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ECB quantitative tightening: Euribor-Overnight Index Swap spread and transmission mechanism efficiency

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Abstract

This paper examines whether the credit risk of banking financial intermediaries can influence the effectiveness of the monetary policy transmission mechanism. The effects are transmitted via the Euribor – Overnight Index Swap (OIS) spread. The Euribor-OIS spread is mainly explained by the credit risk and the probability of default of the panel banks participating in the Euribor. The DCC-MGARCH model confirms a significant relationship between the credit risk of the ten largest Euribor panel banks and the Euribor-OIS spread with an impact on the financing costs of the real sector. The study is based on daily data (1 June 2020 – 30 June 2023). The results of the DCC-MGARCH model are confirmed by a continuous wavelet-based analysis. The research model reveals inefficiencies in the interest rate pass-through mechanism, which calls for a continuous assessment of the Euribor reference rate mechanism, not only with regard to the transparency of interbank transactions, but also to the assessment of the credit risk of Euribor panel banks.

Keywords: Euribor-OIS spread, credit risk, DCC-MGARCH model, transmission mechanism inefficiencies, wavelet coherence analysis

JEL: D44, D53, G12, G14

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1. Introduction

The interbank market plays an important role in the transmission mechanism of monetary policy. The interbank market is not a risk-free market. Counterparty credit risk between the participants in the interbank market must be taken into account in the pricing of interbank market products. Therefore, the bank-lending channel should be the efficient mechanism for transmitting the monetary policy instruments to the real sector of the economy. The presence of credit risk in banking intermediaries can impair the effectiveness of the monetary policy instruments. While changes in the policy interest rate affect the market interest rates, the customer-based interest rates in lending activities of financial intermediaries in the European financial system is interbank interest rate – Euribor. Euribor is the interbank interest rate for unsecured euro deposits exchanged between Euribor contributing banks. It is the most crucial benchmark rate for the funding costs measurement for financial and non-financial euro market participants.

In March 2022, the European Central Bank decided that it was time to move away from the long-term non-conventional monetary policy and initiate quantitative tightening (Schnabel 2023). The most important lever of the European Central Bank's quantitative tightening policy was the increase of the key policy rates (Claeys 2023). Policy makers expected a strong impact on the deterioration of domestic demand, the reduction of corporate sector investment, and the decline in bank assets (Agrippino, Ricco 2021).

The inefficiency of the interbank market may disrupt the expected impact of the monetary policy on the real sector of the economy. The indicator of the deterioration of the credit quality of the reference rate contributing banks is in the existence of Euribor – Overnight Index Swap (OIS) spread (Taylor, Williams 2009). The higher spread between Euribor as the key customer rate and the risk-free OIS rate results from the credit risk premium built into the price of unsecured money market deposits traded between Euribor contributing banks (Schwarz 2019). If the creditworthiness of the financial institutions (contributors) deteriorates, the reference interest rates (Euribor) will be higher than expected by the monetary authorities. As a result, the Euribor-OIS spread may deviate from the expected impact of the monetary authorities' instrument on the overall economy (Schrimpf, Susho 2019). Credit risk volatility of financial intermediaries may be amplified by bank-specific or macroeconomic determinants and cannot be properly integrated into models assessing policy outcome *ex ante*, as it is unobservable from the perspective of monetary policy makers in all circumstances.

The primary research hypothesis of the paper is that the credit quality of market-making European banks has a direct impact on the financing costs of the real sector and reduces the transmission effect of the European Central Bank's quantitative tightening policy. This implies a discrepancy between the expectations of the monetary policy model and the expected real effects, which may disrupt monetary policy objectives. The volatility of the Euribor-OIS spread affects the yield in the corporate debt market, which is the additional research hypothesis and empirical evidence of the expected impact.

This paper is in fact based on Taboga (2013), with the fundamental differences being the size of the research sample, the analysis of the impact of monetary policy on the financing costs of the real sector and the research model applied. While previous studies considered the analysis of the Euribor-OIS spread and the credit risk premium measured by the prime banks' credit default swap rate, the study in this paper only includes Euribor panel banks. In addition, previous research did not consider the impact of spreads on the real sector, which is a crucial objective of quantitative tightening of monetary policy. Previous research (Taboga 2013; Angelini, Nobili, Picillo 2011) focussed on proving that Euribor is no longer the ultimate risk-free benchmark interest rate in financial markets, which is also confirmed in this paper.

The contribution of this paper is multi-layered. First, the paper provides evidence on the impact of the evolution of the banks' credit quality contributing the benchmark interest rate on the Euribor-OIS spread. This means that the respective panel banks transfer the cost of their own credit risk to the daily Euribor valuation mechanism, which affects the price and value of financial instruments linked to the Euribor benchmark rate.

Secondly, the transmission effect of the deterioration of the credit risk of prime banks on the financing costs of the corporate sector is identified, as it results from the difference between the yield on the debt of highly rated companies and the evolution of risk-free policy rates.

Finally, appropriate models for financial time series with heteroscedasticity, unit root and non-normality are identified. In this paper, the DCC-MGARCH model is used together with wavelet coherence analysis in an innovative way. The dynamic conditional correlation (DCC) multivariate generalised autoregressive conditional heteroscedasticity (MGARCH) model is estimated as it deals with heteroscedasticity, while being flexible in modelling both the mean and variance equations. It provides time-varying correlations between the model variables, while wavelet coherence analysis can further reveal the lead-lag relationship between the variables. These combined methods provide a comprehensive representation of the transmission mechanism through a combination of standard econometric modelling and time-frequency domain analysis to better understand the relationship between the variables.

The rest of the paper is organised as follows. Section 2 reviews the relevant current theoretical and empirical literature. Section 3 develops the research methodology and presents the data structure. Section 4 analyses the research findings and discussion; and Section 5 concludes with the research hypotheses.

2. Literature review

Many studies have contributed to understanding the influence of monetary policy on the activities of the real economic system (Durante, Ferrando, Vermenulen 2020). The banking channel of monetary policy is one of the most efficient transmission mechanisms. The banking channel in transmitting monetary policy is operationally realized by the balance sheet channel, bank lending channel, and risk taking channel (Lane 2023). The balance sheet channel's mechanism based on companies' net worth and household impact on investment activities is particularly sensitive to tightening monetary policy (Angelopoulou, Gibson 2009). With increasing policy and market interest rates, net values and investments capacities are decreasing with a direct negative impact on investment decisions. Therefore, the higher funding cost reduces the loan supply, which is the transmission effect of the bank-lending channel on monetary policy changes (Apergis, Miller, Alevizopoulou 2012). Many authors examine the risk-taking channel of monetary policy where the banks downside the investment policy's risk on low policy interest rates and access to central bank liquidity (Acharya, Naqvi 2012).

