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IMPACT OF PANELISTS ON WIBOR RATES – HYBRID APPROACH

The reform of financial benchmarks is one of the key elements of stability and trust in the financial market. In the money market, it is difficult to implement reforms because of the disappearance of the interbank deposit market, which was a reference market for IBOR-type rates. A solution is a hybrid method which combines declarations of panelists and prices of eligible transactions. Based on historic time series, the article analyses the impact of individual banks on the published index and presents the way the hybrid method can be used for WIBOR 3M. On the grounds of empirical data, the impact of particular banks was found to be moderate and the hybrid method proved to generate an interest rate series of a similar level, but of greater variance. The key problem is a limited impact of real-transaction prices on the published rate due to a low share of concluded deals and divergence of their prices from quotes generated by so called expert judgment in the analysed period.

Key words: financial benchmarks, money market, hybrid method.

JEL CODES: G01, G14, G15.

Introduction

The reform of financial benchmarks is an important element of financial market repairs after the crisis in the years 2007-2009. The reforms force benchmark administrators to change the way benchmarks are determined, mainly by increasing the share of prices of actual transactions in the benchmark calculation methodology. This is an interesting economic issue – to examine the impact of changes in the methodology on the level and variance of benchmarks, which influences the continuity of benchmark determination and the stability of the financial system.

The purpose of this work is to analyse a potential impact of the new method on the time series of an index. As the benchmark (by whatever method) is created as an average of quotations (or transactions) of bank-panelists (quotations of contributors used to determine the index), the first thing to examine is the impact of particular banks on the level of the benchmark. To respond to such a question, time series were analysed in terms of factors influencing the final value of the published benchmark. For that purpose, the following analytical work was carried out:

1. Evaluation of the theoretical impact of changes in the sequence of banks in the quotation ladder on the final value of the index, calculated in accordance with the calculation methodology;
2. Analysis of the sensitivity of the index value to the lack of a given panelist;
3. Analysis of the impact of a shift in the panelist's quotation on the value of the index;

4. Simulation of the hybrid method, including the actual transactions on the assumption that only transactions of a character similar to the reference market are taken into account.

The article is composed of three main parts. Part one presents the genesis of the reform of financial benchmarks and the importance of such benchmarks for the economy. Part two presents data sources and study methodology. Part three describes the results and discusses their practical meaning for financial market participants and stakeholders of financial benchmarks.

Theoretical basis

From a formal point of view, the reform of financial benchmarks was implemented in July 2016 on the basis of the EU Regulation on indices used as benchmarks in financial instruments (the so-called BMR Regulation). The Regulation stipulates that the published indices must meet a number of regulatory requirements and, in particular, must be managed by licenced administrators on the basis of a procedure that ensures that the index is representative and resistant to manipulation. The legislators distinctly prefer benchmarks based on transaction data and not declarations, because the latter, as confirmed in practice, are particularly prone to manipulation. In addition, the regulation specifies interest rate indices as indices of critical importance for the economy.

The changes were encouraged by the financial crisis of 2007-2009, which exposed the drawbacks of benchmarks, including in particular IBOR-type indices, which were crucial for the world economy. The fact that IBOR-rates were disconnected from the market they were to represent was their greatest weakness. Such disconnection resulted from the disappearance of unsecured term deposits in the interbank market as a consequence of the growth of credit and liquidity risks due to the financial crisis, which undermined confidence in market participants (Brousseau et.al., 2013; Mielus, Mironczuk, 2015). IBOR rates were no longer representative, thus it was difficult to verify the similarity of their level with transactions made. At the same time, the declaratory nature of IBOR-type rates favoured manipulations (Abrantez-Metz et.al., 2012; Hou, Skeie 2014; Ghandi et.al, 2015). Knowing the formula of the rate, members of the IBOR panel (index contributors) reported quotations which were in favour of their market strategy (thus either generated a profit from derivatives or hid the growth of funding costs from other market participants).

The purpose of regulations promoting the transactional nature of the rate was to repair the financial benchmarks of the market. The regulations penalised declaration-based rates in order to minimise the probability of the return of manipulation practices. Declaration-based indices are created on the basis of panelists' expert judgements, while transactional indices are implemented by replacing expert judgement with prices of actual transactions (Mielus 2016). If the number of actual transactions was small, hybrid solutions combining declarations and transactions on the basis of a precisely defined data waterfall were permitted.

