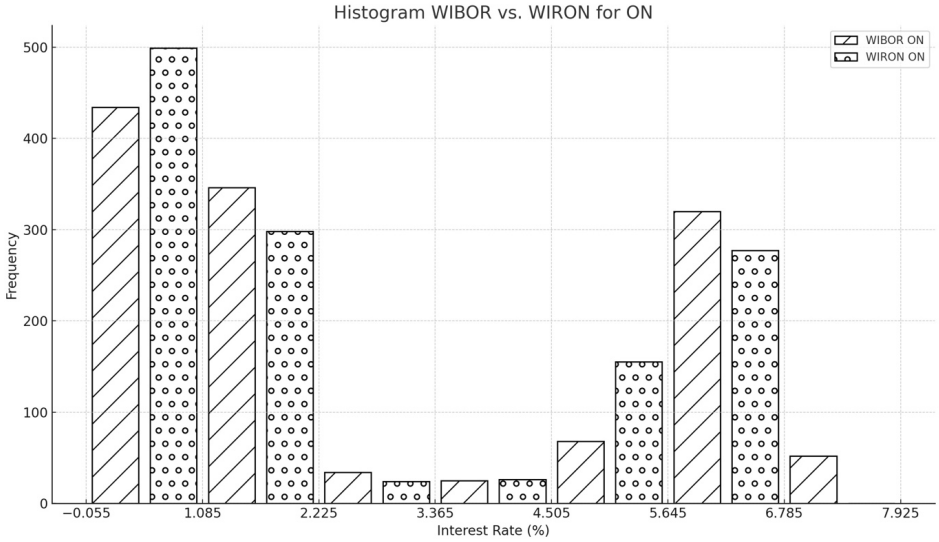
It is crucial to note that metrics like mean, median, skewness, and kurtosis reflect characteristics over the entire examined period and pose challenges when assessing WIBOR and WIRON separately. The indicators' levels may vary based on factors such as the monetary policy's stringency or the occurrence of any crisis phenomena within the period. Nonetheless, comparing these metrics between WIBOR and WIBID can provide insightful contrasts.

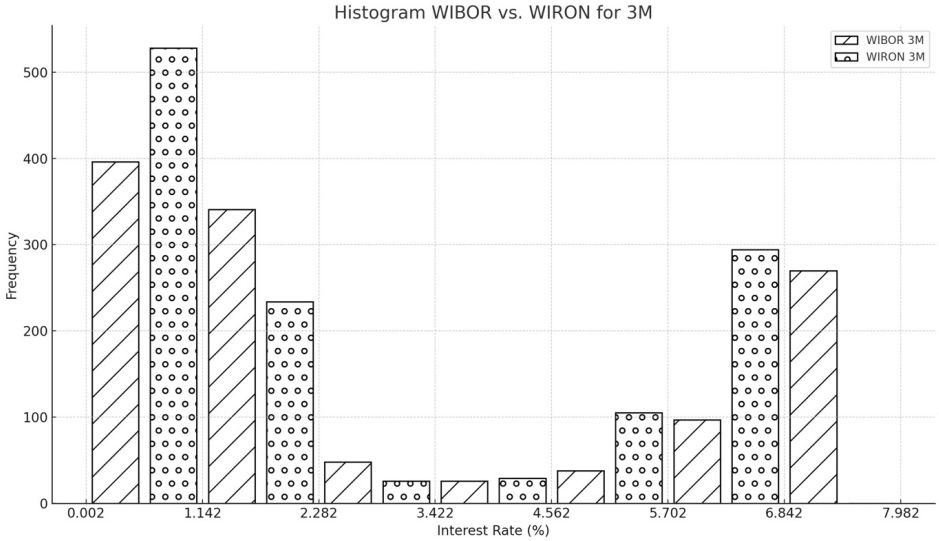
The mean values of WIBOR are consistently higher than those of WIRON by 0.368 percentage points for ON, 0.593 for 3M, and 0.542 for 6M. The median values also show similar differences. This has also been noted by Kagan et al. (2024, pp. 23–26), who simultaneously suggest that after replacing WIBOR with WIRON, banks will lower interest rates on loans. This does not seem likely; rather, bank fees and charges are expected to increase. The lower rates of WIRON are not attributed to its being an unsecured rate, similar to WIBOR, indicating that the disparity stems from other factors.

Moreover, WIBOR is characterized by greater volatility, measured by standard deviation. Both rates exhibit positive skewness, about 0.5. Positive skewness implies that the distribution is skewed to the right, with a longer right tail. This suggests that the majority of the data points are concentrated on the left side of the distribution, with a few larger values pulling the mean to the right. The negative kurtosis indicates that the outlier character of the distribution is less extreme than that of a normal distribution, or the distribution has thinner tails. However, it should be noted that the research period covers a time of exceptionally low interest rates (close to zero), as well as gradually increasing rates by the NBP from the end of 2021 to over 6% for the reference rate. In such a situation, it is difficult to expect a normal distribution of interest rates. This observation is confirmed by the Kolmogorov–Smirnov Test for normality. The results suggests that the distributions of WIBOR and WIRON rates for the ON, 3M, and 6M tenors significantly deviate from normality.

