

# THE VILIBOR–EURIBOR SPREAD DYNAMICS DURING THE RECENT FINANCIAL CRISIS

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**Abstract.** *This article deals with the influence of the international financial crisis on the Lithuanian interbank market interest rates. Specifically, VILIBOR–EURIBOR spread dynamics over the period from the beginning of 2005 until the end of 2010 is analysed. The objective of the study was to estimate and describe the main factors affecting the VILIBOR spread. Methods used in the study include a systemic analysis of related studies, historical data analysis and statistical testing.*

*Several episodes of increased market volatility could be clearly identified during the period, under study and the volatility of the data series as well as changes in their statistical properties and interdependence make the statistical analysis of the relationship very complicated. Statistically robust results could be achieved only after introducing several restrictions. The EURIBOR, RIGIBOR and Lithuanian CDS indexes have been found to explain more than 40 percent of the largest VILIBOR spread changes.*

**Key words:** *Interbank interest rates, VILIBOR, EURIBOR, financial crisis*

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## 1. Introduction

The interbank market is one of the main building blocks of the monetary policy transmission channel. It works as an intermediary between the monetary authorities and general public, transmitting monetary policy signals into retail interest rates. Due to its stability over the last decades, the interbank market was largely neglected in the academic research on the problems of monetary policy or financial stability. The stability of these money market interrelationships ended in August 2007. Tensions in the interbank market were first indicated by the increasing spread between unsecured and secured interbank lending rates and the drastic decrease in unsecured lending amounts. At the same time, spread volatility has disrupted the monetary transmission mechanism, since interbank interest rates no longer kept abreast with the expected path of central banks' policy rates. Against this background, the forgotten and boring topics of money markets were revived, and a number of researchers attempted to describe the dynamics of interbank rates and searched for the factors behind the increased volatility of the interbank interest rates.

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Influenced by the above-mentioned international developments, the Lithuanian interbank market also experienced a considerable impact of the financial crisis. After the positive economic developments of the last decade and hopes for a rapid introduction of euro, the litas–euro interest rate spread decreased substantially. This convergence discontinued in the second quarter of 2007 because of both domestic and international developments. First, Lithuania failed to introduce euro as expected in 2007; second, risk measures increased internationally in the mid-2007 when the first signs of financial crisis appeared. At the peak of the financial crisis, the further increase in the domestic interest rates matched the decrease in euro interest rates. This gave rise to discussions about the health and ineffective functioning of the Lithuanian banking system.

In this work, the VILIBOR dynamics and, specifically, the VILIBOR–EURIBOR spread over the period from the beginning of 2005 until the end of 2010, is analysed. The main **objective** of the study was to estimate and describe the main factors affecting the VILIBOR–EURIBOR spread during the study period. The aim of the research was to determine whether some specific factors could explain VILIBOR spread volatility over the period and to quantify their impact. The six-month VILIBOR was chosen for the analysis because this index represents a very important benchmark used to determine interest rates for general public, and it has a very strong effect on the development of real economy.

An observational rather than statistical approach was used to find the explanations of interest rate setting policy of the recent years. The methods include a systemic analysis of the related studies in the field, as well as historical data analysis and statistical testing.

The article consists of six sections. Section 2 provides a review of recent academic works mainly focused on the eurozone and the US interbank interest rate developments during the recent financial crisis. Section 3 describes the Lithuanian situation. Sections 4 and 5 analyse the statistical data used to identify, describe and quantify the main factors affecting the VILIBOR–EURIBOR spread dynamics for the whole data set and a restricted data set, respectively. Section 6 provides the conclusions.

## **2. A review of the literature**

The interbank market is one of the main building blocks of the monetary policy transmission channel. Until the current financial crisis, international interbank markets appeared to work well, transmitting monetary policy signals to retail interest rates without any observable distortions. Banks were able to obtain funds readily in the market, and the recourse to central bank's lending facilities was very rare. Due to the stability of the money market it was largely neglected in the academic research.

The stability of money market relationships ended abruptly in August 2007. The most common measure of money market tensions used during the present financial crisis was that the spread between unsecured and secured interbank lending interest rates increased

dramatically. In addition to this, spread volatility has disrupted the monetary transmission mechanism because the rate at which banks used to lend to each other no longer moved in line with the expected path of policy rates determined by the central bank. In the case of the eurozone, as the most common measures, the three-month EURIBOR is used as a proxy for unsecured lending, while the three-month EONIA interest swap (OIS) rate is used as a proxy of interest rates for secured lending.<sup>1</sup>

In this environment, a number of researchers attempted to describe the dynamics of interbank rates and searched for the factors behind the increased volatility of the interbank interest rates. There are several research topics in the empirical literature concentrating on the evolution of money markets during the crisis. The first, and the largest, group analyses the problem of the causes of disruptions in the interbank markets by searching for and testing the potential factors which may affect the credit risk and liquidity risk levels in the interbank market. In this work, the VILIBOR dynamics is analysed using the methods similar to those employed by the first research group; the literature covering interbank rate or spread decomposition is analysed in more detail, while other topics are given less attention in this review. The second group of researchers evaluates the effects of the central bank and government policy measures on money market rates (Christensen et al., 2009; Hopkins et al., 2009). The third group analyses specifically whether the quoted interbank rates (in most cases LIBOR) were not manipulated by panel banks during the crisis period (Hartheiser, Spieser, 2010; Abrantes-Metz et al., 2008; Mollenkamp, Whitehouse, 2008).