However, the challenge arising from the BMR Regulation turned out not to be easy to implement. As transactions were not in the reference market, to implement the transactional character postulate, another segment of the money market had to be found. That was, for example, the market of secured transactions or the market including

entities other than banks as counterparties. As a result of the introduction of another segment, the rate shifted and its volatility increased. The change in the economic character of the index infringed the stability of the existing contracts in the financial market (Perkins, Mortby 2015). That problem was particularly important for consumers who took long-term variable-rate mortgage loans.

Thus, analyses aimed at revealing correlation between new and old rates and defining determinants of difference became important. Discrepancy in indices calculated in accordance with various methods generated a basis risk, which could have a negative impact on banks' results (Duffie, Stein 2015; Kirti 2017).

This article is part of the trend of such studies, and analyses the impact of panelists and the changes in methodology on the final benchmark, using the example of WIBOR 3M. Conclusions from this analysis may be useful in the reform of benchmarks implemented in EU states.

Evidence and methodology of the study

The study is composed of three main parts. First, based on stylised facts, the author analyses the theoretical impact of changes in quotations of a single panelist on the published rate, taking into account the existing methodology of WIBOR calculation. Second, based on the collected time series of WIBOR 3M¹, the impact of the lack of a single panelist or changes in such a panelist's quotations on the index value is analysed. Third, the hybrid method including actual transactions was simulated and its impact on the level of WIBOR 3M² in comparison with the published values was examined.

The first study consists of the analysis of the theoretical impact of changes in the sequence of banks in the quotation ladder on the final value of the index calculated in accordance with the calculation methodology. Pursuant to the WIBOR Rules, the rate is calculated as an arithmetical mean without marginal quotations (so called trimmed average). If there are at least 10 panelists, we reject two (top and bottom) marginal quotations. If there are 8 or 9 panelists, we reject one marginal quotation. In the case of a smaller number, all quotations are taken into account. Table 1 presents the variability of the number of quotations incorporated in the calculation, depending on the number of active panelists in the panel on a given day.

Table 1. Relation between a number of quotations and a number of panelists

Number of active panelists on a given day	Number of quotations included in arithmetical mean
12	8
11	7
10	6
9	7
8	6
7	7
6	6

Source: author's own compilation based on the WIBOR Rules.

¹ The Thomson Reuters system contains 2113 daily observations from 2009-2017 with regard to 14 panelists.

² The database of the Thomson Reuters and SMRP system contains 1527 daily observations from 2012-2018 with regard to 11 panelists. Divergent ranges of start and end dates of time series and numbers of panelists result from the availability of analytic data.

It was assumed that in every case two banks have quotations greater by 10 bp and two banks have quotations smaller by 10 bp than the index determined on the previous day, whereas the other panelists gave quotations at the rate determined on the previous day. In this case, whatever the number of panelists, there is the following relation:

$$IBOR_t = IBOR_{t-1}$$

where $IBOR_t$ is a rate published today, and $IBOR_{t-1}$ is a rate published yesterday. As a result of the symmetrical distribution of marginal quotations and a great share of quotations consistent with the market of the previous day, the rate is determined invariably at the same level, whatever the number of panelists.

The rate would be different if, given the fixed number of participants, one of them shifted from a marginally high rate to a marginally low rate (or vice versa). Then, we observe the impact of such a shift on a change in the value of the published index. This is reflected in Table 2:

Table 2. Impact of a change in quotations of a single panelist on the sequence in the quotation ladder and the index value

Normal panel		Bank A quotes low		Bank J quotes high	
A	2.10	BB	2.10	J	2.10
B	2.10	C	2.00	A	2.10
C	2.00	D	2.00	BB	2.10
D	2.00	E	2.00	C	2.00
E	2.00	F	2.00	D	2.00
F	2.00	G	2.00	E	2.00
G	2.00	H	2.00	F	2.00
H	2.00	I	1.90	G	2.00
I	1.90	J	1.90	H	2.00
J	1.90	A	1.90	I	1.90
2.00		1.98		2.02	

Quotations that were included in the calculation are marked grey and the bank which changed its quotation is in bold. The last line presents the value of the index calculated on the basis of the quotations.

Source: author's own compilation.

The analysis indicates that the index value is sensitive to changes in the bank's quotations even if such a bank's quotations are not included in the calculation of the index value (because they are always rejected as marginal). The shift of quotations, e.g. so that the highest quotation became the smallest one, changes the sequence of banks in the ladder and causes different banks to be included in the final calculation, which changes the index value. Therefore, the trimmed average method used to calculate a declaration-based benchmark does not make the benchmark significantly less prone to manipulation.