Ireland (2005) extended the effect of monetary policy instruments and transmission channels to interest rates, exchange rates, equity and property prices, bank lending, and corporate balance sheets.

Research is looking for a market equilibrium, considering the role of the banking sector and the importance of lending (Blinder, Stiglitz 1983). Endut, Morley and Tien (2018) further analysed the role of bank financial intermediation in monetary policy. They recognized the difference in the banking sector's response to monetary policy instruments over the last 50 years and emphasised the complex impact of intermediary institutions on policy objectives. Mojon and Peersman (2001) presented one of the first analyses of the monetary policy transmission mechanism in the Eurozone countries.

Despite the cross-country differences, the research model recognized similar trends in the effects of GDP monetary policy on Eurozone economies. The original model of the expected effects of monetary policy in the Eurozone countries became even more complex with the enlargement of the euro member states and the development of theoretical and empirical evidence on the relationship between the monetary and real sectors. Angelini et al. (2019) presented the ECB's baseline model of the expected impact of the policy instrument. The new official model predicts the policy simulation, assesses the relationships between the macroeconomic variables, forecasts the effect, and produces scenario analyses of the transmission channels.

Many authors emphasize the important role of the interbank market in the monetary policy transition mechanism (Freixas, Jorge 2008). After the 2007 financial crisis, asymmetric information between interbank market participants has increased. Angelini, Nobili and Picillo (2011) analysed the growth of the spread between secured and unsecured deposits in the interbank market, which is mainly determined by risk aversion, the expectation of the borrower's creditworthiness, and the presence of moral hazard. Michaud and Upper (2008) found that the daily quotation of interest rates on the interbank market depends on volatility of counterparties' credit risk. The authors concluded that market imperfections lead to transmission costs for the final decision-makers.

Since the 2007 financial crisis, tensions in the Eurozone interbank financial markets have been seen in the differences between Euribor and OIS rates (Taboga 2013). McAndrews, Sarkar and Wang (2008) identified the market imperfections and proposed the expansion of facilities of monetary authorities toward market participants. Other authors point to the transfer of credit risk from financial intermediaries to market reference rates, which significantly reduces the achievement of policy objectives (Taboga 2013). Taylor and Williams (2009) analysed the impact of counterparty risk on the interest rate spread but not as much as the contribution of liquidity risk. Krishnamurthy and Vissing-Jorgensen (2011) warned of the complexity of the impact of quantitative easing policy on a particular set of financial assets in a dynamic financial market.

Taboga (2013) presented the most similar research in this paper. The primary motive for the research is identical: to prove that the Euribor interest rate is not risk-free and that it incorporates the credit risk of the interbank market. The fundamental differences lie in the size of the research sample, the analysis of the impact of monetary policy on the financing costs of the real sector, and the research model applied. While the previous research considered the analysis of the Euribor-OIS spread and the credit risk premium measured by prime banks' credit default swap rate, the research in this paper only includes Euribor panel banks. In addition, the previous research has not considered the impact of spreads on the real sector, which is a crucial objective of quantitative tightening of monetary policy. Prior research (Taboga 2013; Angelini, Nobili, Picillo 2011) has focussed on proving that Euribor is no longer the ultimate risk-free benchmark interest rate in financial markets, which is also confirmed in this paper.

Whether the policy of quantitative tightening achieves the desired and expected effects presented to the European Parliament (Claeys 2023) depends on the efficiency of the transmission measures and the structural characteristics of the member states' economies.

3. Methodology and data

The outcome of the research model is to identify the impact of the deterioration of panel banks' credit risk affecting the market's benchmark rates on the Euribor-OIS spread with a direct effect on the increase of the corporate sector's financing costs.[1] The list of the variables used in the model are given in Table 1.

The research uses the daily values of available public data (Bloomberg and Refinitive data source) from 1 January 2018 to 30 June 2023. Graphical presentation of the credit default swap rate (CDS), Euribor-OIS spread (e_ois) and corporate debt yield-deposit facility rate (y_depo) is given in Figure 1 in panels (a)–(c). The constant value of CDS of 30.813 from 10 April 2018 to 11 March 2020 does not enable us to extract the information about the impact of the movement in the credit quality of the prime contributing banks of benchmark market interest rate on the Euribor-OIS spread. Therefore, this period is excluded from further consideration. Additionally, to move away from the excess volatility at the beginning of the COVID-19 crisis, the starting period for further calculation is 1 June 2020. All the variables of interest exhibit a similar pattern, i.e. after the initial jump in their values at the start of the COVID-19 crisis, they continue with a period of slow decline in values characterized by low volatility. However, after 1 January 2022 the values of all three variables sharply increased, exhibiting high fluctuations and extreme volatility. In particular, y_depo exhibited a significant slump after a peak of 3.965 in 21 June 2022, reaching its lowest value of 0.143 on 26 June 2023.

Descriptive statistics with normality, stationarity, homoscedasticity, and independence tests are given in Table 2 from 1 June 2020 up to 30 June 2023. Table 2 shows the mean value of CDS (Figure 1a) is 30.96, while its standard deviation is 15.59. It ranges from 13.27 to 72.80 with positive skewness and kurtosis. Descriptive statistics for e_ois (Figure 1b) shows that the mean value is 0.188 with standard deviation of 0.226. It ranges from -0.028 to 1.083 with positive values of skewness and kurtosis. Variable y_depo (Figure 1c) has the mean value of 1.402 with standard deviation of 0.871. The range of values goes from 0.143 to 3.965, with positive skeweness and kurtosis. Normality of returns is tested using a skewness and kurtosis test for normality (SK). The null hypothesis that the time series is normally distributed can be rejected for all variables at 1% significance level. The stationarity is tested using the Augmented Dickey-Fuller (ADF) test, where the null hypothesis is that a unit root is present in a time series sample. Since the null hypothesis for CDS and y_depo cannot be rejected, a unit root is present in these time series. The null hypothesis can be rejected only for e_ois based on 5% significance level, i.e. the variable is a stationary process. The ADF test for the first differences between CDS and y_depo shows that they are stationary processes.