Nevertheless, we can examine the graphical distribution of WIBOR and WIRON to potentially identify certain similarities and differences between them. To determine an appropriate bin size for the frequency distributions and histograms, the Freedman–Diaconis rule was used, which is based on the interquartile range of the data

and aims to minimize the difference between the area under the empirical probability density function and the area under the theoretical probability density function. To ensure uniformity in bin width across all histograms, the maximum calculated bin width of approximately 1.14 will be used for all tenors (ON, 3M, 6M). This uniform bin width facilitates direct comparability between the WIBOR and WIRON rates for every tenor. The lower bin limit was set at the minimum level of quotes for a given tenor (Figure 1).





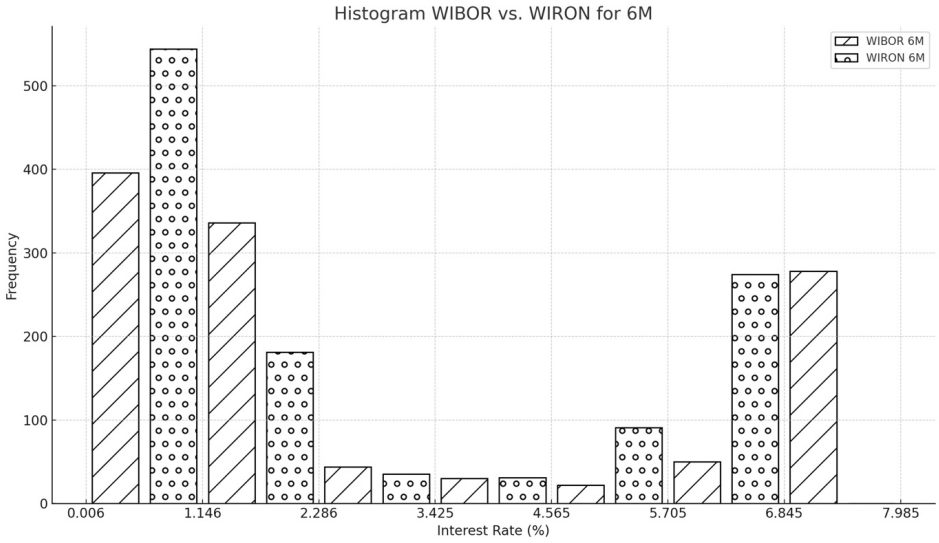


Figure 1. Frequency distribution of WIBOR and WIRON quotations for ON, 3M and 6M

Source: Author's own study.

Given the strong correlation between WIBOR and WIRON rates and recognizing the need to consider the paired nature of our data, the Wilcoxon signed-rank test is an appropriate choice. This non-parametric test compares two related samples, matched pairs, or repeated measurements on a single sample to assess whether their population mean ranks differ. It is particularly suitable for situations like ours, where the independence assumption required for the Mann–Whitney *U* test is violated due to the intrinsic correlation between the two series.

Table 4. Wilcoxon signed-rank test results for WIBOR and WIRON

Tenor	W Statistic	*p*-value
ON	4425	3.3 E-206
3M	10066	8.9 E-190
6M	86292	7.7 E-106

Source: Author's own study.

The findings (Table 4) reveal a statistically significant difference in the median values of WIBOR and WIRON rates for all durations, underscored by very low *p*-values. These *p*-values strongly affirm the significant disparities between WIBOR and WIRON rates across the examined tenors.

WIBOR and WIRON demonstrate differing distributions, even for overnight rates, where discrepancies should be minimal. This can be attributed to several factors: the entities reporting WIBOR and WIRON data differ, transactional data are sourced from distinct entities, data are drawn from varied time frames, and the methodologies for calculating WIBOR and WIRON diverge (WIBOR involves averaging rates by fixing

participants, while WIRON is based on individual transaction reports). Additionally, the criteria for excluding outlier quotes are not consistent between the two.

For longer durations like 3M and 6M, differences between WIBOR and WIRON arise from their inherent designs: WIBOR, being forward-looking, anticipates future interest rates and market conditions, incorporating market expectations, credit, and liquidity risks. This makes 3M and 6M WIBOR rates potentially higher due to the longer-term risks compared to overnight transactions. WIRON, conversely, calculates 3M and 6M rates by compounding past overnight rates. During stress periods, banks' higher WIBOR submissions for these tenors, unlike WIRON's reliance on past rates, lead to a right-shift in WIBOR's frequency distribution.