The above analysis, based on stylised facts, will be important in the analysis of actual time series observed in the WIBOR 3M panel. The analysis incorporates a study of the impact of a single panelist on the index value, given the existing WIBOR calculation methodology (i.e. based on trimmed average). Several versions of the study were conducted, i.e.:

1. Analysis of the sensitivity of the index value to the lack of a given panelist;

2. Analysis of the impact of a shift in the panelist's quotation on the index value on the assumption that the quotation changes continuously (by different level) up and down.
3. Analysis of the impact of a shift in the panelist's quotation on the value of the index in the case of a (upward or downward) change dependent on the level of the present dispersion of prices in the panel.

Finally, there is the simulation of the hybrid method, including the actual transactions on the assumption that only transactions whose character is similar to the reference market are taken into account. Such transactions are unsecured deposits with a maturity close to 3 months (between 85 and 95 calendar days) accepted by banks who are WIBOR panelists from other banks (from the panel or not) and non-bank financial institutions whose value is at least PLN 10 million. We chose deposits that meet the definition of a wholesale market and expand the representativeness of the rate³. It was assumed that if a bank has an eligible transaction (i.e. meeting the above criteria), such a transaction replaces the original quotation (i.e. expert judgement). When old data was replaced with new input data, differences between an original and a new (hybrid) time series were verified.

The results are presented in the following section.

Results and discussion

Table 3 summarises the results of the sensitivity analysis for selected panelists by the use of the aforementioned study methodology.

Panelists' maximum impact of slightly above 2 bp must be considered moderate. The above study was supplemented with the analysis of anomalies in banks' quotations. For that purpose, the following formula was used:

$$Z = \frac{X_t - \bar{X}}{\sigma}$$

where:

Z – a measure of a quotation anomaly;

X_t – a difference between a bank's quotation and WIBOR fixing on day t

\bar{X} – an average difference on the last 20 working days of a particular bank's quotes

σ – standard deviation of the difference for the last 20 working days

The results are presented in Table 5.

The results suggest that in the long run quotations of particular banks are stable and consistent with the market situation of the panel. However, some single quotations are unnaturally divergent from the actual index. Taking into account the previous analysis of such a quotation, it must be assumed that in these cases the quotation is neither taken into account to calculate an average mean nor has a substantial impact on the index.

The final study consists of a simulation of the hybrid method. Two sets of data were prepared: original series made of expert judgement and eligible transaction series. On the day the bank concluded a transaction, the transaction price replaced the original quotation. In the case of a greater number of transactions with a given panelist, an

³ It is useless to select solely deposits meeting requirements of the WIBOR Rules (i.e. deposits accepted from panelists of 20 million for 3M) because there are no such transactions.

average interest rate weighted with a transaction amount was calculated. As a result, we obtained a new series of WIBOR 3M rates calculated in accordance with the same algorithm as the original one (i.e. on the grounds of the trimmed mean), but based on other input prices, which is reflected in Figure 1.

Table 3. Maximum change in the index as a result of the lack of or change in quotation of a given bank

Bank ⁴	No MAX	No MIN	+10bp MAX	-10bp MIN	+20bp MAX	-20bp MIN	+DISP MAX	-DISP MIN
BGKW	0.02	-0.02	0.02	-0.02	0.03	-0.02	0.00	0.00
BGZW	0.02	-0.01	0.02	-0.02	0.03	-0.02	0.03	-0.02
BPHW	0.00	-0.01	0.01	-0.01	0.01	-0.01	0.01	-0.01
BHWL	0.02	-0.02	0.02	0.00	0.03	-0.02	0.03	-0.02
MILL	0.01	-0.02	0.02	-0.02	0.02	-0.02	0.02	-0.02
PKOP	0.02	-0.01	0.02	-0.02	0.03	-0.02	0.03	-0.02
WBKP	0.02	-0.02	0.02	-0.02	0.03	-0.02	0.03	-0.02
DBPL	0.00	-0.01	0.01	-0.01	0.01	-0.01	0.01	-0.01
INGW	0.01	-0.01	0.02	-0.02	0.03	-0.02	0.03	-0.02
BREX	0.01	-0.02	0.02	-0.02	0.03	-0.02	0.03	-0.02
SSBW	0.02	-0.02	0.02	-0.02	0.03	-0.02	0.03	-0.02
RCBW	0.01	-0.02	0.02	-0.02	0.02	-0.02	0.02	-0.02
GNBW	0.00	-0.01	0.00	-0.01	0.00	-0.01	0.00	-0.01
SOCW	0.00	-0.01	0.01	-0.01	0.01	-0.01	0.01	-0.01