Moreover, an ARCH effect is tested using a Lagrange multiplier (LM) test for the null hypothesis that the residuals do not show any autocorrelation pattern. The LM ARCH test strongly rejects the null hypothesis of no ARCH effect for all the variables. Descriptive statistics for the whole sample show the same pattern, although with lower volatility. It is available from the authors upon reasonable request.

The correlation matrix for all variables in pairs for the selected period can be found in Table 3. All correlation coefficients are statistically significant at a significance level of 1%. In addition, there is a positive and strong correlation between CDS and e_ois of 0.812. The correlation coefficients between CDS and y_depo and between e_ois and y_depo are also positive but moderate, reaching values

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[1] Research model include most important Euribor contributing banks: Banco Santander, Banco Bilbao Vizcaya Argenta, BNP Paribas, Commerzbank, Credit Agricole, Deutsche Bank, Intesa Sanpaolo, Societe Generale, and Unicredit.

of 0.528 and 0.584, respectively. The correlation between the variables of interest for the whole sample shows a similar pattern. However, the correlations in the entire sample are slightly lower than for the sample after the COVID-19 crisis. This indicates that the relationship between the variables in the selected period is even stronger than in the entire sample and should therefore be analysed with greater attention.

Due to inherent heteroscedasticity in the variables of interest, which should be modelled appropriately, the DCC-MGARCH approach is used in this paper. DCC-MGARCH stands for dynamic conditional correlation (DCC) multivariate generalized autoregressive conditional heteroscedasticity (MGARCH) model. The DCC-MGARCH model was developed by Engle (2002). This model considers the dynamics of the conditional correlations, while the two-stage procedure ensures the feasibility of optimization and calculation even with many time series. Their advantages lie in the flexibility of modelling both the mean and variance equations. More specifically, they can choose any GARCH-type model for each time series, which is simpler compared to the Vech, BEKK, and factor models.

Furthermore, Vech models require additional restrictions to ensure positive semi-definiteness of the variance-covariance matrix, which is not a problem with DCC-MGARCH-type models. It leads to a better interpretability of the model and an improvement in the ease and speed of calculation. They also have the advantage over constant conditional correlation (CCC) models, as CCC assumes constant conditional correlations, which is unrealistic in most empirical applications (Boffelli, Urga 2016). In this paper, however, dynamic conditional correlations and GARCH-type models are not of primary interest. They are included in the model to control for the inherent heteroscedasticity of the variables.

The main advantage also comes from modelling the mean equations for each variable. Each variable can be modelled very simply as a constant or with only the lags of the dependent variable, or different designs can be used depending on the problem, including VAR (Vector AutoRegression) or VECM (Vector Error Correction) specifications. In this context, two intermediate equations are specified in this paper. The first equation is set up to determine the impact of the development of the credit quality of the banks that define the reference market interest rate on the Euribor-OIS spread. The second equation attempts to determine the transmission effect of the deterioration in the credit risk of top-rated banks on the financing costs of the corporate sector, which is indicated by the difference between the yield index for highly rated companies and the key interest rates.

First, logarithmic transformation of variables CDS and y_depo is performed to fulfil the characteristics of the variables of interest. This is a suitable means of transforming a highly skewed variable into normalized data. As both variables are stationary in the first differences, this is also included in the model. The final model of the mean equations for the two variables is as follows:

$$\begin{gathered} e\_ois_t = e_0 + e_1 \Delta \ln\_CDS_t + \varepsilon_{1t} \\ \ln\_y\_depo_t = d_0 + d_1 \Delta \ln\_y\_depo_{t-1} + d_2 e\_ois_t + d_3 \Delta \ln\_CDS_t + \varepsilon_{2t} \end{gathered} \tag{1}$$

where ε_t is the vector of residuals defined as $\varepsilon_t = u_t \sqrt{h_t}$, where $u_t \mid I_{t-1}$ is an i.i.d. process following a standard normal distribution while I_{t-1} is the information set available up to time $t-1$; for the two different equations the residuals are denoted with ε_{1t} and ε_{2t}.

Variance equations are GARCH (2,2) and GARCH (1,1) models for the two variables respectively, i.e.:

$$\begin{gathered} h_{1,t} = \alpha_0 + \alpha_1 \cdot \varepsilon_{1,t-1}^2 + \alpha_2 \cdot \varepsilon_{1,t-2}^2 + \beta_1 \cdot h_{1,t-1} + \beta_2 \cdot h_{1,t-2} \\ h_{2,t} = \alpha_0 + \alpha_1 \cdot \varepsilon_{2,t-1}^2 + \beta_1 \cdot h_{2,t-1} \end{gathered} \tag{2}$$

where h_t ($h_{1,t}$ and $h_{2,t}$) are the conditional variances.

In the second line of the equation (2) α_0 is the constant ($\alpha_0 > 0$), α_1 is the parameter that captures the short-run persistence of the ARCH effect, while β_1 represents the GARCH effect or the long-run persistence of volatility ($0 \leq \alpha_1 + \beta_1 < 1$). The first line is just an extension of GARCH (1,1) model with additional parameters α_2 and β_2 for the additional ARCH and GARCH terms.

Namely, after the estimation of GARCH (1,1) model for the e_ois, the residuals show the remaining of the ARCH effect, which is then solved by incorporating additional ARCH and GARCH terms. Therefore, in the first step of the estimation procedure multivariate GARCH (2,2) and GARCH (1,1) models are fitted.

In the second step the DCC model by Engle (2002) starts from the decomposition of the matrix H_t, i.e. the variance-covariance matrix of returns:

$$H_t = D_t R_t D_t \tag{3}$$

where D_t is the diagonal matrix of conditional standard deviations computed by univariate GARCH models from the first step and R_t is the conditional correlation matrix of returns which is time dependent and takes the following form:

$$R_t = \operatorname{diag}\left(q_{11,t}^{-1/2}, q_{22,t}^{-1/2}, \ldots, q_{mm,t}^{-1/2}\right) Q_t \operatorname{diag}\left(q_{11,t}^{-1/2}, q_{22,t}^{-1/2}, \ldots, q_{mm,t}^{-1/2}\right) \tag{4}$$

The $m \times m$ symmetric positive definite matrix Q_t is given by:

$$Q_t = \left(1 - \lambda_1 - \lambda_2\right)\bar{Q} + \lambda_1 \frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\left(\frac{\varepsilon_{t-1}}{\sqrt{h_{t-1}}}\right)' + \lambda_2 Q_{t-1} \tag{5}$$

where λ_1 and λ_2 are time invariant parameters while the constraint $\lambda_1 + \lambda_1 < 1$ ensures that the process is stationary and where $\bar{Q}$ is the sample counterpart of the unconditional correlation matrix; in this two-step optimization procedure, the parameters are estimated using maximum likelihood (Boffelli, Urga 2016).