5. This condition refers to clear rules for reference rate production. For both WIBOR and WIRON, detailed rules for calculating both rates have been developed and published. These rules are transparent and include specific fallbacks for periods of no underlying transactions or market stress.

6. We will now scrutinise calendar anomalies in reference rates, ensuring they do not display atypical behaviour on month-ends. Additionally, we could assess WIBOR and WIRON's performance on contract expiration days. However, in November 2019, the Warsaw Stock Exchange halted futures trading on WIBOR rates due to diminished interest. To date, WIRON futures contracts have yet to be introduced on the Exchange.

We follow Baig and Winters (2021) and use GARCH(1,1) model for the analysis of end of month irregularities. For the study, WIBOR and WIRON quotations without adjustments were used, i.e. those published on the given day.

Mean equation of the GARCH(1,1) model includes the dependent variable, ΔR_t, which represents the change in the WIBOR ON rates. This can be considered as the first difference of the rates to model the returns. The independent variables include a constant term and a dummy variable representing the end-of-month effect:

$$\Delta R_t = \mu + mxreg_1 \cdot EOM_t + \varepsilon_t$$

where: ΔR_t is the change in the WIBOR ON rates, μ is the constant term of the mean equation, $mxreg_1$ is the coefficient for the end-of-month dummy variable, EOM_t is the dummy variable that takes the value of 1 on the last trading day of every month and 0 otherwise. ε_t is the error term.

The variance equation of the GARCH(1,1) model includes terms for a constant variance component (ω), the impact of the squared residual from the previous period (α_1), and the impact of the previous period's conditional variance ($ß_1$).

$$\sigma_t^2 = \omega + \propto_1 \cdot \varepsilon_{t-1}^2 + \beta_1 \cdot \sigma_{t-1}^2$$

where: σ^2_t is the conditional variance at time t, ω is the constant variance component, α_1 measures the effect of the lagged squared residual on current variance (ARCH effect) and β_1 measures the effect of lagged conditional variance on current variance (GARCH effect).

The estimation of model parameters was conducted using the R programming language, specifically employing the "rugarch" package, for both WIBOR and WIRON across all tenors under investigation (ON, 3M, 6M). Only one coefficient for the end-of-month dummy variable (EOM) appeared to be statistically significant when using the conventional standard errors method, due to a *p*-value of 0.000715, which falls below the customary threshold of 0.05 for statistical significance (-0.013865), specifically for WIBOR ON. This would imply that a decrease in WIBOR ON rates is observed on the last trading day of the month. However, robust standard errors were calculated because they offer a more dependable estimate of standard errors in the presence of heteroskedasticity or autocorrelation, which is prevalent in financial time series data. With this adjustment, the situation appears markedly different. The results for WIBOR ON are detailed in Table 5.

Table 5. Estimation results for GARCH(1,1) model for WIBOR ON (robust standard errors)

Coefficient	Estimate	Std. Error	*t* value	*p*-value
μ	-0.000054	0.000487	-0.11042	0.912076
$mxreg_1$	-0.013865	0.025624	-0.54108	0.588454
ω	0.000008	0.000024	0.32723	0.743493
$\propto_1$	0.062968	0.014736	4.27292	0.000019
β_1	0.936032	0.016370	57.18108	0.0

Source: Author's own study.

The robust standard errors yield a high p-value of 0.588454 for the mxreg1 parameter, indicating that the mxreg1 parameter is not statistically significant. A similar procedure was undertaken for WIRON ON, with the results presented in Table 6.

Table 6. Estimation results for GARCH(1,1) model for WIRON ON (robust standard errors)

Coefficient	Estimate	Std. Error	*t* value	*p*-value
μ	-0.000073	0.000848	-0.085766	0.931652
$mxreg_1$	-0.002806	0.003309	-0.847883	0.396503
ω	0.000003	0.000008	0.351567	0.725163
$\propto_1$	0.138629	0.028438	4.874791	0.000001
β_1	0.860371	0.026898	31.986017	0.0

Source: Author's own study.

The mxreg1 estimate is -0.002806. This coefficient is suggesting a decrease in WIRON ON rates on the last trading day of the month but is considerably smaller than that observed for WIBOR. However, the *p*-value associated with mxreg1 (0.396503) indicates that the mxreg1 parameter does not achieve statistical significance at conventional levels. Consequently, there is insufficient evidence to conclusively support the presence of significant irregularities in WIRON ON rates at the end of the month. As for the 3M and 6M tenors, no irregularities at the end of the month were detected, even when employing conventional estimation methods.

7. Reference rates ought to be derived from a representative sample of the market quotations in question to ensure accurate pricing. In this context, it is pertinent to highlight another distinctive aspect of WIBOR quotations. Specifically, they may remain unchanged over consecutive days, which arises from the flawed methodology used to determine the value of this interest rate. In the case of WIRON, this phenomenon also occurs, albeit on a significantly smaller scale (Table 7).