No MAX – maximum positive impact if the bank does not provide a quote

No MIN – maximum negative impact if the bank does not provide a quote

+10bp MAX – maximum positive impact if the bank shifts 10bp upwards

-10bp MIN – maximum negative impact if the bank shifts 10bp downwards

+20bp MAX – maximum positive impact if the bank shifts 20bp upwards

-20bp MIN – maximum negative impact if the bank shifts 20bp downwards

+DISP MAX – maximum positive impact if the bank shifts by actual dispersion upwards

-DISP MIN – maximum negative impact if the bank shifts by actual dispersion downwards

Source: author's own compilation based on Thomson Reuters data.

On the basis of Table 3, “a ranking of impact” which reflects an average maximum impact on a change in the index, including all analysed categories, was prepared:

⁴ BGKW – Bank Gospodarki Krajowej, BGZW – BGŻ (now BNP BGŻ), BPHW – Bank BPH, BHWL – Bank Handlowy, MILL – Bank Millennium, PKOP – Bank Pekao, WBKP – BZ WBK (now Santander), DBPL – Deutsche Bank Polska, INGW – ING Bank Śląski, BREX – mBank, SSBW – PKO Bank Polski, RCBW – Raiffeisen Bank Polska, GNBW – Getin Bank, SOCW – Societe Generale (Warsaw branch).

Table 4. Ranking of a bank's average maximum impact on a change in the index value

Ranking	Bank	Average maximum impact in bp		Ranking	Bank	Average maximum impact in bp
1	WBKP	2.25		8	MILL	1.88
1	SSBW	2.25		8	RCBW	1.88
3	BGZW	2.13		10	BGKW	1.63
4	PKOP	2.13		11	BPHW	0.88
4	BREX	2.13		11	DBPL	0.88
6	BHWL	2.00		11	SOCW	0.88
6	INGW	2.00		14	GNBW	0.50

Source: author's own compilation.

Table 5. Measurement of anomalies in quotations of particular banks

Bank	Average Z	Max Z	Min Z
BGKW	-0.01	11	-18
BGZW	0.02	10	-11
BPHW	-0.24	1	-5
BHWL	0.05	14	-9
MILL	-0.02	10	-12
PKOP	-0.02	7	-8
WBKP	0.00	9	-5
DBPL	0.04	5	-3
INGW	0.04	25	-19
BREX	0.07	30	-9
SSBW	-0.05	14	-9
RCBW	-0.06	7	-14
GNBW	0.26	4	-4
SOCW	0.17	4	-4

Average Z – arithmetical daily average of Z values

Max Z – maximum positive Z value

Min Z – maximum negative Z value

Source: author's own compilation based on Thomson Reuters data.

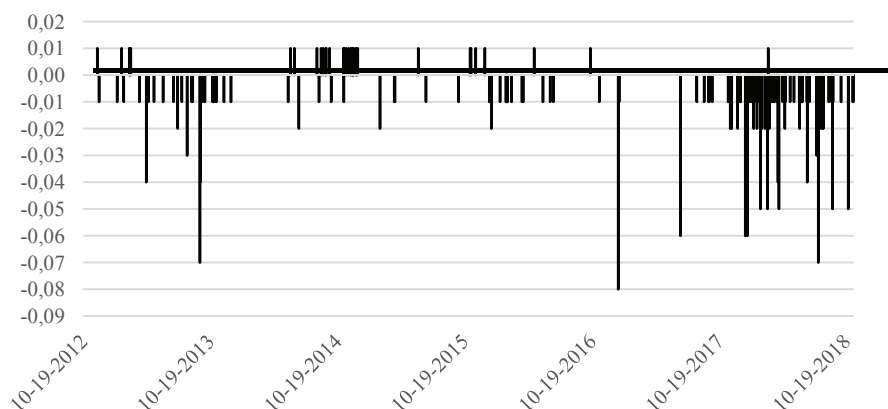


Figure 1. Difference between WIBOR 3M indices calculated in accordance with the original and hybrid methods

Source: author’s own compilation.

We can see that the hybrid WIBOR is more often lower than higher in comparison to the old methodology. This is due to the fact that the WIBOR rate is an “offer” quote (the rate at which the bank is willing to lend). In practice, the majority of deals, especially from a non-banking sector, come at a “bid rate” that is a bit lower.