On the other hand, the DCC-MGARCH model has limitations since it cannot distinguish which variable is a source of correlation, i.e. which variable is a lead and which variable lags in their relationship. Therefore, wavelet coherence analysis (WTC) is used as it can study periodic phenomena in time series, particularly in the presence of potential changes across time. It is free of model selection parameters. This paper uses the Morlet wavelet to analyse the frequency structure of uni- and bivariate time series (Rösch, Schmidbauer 2018).

The time-varying and time-scale-dependent co-movements between the variables in the model are assessed using a WTC. Specifically, given the original time series as a function of time, the WTC separates it into a function of two variables: time and frequency. The series correlation in a two-dimensional diagram helps to identify and interpret the pattern or hidden information. The analysis of the correlation between two WTCs is known as wavelet coherence. The diagram specifies the degree of correlation between two variables with varying time and frequency. Therefore, the WTC provides an alternative representation of the variability and relationship structure of specific stochastic processes on a scale-by-scale basis (Bhuiyan, Husain, Zhang 2023). It is the appropriate tool for comparing the frequency contents of two-time series and drawing conclusions about the series' synchronicity at specific periods and across certain time ranges. To obtain the lead-lag relationship, the phase differences are plotted. Namely, the arrow direction reflects the phase differences in wavelet coherent spectrum (→←↗↙↘↖). The arrows pointing to the right (→) signify that the variables are in phase (positive correlation). Conversely, when arrows pointing to the left (←) imply they are out of phase (negative correlation). In addition, the right-up and left-down arrows (↗, ↙) reflect that first variable leads the second variable, while the right-down and left-up arrows (↘,↖) indicate that the first variable is lagging behind the second variable (Jana, Sahu 2023).

Most of the papers combining wavelets and DCC-MGARCH models actually deal with examining co-movement and spillovers on the capital markets also including cryptocurrency markets, gold, oil, and/or other natural resources as well as currencies (Jana, Sahu 2023; Bhuiyan, Husain, Zhang 2023; Ghosh, Sanyal, Jana 2020; Jiang, Zhou, Qiu 2023). However, to our knowledge, none of the papers have studied the proposed approaches for transmission mechanism validation. Namely, papers like Oddo and Bošnjak (2021) assess the effectiveness of transmission channels for US monetary policy from 1995 Q1 to 2019 Q3, using the wavelet coherence approach. Ryczkowski (2019), on the other hand, investigates the relationship between money/credit growth and house price inflation for a sample of twelve developed countries using the continuous wavelet transform from 1970 to 2016. Alaoui et al. (2019) analyse the relationship between the quantity of money, interest rate, inflation, exchange rate, index of industrial production, and equity indices in the case of Malaysia using the wavelet technique. However, they all use quarterly or yearly data instead of daily data, as well as different variables, periods, and markets. This paper, however, examines whether the credit risk of bank financial intermediaries can influence the effectiveness of the monetary policy transmission mechanism and whether the effects are transmitted via the Euribor-OIS spread.

4. Results and discussion

The results of the DCC-MGARCH model with specifications of the mean and variance equations, as in equations (1) and (2) are presented in Table 4, along with parameter estimates and standard model diagnostics. The output table first presents results for the mean parameters used to model each dependent variable e_ois and y_depo. In the first equation, CDS has a positive influence on e_ois spread. It is also statistically significant at 1% significance level. In the second equation, e_ois has a positive and statistically significant influence on y_depo at 1% significance level, while CDS has an insignificant influence. This confirms the mediating effect of e_ois spread on y_depo.

Subsequently, the output table presents results for the variance equations, and the last part of the output table presents results for the adjustment parameters λ_1 and λ_2 and the conditional quasi-correlations R_t, Wald test results, the log-likelihood (*LL*) value, and the number of observations (*N*).

Most parameters of the model are statistically significant at a significance level of 1%, as are the estimates of the ARCH and GARCH terms. The results of the Wald test, in which the null hypothesis is that all coefficients of the independent variables in the mean equations are equal to zero, reject the null hypothesis at the 1% level.

The estimates for both λ_1 and λ_2 are statistically significant. Additionally, positive parameters α_1 and β_1 ensure that estimated variances are favourable, while the satisfied constraints $\alpha_1 + \beta_1 < 1$ and $\lambda_1 + \lambda_2 < 1$ ensure that the process is stationary. All this indicates that the DCC-MGARCH model, estimated using the maximum likelihood estimation method in two steps, is correctly specified.

The long-run or conditional correlation is $R_t = 0.3149$, which means that e_ois and y_depo have weak and positive conditional correlations. The evolution of the estimated daily conditional correlations of the DCC model is shown in Figure 2. It shows that in most periods the correlation between e_ois and y_depo is strong and positive (57.2% of days), although in some periods the correlation is negative. These periods with negative correlations occur in times of higher volatility of y_depo, while the volatility of e_ois remained somewhat lower. The first period with negative conditional correlations is July to November 2020, the second is May and June 2021, October 2021 to January 2022 and the last is from March to June 2023. The graphical representation of the estimated volatilities for the variables e_ois and y_depo can be found in Figure 3a and Figure 3b respectively.

The pairwise wavelet coherence between the pairs of variables in the models in equation (1) is given in Figure 4a–4c. The vertical right-side colour scale bar reflects the strength of squared coherence (0–1) between the variables, the left-side vertical axis depicts the frequency (in days scale), and the horizontal line below the graph represents the study period. The red indicates the variables are strongly interconnected, whereas the blue indicates they are not. The arrows pointing to the right (→) signify that the variables are in phase (positive correlation). Conversely, when arrows pointing to the left (←) imply they are out of phase (negative correlation). In addition, the right-up and left-down arrows (↗, ↙) reflect that first variable leads the second variable, while the right-down and left-up arrows (↘,↖) indicate that first variable is lagging behind the second variable. Finally, there are three categories of relationship, i.e. long-term (128–256 days), mid-term (64–128 days), and short-term (2–64 days) (Jana, Sahu 2023).