Table 7. Repetitions of WIBOR and WIRON quotations from day to day

Tenor	WIBOR ON	WIRON ON	WIBOR 3M	WIRON 3M	WIBOR 6M	WIRON 6M
Number of days with the same quotations as the previous day	311	33	817	21	830	13
Number of days with the same quotations as the previous day as a percentage of total observations	24.3%	2.6%	67.2%	1.7%	71.9%	1.1%
Maximum number of consecutive days with repetitions	17	2	195	1	291	3

Source: Author's own study.

Especially for longer tenures, series of days with the same WIBOR are clearly noticeable, for instance, for WIBOR 6M the number of days with rates identical to the previous day reaches nearly 72%, and the longest period without a change in quotations lasted over 290 (!) working days.

Meanwhile, for WIRON, the persistence of the same quotations from day to day was an exceptional phenomenon and did not exceed 2.6% of observations, with the longest series of repetitions amounting to only 3.

It is evident that in the case of WIBOR, especially for longer terms, the quotations did not reflect market conditions due to the absence of relevant transactions made by a sufficient number of fixing participants. Consequently, the fourth level of the waterfall was applied, namely committed quotes, which obligate reporting banks to execute transactions at those prices, but only for 15 minutes and within a limited monetary range.

Discussions

To the best of our knowledge, no comparative studies of WIBOR and WIRON in the context of these rates fulfilling the function of benchmark rates have been published. Our results so far show that WIRON is a slightly better reference rate than WIBOR.

Both WIBOR and WIRON rates are easily verifiable, with their current and historical quotations available online. Both rates seem resistant to manipulation, although WIBOR's reliance on less transactional data for longer tenors raises concerns about its market-orientation. WIRON's methodology, focused on actual transactions

for the ON term, includes mechanisms to prevent statistical distortions, enhancing its integrity.

Both rates are calculated daily. WIBOR covers all tenors directly, whereas WIRON calculates rates for various terms based on past daily quotations, making WIRON backward-looking compared to WIBOR's forward-looking nature.

Neither rate acts as a policy rate, though they show high correlation with National Bank of Poland policy rates. This correlation suggests that both rates align closely with monetary policy movements, particularly for shorter tenors.

WIBOR and WIRON possess clear rules for reference rate production, including transparent fallbacks for periods of market stress or no transactions, fulfilling the criterion for resilience to market failure.

Analyses show that WIBOR, and to a lesser extent WIRON, may exhibit end-of-month effects, consisting of lower quotations on the last day of the month, but they are not statistically significant.

The main problem of WIBOR is the lack of the underlying activity supporting the benchmark rate, at least for longer terms. It may not always reflect market conditions due to the methodology and the less frequent changes in quotations. WIRON, however, shows a significantly smaller scale of repetition in its quotations, suggesting better market representativeness.

On the other hand, the critique of the current WIRON framework centres on its inability to encapsulate expected future policy rates and macroeconomic fundamentals. While the mathematical techniques for compounding overnight rates – whether backward or forward-looking – serve their purpose, they only mirror overnight market conditions. This limitation fosters a misleading perception of their applicability to term money markets. Maybe for a range of applications it is rather the pre-determinedness that matters and not so much the feature that the term rate is forward-looking? So, we might use past RFRs, e.g. WIRON, known at the beginning of an interest rate period in order to define a pre-determined term rate.

WIRON and other novel reference rates present challenges not only for economists but also for legal professionals. Legal advisors, experts, and tribunals will need to dedicate more time to comprehending the nuances of these alternatives. This understanding is essential to ensure that tribunals make adjustments that are appropriate for the specific circumstances they are dealing with (Kalinin & Peer, 2021).

Conclusions

The comparative analysis indicates that while both WIBOR and WIRON generally meet the criteria for a proper reference rate, WIRON exhibits advantages in terms of easier verifiability, resilience, avoidance of calendar regularities (or at least, they are not statistically significant), and representativeness, particularly for the ON term. For longer tenors, WIBOR's methodological approach and its alignment with

market expectations through forward-looking rates present distinct characteristics. However, WIRON's stronger alignment with actual transaction data and its lower susceptibility to calendar regularities suggest that it may offer a more robust reference rate under specific conditions. In this sense, there is no basis to reject the hypothesis stated at the beginning of the article, namely that WIRON fulfils more of the criteria for an ideal reference rate than WIBOR.

In conclusion, it is worth noting that both rates, WIBOR and WIRON, are difficult to deem representative for determining the refinancing cost of banks. In this sense, the question of whether and to what extent their use is justified in other market segments, such as for mortgage loans, always arises. However, this issue would require separate analysis.

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