During the analysed period, the transactions were only made on 496 out of 1527 banking days (32%), which is reflected in Table 6.

Table 6. Number of transactions in the hybrid method

Number of panelists with transactions	Number of daily observations
0	1031
1	393
2	83
3	16
4	3
5	1

Source: author’s own compilation based on SMRP data.

Thus, it can be assumed in advance that the hybrid WIBOR for 1031 banking days will be fixed precisely at the same level as the original index because on these days none of the banks within the panel made a transaction that would have met the required criteria. On other days, the WIBOR rate changed only in 148 cases, what amounts to 10% of the sample. In turn, on 348 days, despite transactions, the WIBOR did not change because the prices of those transactions were rejected in the calculation algorithm as marginal (i.e. exceeding the trimmed mean)⁵. The impact of transactions on the WIBOR modifications due to the hybrid method is summarised in Table 7.

⁵ Maximum deviation of prices of transactions made by the bank from the bank’s quotation based on expert judgement was 124 bp, and average deviation was 23 bp.

Table 7. Number of days on which a hybrid rate differed from the original rate of WIBOR 3M

Modification in WIBOR	Number of daily observations
Zero because of the lack of transactions	1031
Zero because of the rejection of transaction prices ⁶	348
1 basis point	114
2 basis points	17
between 3 and 8 basis points	15

Source: author's own compilation.

It is clearly seen that in 67.6% of cases we did not record any deals so the WIBOR – even after application of the hybrid methodology – would be created 100% by expert judgement. In the following 22.8% cases transactions were excluded from the panel due to the trimmed average algorithm. If a deal rate of one bank is divergent with the majority of other banks' expert judgments, it is not taken into account anyway. Only 9.6% of observations are affected by concluded deals that are included into the fixing panel. The maximum impact was 8 basis points⁷.

The hybrid method, despite taking into account the prices of concluded deals, in over 90% has no effect on the WIBOR rate which is fully created, as so far, by the expert judgment. It means that in order to provide a deal-based benchmark one must use another (broader) set of input data. It will have, however, a negative impact on stability and continuity of the published index. This suggests that a scenario with “parallel listing” of several indices (estimated on the basis of various methods suitable for numerous groups of stakeholders) might be the optimal solution in this case (Mielus 2017).

Next, a change in the level and volatility was analysed by the use of the hybrid method broken down into two analysed periods resulting from the implementation of a bank tax (which had a great impact on the interbank money market):

1. period from 19 October 2012 to 31 January 2016
2. period from 1 February 2016 to 9 November 2018

The results are presented in Table 9.

Table 9. Impact of the use of the hybrid method on the level and volatility of the index

Period	Average level (original method)	Average level (hybrid method)	SD (original method)	SD (hybrid method)
Whole sample	2.156	2.155	1.1	1.3
Period 1	2.530	2.530	1.4	1.5
Period 2	1.713	1.711	0.2	1.1

SD calculated as standard deviation of a daily index change in basis points.

Source: author's own compilation.

There was a small change in the index given the six times greater volatility for the period following the implementation of the bank tax. This may be explained with an

⁴ In theory it is also possible to observe no difference because the concluded transaction is very close to the original quote of the bank. In practice such events were very rare.

⁷ Note that a difference between the hybrid and original rate can be caused both by inclusion or exclusion of such a rate into the trimmed average. A detailed analysis of such phenomenon can be performed in further research.

unnatural compression of volatilities upon the implementation of the tax, which resulted from the permanent disappearance of the reference market and the “freezing” impact of the BMR Regulation on panelists’ quotations based on expert judgement (Mielus 2018). The latter means that panelists give quotes that are similar to other banks and are reluctant to change their quote in comparison to the previous day in order to avoid question from the supervisory authority.

Summary

The calculation and application of financial benchmarks are important elements of the financial system and determine the stability and susceptibility of this market to disturbances. Disturbances generated by benchmarks result from manipulations which distort the benchmark and have a negative impact on its informative value and the valuation of instruments which use benchmarks. Therefore, regulating financial benchmarks is an important element stabilising financial markets.

The implementation of new regulations is a great challenge because it is sometimes impossible to incorporate a transaction factor in declaration-based indices due to the disappearance of the reference market. In turn, the use of other market segments may distort the level and volatility of the benchmark, which has a destabilising impact on financial contracts entered into on the basis of such a benchmark.