From the two sets of plots accounting for dynamic co-movement, we see that the propensity of high association predominantly emerges in low frequency. Namely, short interrelationships between the selected time series are less intense than medium and long-run dynamics. The same pattern can be seen for all pairs of variables, i.e. e_ois and cds, y_depo and cds, and y_depo and e_ois, since for all the pairs of variables, the red colour predominates in the medium and long term. There are some strong correlations between the variables in the short term, but they are predominantly found in 32- to 64-day periods. Only the relationship between y_depo and e_ois is particularly strong even in shorter periods, i.e. even starting from the 8-day period. The period of high correlation between the variables starts around the beginning of 2022 and is even more pronounced in the beginning of 2023.

As for the direction of correlation between the variables and their lead-lag relationship, the cross-wavelet power levels between e_ois and cds (Figure 4a) show high positive correlations in the long run starting from January 2022, with e_ois lagging behind cds, which means that cds positively influences e_ois in the long run. In the medium and short term, the correlation is also positive and robust from January 2022 to December 2022, while at the end of the period it turns into a negative correlation between e_ois and cds.

The correlations between y_depo and cds (Figure 4b) show a strong positive relationship between the variables in the long term in the period from the end of 2020 to October 2021, while the strong medium- and short-term relationship again starts from January 2022, where most of the arrows indicate the leading role of y_depo up until December 2022. Beginning in December 2022, the medium-term correlation showed a positive relationship, with y_depo lagging behind CDS. After February 2023, the medium- and short-term relationship became negative.

The correlations between y_depo and e_ois (Figure 4c) indicate that there is a strong positive relationship between the variables, starting from July 2021 for the medium- and short-term relationships, where most of the arrows indicate the leading role of y_depo, while in the end of 2022 and the beginning of 2023 y_depo lags behind e_ois in the medium term.

Given that Euribor is the reference interest rate for most customer-related transactions in the financial sector, the results of the research model indicate a significant contribution of the banks' financial intermediaries to the inefficiency of the transmission mechanism. The structural distortions in the banking sector that led to the global financial crisis in 2007 disrupted the functioning of the interbank system and meant that global and systemically important banks were no longer seen as risk-free institutions. Regulatory reform contributed to a new resilience of the banking sector to business-related risks (IMF 2023). Higher regulatory costs and restrictions on the operations of bank financial intermediaries led to negative market sentiment and increased the cost of capital for banking firms (Ercegovac, Pečarić, Klinac 2020). The upcoming process of banking sector transformation and the challenges of implementing banks' new business models jeopardize banks' creditworthiness (Hernáez et al. 2022).

This means that those responsible for the monetary policy must consider the credit risk of bank financial intermediaries when analysing and projecting the impact of transmission policy on the real economic system. This is reflected in the Euribor-OIS spread and the panel banks' credit spread integration into borrowers' financing costs. The effect is particularly significant during the quantitative tightening period and high policy rates (see Figure 1a–1c). This means that bank-specific characteristics affect the bank channel, changing the expected market rates, increasing funding costs, and reducing the expected output. Although the model is based on market data of various financial instruments inside the single market, their high liquidity and currency homogeneity ensure the relevance of the research results. Relying on the theory of market price, between the model-related instruments, there are arbitrage opportunities, and the cost of carry of trading position can be measured by Euribor rates, with zero profit effect (Guidotti 2023). Therefore, the research model ignored the bid-ask price dynamic of market yield important in the interaction between market participants trading orders, particularly in the absence of trading liquidity (Sarkissian 2020). Concerning the former, the macro liquidity variable was insignificant and excluded from the research model.[2] The conclusion is that the Euribor--OIS spread mostly arises from Euribor panel banks' credit risk.

However, monetary and supervisory authorities must continue the regulatory dialogue with financial intermediaries to maintain the negative effects of impairment of their creditworthiness to keep the transmission mechanism of monetary policy efficient (Regis et al. 2021).

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[2] Macro liquidity is measured by Eurozone Excess Liquidity indicator provided by the European Central Bank representing the deposits at the deposit facility net of the recourse to the marginal lending facility.

5. Conclusion

In assessing the impact of the quantitative tightening policy, policymakers have ignored the Euribor-OIS spread, which is confirmed by the research model in this paper that disrupts the efficiency of the interest rate transmission mechanism and amplifies the adverse side effects of quantitative tightening instruments. Considering that Euribor is the primary reference rate for most floating rate lending transactions, including derivatives used for trading or hedging purposes, the existence of the Euribor-OIS spread shows that panel banks transfer their risk of credit deterioration to the price of client-related financial instruments.

The research model in the study found a significant correlation between the credit risk of the Euribor panel banks, as measured by the credit default swap rates, and the value of the Euribor-OIS spread. The existence of the Euribor-OIS spread since the last global financial crisis in 2007/2008 implies a violation of risk-free interest rates in the European financial sector, which leads to a transfer of banks' credit risk costs to other market participants and increases the financing risk of the corporate sector, potentially with a negative impact on the growth of the real economy (Schularick, Taylor 2012). The positive correlation between key interest rates and yields on highly rated fixed-rate corporate bonds and the Euribor-OIS spread confirms the intermediation effect of transferring the credit risk of bank intermediation to customer-related financial products.

The model results suggest that policymakers should consider the impact of financial intermediation risk in pricing customised financial instruments with adverse effects on real economic activities and expected macroeconomic parameters. The recommendation to the authorized administrator of Euribor rates is to continue the dialogue with stakeholders to improve the efficiency of the calculation methodology.[3]

Since 2019, the transaction-based method has offered a robust and transparent procedure for setting benchmark rates with minimal risk of manipulation between the panel banks. The fact is that the credit risk of the panel banks, as assessed by market participants, directly impacts the price of a given bilateral deposit, as the lending bank must adjust the credit assessment of the exposure to the borrowing counterparty. The market-based credit spread of the respective panel bank is transferred to the daily Euribor valuation mechanism. It affects the price and value of financial instruments linked to the Euribor benchmark rate.

Although the new regulatory framework has made European banks more resilient to financial shocks and crises than ever before, the uncertainty of the global economy can increase the emerging risk in the banking sector, which can seriously jeopardise the effectiveness of policy instruments and the achievement of policy objectives (McCaul 2023).

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[3] The European Money Market Institute is responsible to contribute Euribor rates under the Benchmarks Regulation of the European Union (BMR) covered by Regulation (EU) 2016/1011.

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Appendix

Table 1

List of the variables

Variable	Variable name	Description
E_OIS	Euribor – OIS spread	Difference between two main market benchmark rates: Euribor and Overnight Index Swap rate on euro funds (matched maturities)
Y_DEPO	Corporate debt yield – deposit facility rate*	Difference between EUR denominated unsecured fixed rate debt instruments issued by European companies with Bloomberg composite rating indicator of A+, A or A- and rate on the deposit facility which banks may use to make overnight deposits with the Eurosystem
CDS	Credit default swap rate	Credit default swap rate on selected prime and the most significant banks contributing Euribor and OIS rates

[*] The rate on the deposit facility which banks may use to make overnight deposits with the Eurosystem.

Source: the authors' calculations.

Table 2

Descriptive statistics with normality, stationarity, homoscedasticity and independence tests from 1 June 2020 up to 30 June 2023

	CDS	e_ois	y_depo
N	1,125	1,125	1,125
μ	30.9634	0.1884	1.4021
σ	15.5916	0.2265	0.8712
min	13.275	-0.028	0.143
max	72.802	1.083	3.965
α_3	0.6858	1.4874	1.1379
α_4	2.1744	4.7084	3.2079
SK	177.53***	282.58***	165.88***
ADF	-1.052	-3.109**	-1.141
ADF(D)	-15.079***	–	-18.295***
LM(1)	1,099.682***	964.617***	1,100.151***
LM(5)	1,098.706***	963.024***	1,096.795***
LM(10)	1,094.740***	959.278***	1,091.986***

Note: $^{*}\,p < 0.1$, $^{**}\,p < 0.05$, $^{***}\,p < 0.01$

Source: the authors' calculations in STATA 18.0.

Table 3

Correlation matrix from 1 June 2020 up to 30 June 2023

	CDS	**e_ois**	**y_depo**
CDS	1		
e_ois	0.8122***	1	
y_depo	0.5283***	0.5848***	1

Note: * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$

Source: the authors' calculations in STATA 18.0.

Table 4

Estimated parameters with standard model diagnostics for DCC-MGARCH Model from 1 June 2020 up to 30 June 2023

	e_ois		**y_depo**
e_0	0.02814*** (0.00049)	d_0	-0.08064*** (0.00545)
e_1	0.00839** (0.00401)	d_1	0.30768*** (0.06608)
		d_2	0.84906*** (0.01071)
		d_3	-0.07670 (0.04776)
α_0	9.68e-7*** 2.21e-7	α_0	0.001348*** (0.00014)
α_1	0.94081*** (0.08463)	α_1	0.30757*** (0.02017)
α_2	-0.89795*** (0.08301)		
β_1	0.95879*** (0.06854)	β_1	0.66475*** (0.01721)
β_2	-0.00314 (0.06626)		
$\alpha_1 + \alpha_2 + \beta_1 + \beta_2$	0.99851	$\alpha_1 + \beta_1$	0.97232
$\lambda_1 + \lambda_2$	0.98362		
λ_1	0.50754*** (0.04592)		
λ_2	0.47608*** (0.04861)	Wald chi	6,545.52***
R_t	0.314975*** (0.07551)	LL	2,664.997
		N	1,125

Note: standard errors in parentheses, * $p < 0.1$, ** $p < 0.05$, *** $p < 0.01$.

Source: the authors' calculations in STATA 18.0.

Figure 1

Credit default swap rate, Euribor-OIS spread and corporate debt yield – deposit facility rate from 1 January 2018 up to 30 June 2023

Figure 1a. Credit default swap rate

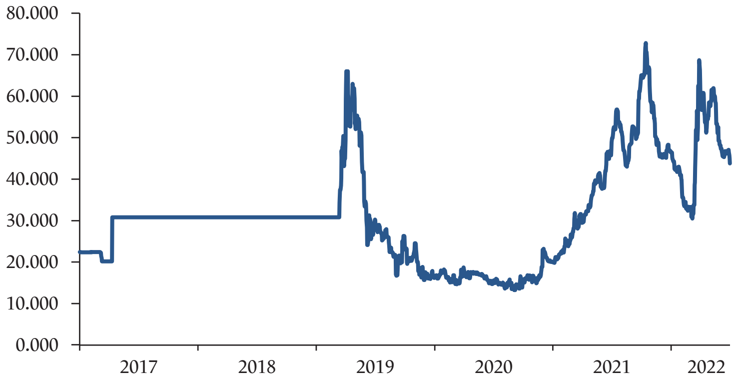


Figure 1b. Euribor-OIS spread

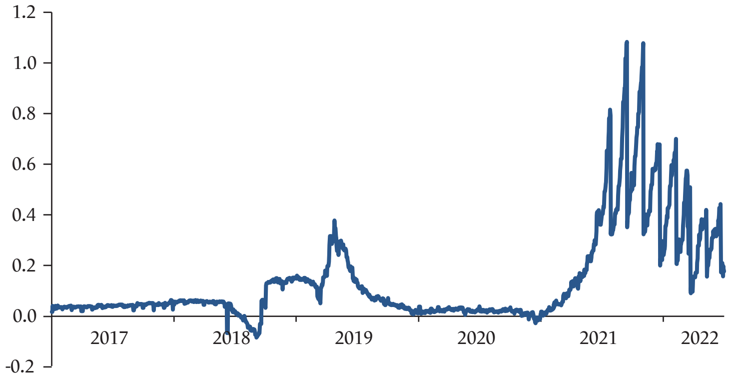


Figure 1c. Corporate debt yield – deposit facility rate

Figure 2

Estimated conditional correlations from 1 June 2020 up to 30 June 2023

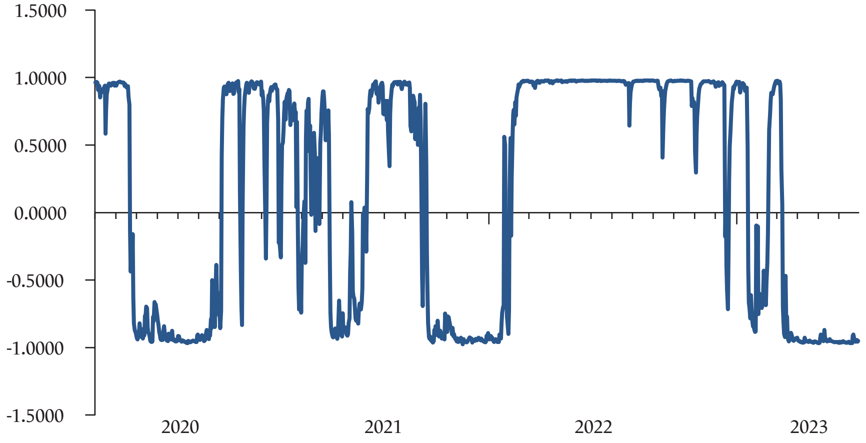


Figure 3
Estimated variances of e_ois and y_depo from 1 June 2020 up to 30 June 2023