These problems can be solved by the use of hybrid methods which combine declarations based on banks’ expert judgement with actual transactions meeting strictly defined criteria. In the case of these methods, we must be aware, however, of the impact of single panelists on the index calculation. Furthermore, market participants should understand the specific character of the distribution of transaction prices.

The article, given on the example of WIBOR 3M, presents methods used to assess the impact of particular panelists on the published benchmark, as well as consequences of the use of the hybrid method for the index. Empirical data indicate that particular banks have a moderate impact on the published rate and the hybrid method is highly convergent with the index calculation methods used to date. The index based on the actual transactions is, however, more volatile than the fully declaratory index. An additional problem is the limited impact of real-transaction prices on the published rate due to a low share of concluded deals and divergence of their prices with quotes generated by expert judgment in the analysed period.

Bibliography

- Abrantes-Metz R., Kraten M., Metz A., Seow G. (2012), Libor manipulation?, *Journal of Banking & Finance*, Vol. 36, no. 1, p. 136-150
- Brousseau V., Chailloux A., Durre A. (2013), Fixing the Fixings: What Road to a More Representative Money Market Benchmark?, *IMF Working Paper No. 13/131*, 29.05.2013
- Duffie D., Stein J. (2015), Reforming LIBOR and Other Financial Market Benchmarks, *Journal of Economic Perspectives*, Vol. 29, no. 2, Spring, p. 191-212
- EMMI (2017): Position Paper Setting out the Legal Grounds for the Proposed Reforms to Euribor, 8.03.2017
- Gandhi P., Golez B., Jackwerth J.C., Plazzi A. (2015), Libor Manipulation: Cui Bono?, *Finance Research Seminar*, April 2015
- GPWB (2017), Regulamin stawek referencyjnych WIBID i WIBOR, 30.11.2017
- Hou D., Skeie D. (2014), LIBOR: Origins, Economics, Crisis, Scandal and Reform, *Federal Reserve Bank of New York Staff Report No. 667*, March 2014
- Kirti D. (2017), What are reference rates for?, *IMF Working Paper, WP/17/13*, January 2017

- Mielus P. (2016), Dylematy reformy indeksów rynku finansowego, *Gospodarka Narodowa*, 4/2016, p. 91-114
- Mielus P. (2017), Vicious circle of the benchmark reform, *Bezpieczny Bank*, Vol. 69, No. 4, p. 108-129
- Mielus P. (2018), Behavioural aspects of benchmark quotation – the WIBOR case, *Acta Universitatis Lodziensis Folia Oeconomica*, 3(335), p. 189-205
- Mielus P., Mironczuk T. (2015), Structure of the cost of deposits in selected EU countries, *Bezpieczny Bank* 3(60), Warszawa 2015, p. 89-101
- Perkins J., Mortby P. (2015), Evolving financial benchmarks: The impact on legacy contracts, *Journal of Securities Operations & Custody*, 7.4, Autumn/Fall 2015, p. 296-304
- Regulation of the European Parliament and of the Council (EU) 2016/1011 of 8 June 2016 on indices used as benchmarks in financial instruments and financial contracts or to measure the performance of investment funds

Wpływ panelistów na kształtowanie się stawki WIBOR – podejście hybrydowe

Streszczenie

Reforma wskaźników finansowych jest jednym z kluczowych elementów stabilności i zaufania na rynku finansowym. Na rynku pieniężnym, wdrożenie reformy jest trudne ze względu na zanik międzybankowego rynku depozytowego, który stanowił rynek referencyjny dla stawek typu IBOR. Rozwiązaniem jest metoda hybrydowa stanowiąca połączenie deklaracji panelistów oraz cen zawartych transakcji spełniających wyznaczone kryteria. Artykuł, na podstawie historycznych szeregów czasowych, analizuje wpływ poszczególnych banków na kształtowanie się publikowanego indeksu oraz prezentuje aplikację metody hybrydowej dla wskaźnika WIBOR 3M. Na podstawie danych empirycznych ustalono, że wpływ poszczególnych banków jest umiarkowany, a metoda hybrydowa generuje szereg stóp procentowych o podobnym poziomie stawki, ale o wyższej wariancji. Problemem jest niski udział cen transakcyjnych w procesie kształtowania stawki, ze względu na ograniczoną liczbę zawartych transakcji oraz rozbieżność ich cen z ocenami eksperckimi składanymi w okresie analizowanej próby.

Słowa kluczowe: wskaźniki finansowe, rynek pieniężny, metoda hybrydowa.

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