Figure 3a. Estimated variances of e_ois

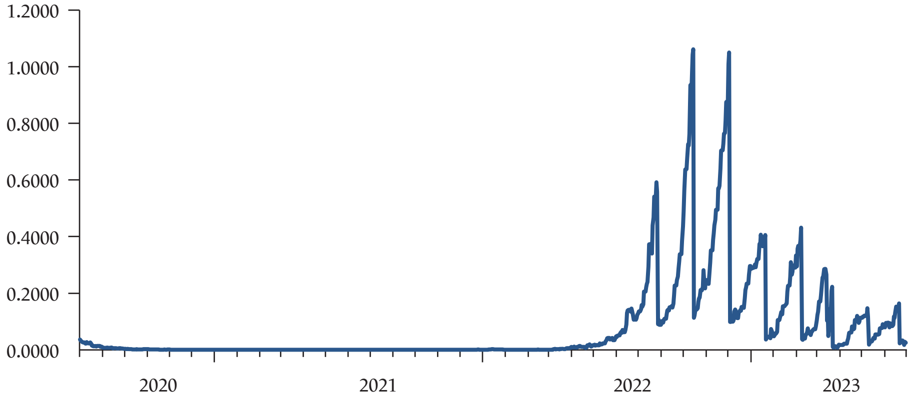


Figure 3b. Estimated variances of y_depo

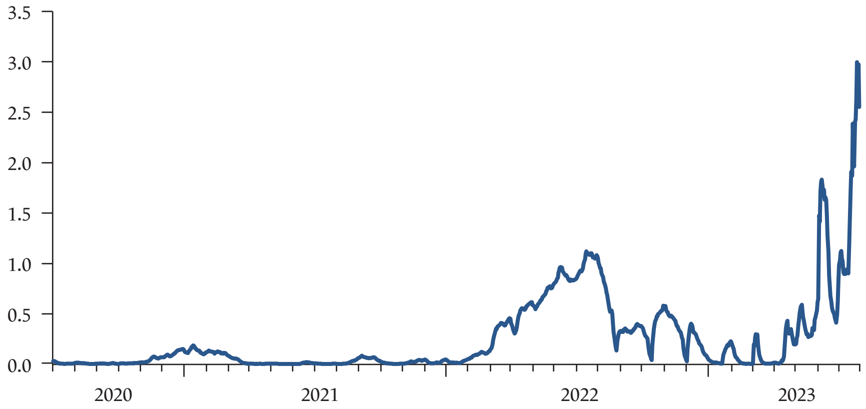


Figure 4

Cross-wavelet power levels for pairs of variables in models from 1 June 2020 up to 30 June 2023

Figure 4a. e_ois vs cds

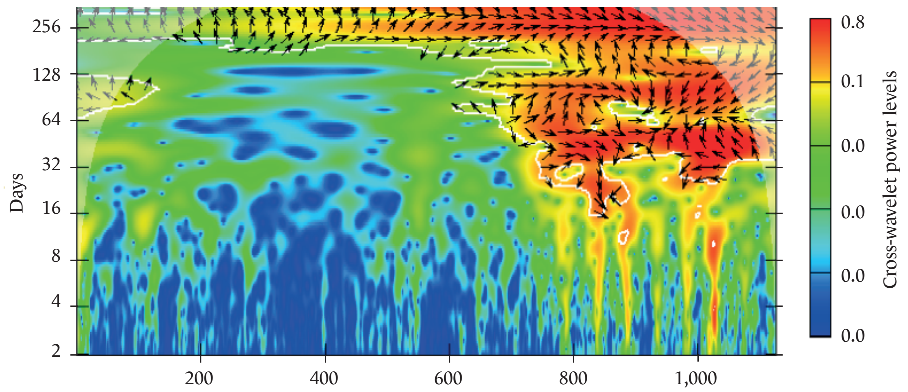


Figure 4b. y_depo vs cds

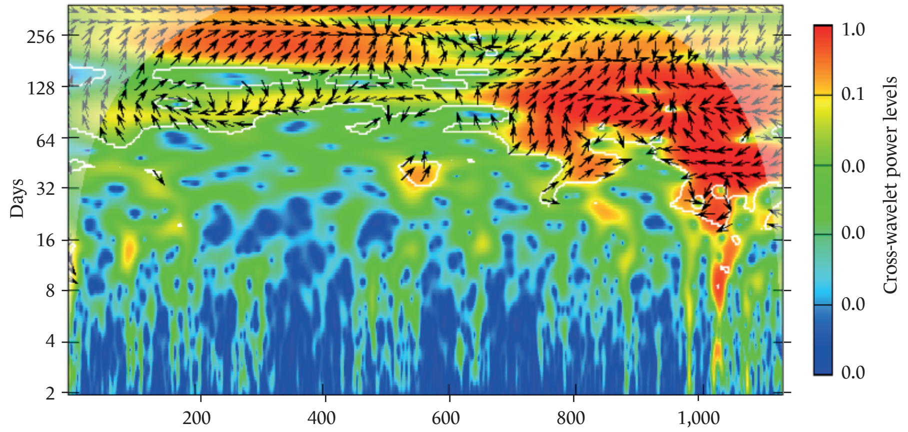
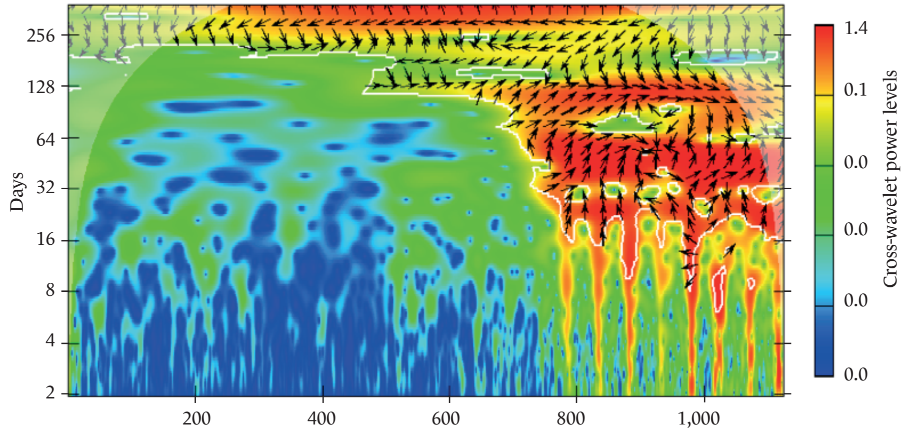


Figure 4c. y_depo vs e_ois



Polityka zacieśniania ilościowego EBC: Euribor – spready swapów indeksowanych stopą *overnigth* (OIS) a efektywność mechanizmu transmisji

Streszczenie

W artykule przeanalizowano wpływ bankowych pośredników finansowych na skuteczność mechanizmu transmisji polityki pieniężnej. Rynek międzybankowy odgrywa ważną rolę w procesie transmisji instrumentów polityki pieniężnej do realnego sektora gospodarczego, jednak nie jest wolny od ryzyka z uwagi na fakt, że uczestnicy tego rynku charakteryzują się różnymi profilami ryzyka. Kanał kredytowy jest jednym ze standardowych mechanizmów transmisji instrumentów polityki pieniężnej do realnego sektora gospodarczego, ale ryzyko kredytowe pośredników bankowych może pogorszyć skuteczność oddziaływania instrumentów polityki pieniężnej. W marcu 2022 r. EBC rozpoczął politykę zacieśniania ilościowego, podnosząc podstawowe stopy procentowe. Spodziewano się, że wpłynie to na słabnący popyt krajowy, ograniczenie inwestycji w sektorze przedsiębiorstw i spadek aktywów bankowych. Zaobserwowano jednak spread między swapami indeksowanymi stopą *overnigth* (OIS) oraz stopą Euribor, określany jako Euribor-Overnight Index Swap (E-OIS). Jego istnienie sugeruje, że rynek jest nieefektywny w transmisji stóp procentowych do realnego sektora gospodarczego. Wyższy spread między Euribor (kluczową stopą dla klientów banków) a stopą wolną od ryzyka OIS wynika z premii za ryzyko kredytowe, która jest uwzględniona w cenie niezabezpieczonych depozytów na rynku pieniężnym. W przypadku pogorszenia się zdolności kredytowej banków stosujących stopę Euribor stopa ta wzrośnie i tym samym będzie miała silniejszy, niż oczekiwano, wpływ na gospodarkę realną.

Niniejszy artykuł opiera się głównie na pracy Tabogi (2013), z tą różnicą, że do analizy wpływu polityki pieniężnej na koszty finansowania sektora realnego zastosowano zmodyfikowany model badawczy. Poprzednie badania uwzględniały analizę spreadu E-OIS i premii za ryzyko kredytowe mierzone stopą swapu ryzyka kredytowego (CDS) dla najlepszych banków, tymczasem niniejsza praca ogranicza panel jedynie do banków stosujących Euribor. Ponadto wcześniejsze badania nie uwzględniały wpływu spreadów na sektor realny, co w przypadku ilościowego zacieśniania polityki pieniężnej jest sprawą kluczową. Z kolei inne badania (Taboga 2013; Angelini, Nobili, Picillo 2011) koncentrowały się na wykazaniu, że Euribor nie jest już podstawową, najważniejszą i wolną od ryzyka referencyjną stopą procentową na rynkach finansowych, co zresztą w niniejszym artykule zostało potwierdzone.

Główna hipoteza badawcza jest następująca: wiarygodność kredytowa banków europejskich tworzących rynek międzybankowy bezpośrednio wpływa na koszty finansowania sektora realnego i ogranicza efekt transmisji prowadzonej przez EBC polityki zacieśniania ilościowego. Oznacza to, że mamy do czynienia z niedopasowaniem między oczekiwaniami wynikającymi z modelu polityki pieniężnej a realnymi wynikami makroekonomicznymi. Pomocnicza hipoteza badawcza brzmi, że zmienność spreadu E-OIS oddziałuje na rentowność na rynku długu korporacyjnego, co może być empirycznym dowodem oczekiwanego wpływu tej zmienności na przebieg realnych procesów gospodarczych. W badaniu głównej hipotezy zmienną zależną jest spread E-OIS, a zmienność jakości kredytowej banków tworzących rynek jest mierzona za pomocą CDS. Spread między denominowanymi w euro niezabezpieczonymi instrumentami dłużnymi o stałym oprocentowaniu, wyemitowanymi przez europejskie przedsiębiorstwa o wysokim ratingu, a stopą depozytową EBC jest wykorzystywany do oszacowania skali wpływu spreadu E-OIS na koszty finansowania sektora niefinansowego. W tym celu zastosowano model DCC-MGARCH. Jest on właściwy w przypadku występowania heteroskedastyczności, a ponadto charakteryzuje się elastycznością w modelowaniu zarówno średniej, jak i wariancji. Tym samym pozwala ustalić czasową zmienność korelacji między zmiennymi, podczas gdy falkowa analiza spójności może dodatkowo ujawnić występowanie związku między wyprzedzeniem a opóźnieniem. Tak połączone metody zapewniają kompleksową analizę mechanizmu transmisji w innowacyjny sposób, zarówno przy użyciu standardowego modelowania ekonometrycznego, jak i analizy czasowo-częstotliwościowej. Wyniki pozytywnie weryfikują hipotezę badawczą – że istnieje statystycznie istotna korelacja między ryzykiem kredytowym banków z panelu Euribor, mierzonym za pomocą CDS, a spreadem E-OIS. Ponadto zmienność E-OIS ma pozytywny i statystycznie istotny wpływ na koszt finansowania sektora niefinansowego, co wyraża się w odzwierciedleniu ryzyka pośrednika bankowego w wycenie instrumentów o stałym dochodzie emitowanych przez przedsiębiorstwa. Wyniki badania mogą być użyteczne dla władz monetarnych zarówno przy uwzględnianiu rynkowych efektów zewnętrznych w wewnętrznych modelach oceny wpływu instrumentów polityki pieniężnej, jak i przy monitorowaniu oddziaływania parametrów rynkowych związanych z klientami banków. Ewentualne dalsze prace powinny się koncentrować na badaniu, czy sformułowane w artykule generalne wnioski pozostaną aktualne, jeśli w modelu dodatkowo zostanie uwzględniona płynność lub inne zmienne, mogące być przedmiotem zainteresowania.

Słowa kluczowe: spread Euribor-OIS, ryzyko kredytowe, model DCC-MGARCH, nieefektywność mechanizmu transmisji, falkowa analiza spójności