The most common measure used to analyse tensions in the interbank market is the spread between unsecured and secured lending. In many cases, the overall risk is decomposed into the liquidity risk and the credit risk components. The main idea behind this decomposition is a need for a better understanding of the general bank behaviour during the financial turmoil period, and, more specifically, for understanding and evaluating the central bank and government policy implications. If the tension in the money market was caused by the liquidity risk, provision of more generous liquidity by central banks would help to address the problem. On the other hand, if the money market tension is a reflection of the increased credit risk, additional liquidity would not be an appropriate measure, because credit risk can only be decreased by collective actions of banking institutions, their regulations and authorities.

The details of the studies vary in the selection of particular secured and unsecured interbank interest rates, the methods used and the time span, but there seems to be some consensus. Most researchers show that initially (from August 2007) the unsecured–

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<sup>1</sup> In general, the EURIBOR rates reflect the current and the expected future overnight interest rates (i.e. the expected path of monetary policy) and the premium associated with the liquidity and credit risk. The latter arises because the EURIBOR rates relate to unsecured interbank lending and are therefore subject to the risk of the borrower defaulting. The same maturity OIS also represents the path of monetary policy rates but does not entail the default risk.

secured interest rate spread was better explained by an increase in the liquidity premium (Bank of England, 2007; Kamps, 2009; Desocio, 2010), while the further increase of tensions in the money market after the bankruptcy of Lehman Brothers on 15 September 2008 was better described by the growing credit risk. This conclusion was not backed unanimously, and several authors provided different results. Drehhman and Nikolaou (2009) used a new indicator of the funding liquidity risk and found that the liquidity risk premium increased in August 2007, but was even higher at the end of 2008. Taylor and Williams (2009) claim that already from 2007 the counterparty risk was the key factor in explaining the spread between the Libor and OIS rate for the period from August 2007 to March 2008, and that the measures introduced by the Federal Reserve System should not have any effect on the spread. Kwan (2009), while analysing the U.S. dollar LIBOR dynamics, found that the increase in the Libor–OIS spread reflected a heightened credit risk premium and, most likely, an elevated liquidity risk premium demanded by lenders; while charging the credit risk premium was consistent with market functioning, the elevated liquidity premium represented the market friction that provided a rationale for actions by policymakers.

These approaches were aimed to identify a single risk category by using best available proxy variables, while the remaining component was interpreted as a measure of the remaining risk category. The most commonly used variables for credit risk estimation were as follows: individual banks' credit default swaps (CDS) or general market CDS indexes, stock prices and, specifically in the US, the spread between an asset-backed commercial paper and a dealer-placed commercial paper. In some cases, the general risk aversion measures were used: the Chicago Board of Options Exchange Volatility Index (VIX), the exchange rate between the Swiss franc and the Australian dollar, and the spread between the Italian and German government bonds. Liquidity risk was estimated by the spread between the 3-month EUREPO and EONIA swap, as well as by the deviation from the covered interest parity for the euro / dollar exchange rate and various central bank liquidity operation measures; specifically, funding liquidity risk was defined as the volume of the banks' bids at rates above the expected marginal rate.

### **3. The empirical data**

Influenced by international developments, the Lithuanian interbank market experienced a considerable impact of the financial crisis. As shown in Fig. 1, the litas interbank interest rates (VILIBOR) initially moved in line with the eurozone interbank interest rates (EURIBOR) and were almost identical in the period from the last quarter of 2005 to mid-2007. A positive economic development and hopes for a rapid introduction of euro created optimism in the market and lead to a substantial decrease of the litas–euro interest rate differential. Unfortunately, the convergence discontinued when Lithuania failed to introduce euro in 2007, and volatility in international financial markets increased in the

mid-2007, indicating the beginning of a financial crisis. Moreover, interest rates even moved in opposite directions at the end of 2008. An increase in domestic interest rates, matching the decrease in euro interest rates, gave rise to discussions about the health and effectiveness of the Lithuanian banking system. One of the main issues concerned the idea that banks possibly set interbank interest rates artificially high in order to adjust the lending rates accordingly and earn the above-normal profit from lending operations.<sup>2</sup>

In this work, the VILIBOR dynamics and, specifically, the VILIBOR–EURIBOR spread over the period from the beginning of 2005 until the end of 2010 is analysed. The main task is to identify and describe the main factors affecting changes in the VILIBOR spread during the study period. Similarly to the research works mentioned in the previous section, the assumption is made that the international financial crisis had a strong effect on the Lithuanian money market interest rates, and there are specific factors that may statistically describe the VILIBOR spread dynamics.

Since the litas exchange rate is fixed to euro, in theory, the VILIBOR should fluctuate in line with the EURIBOR, i.e. the spread should remain constant. Therefore, in order to limit the scope of this article and without ambitions to describe the EURIBOR changes, this work is focused on the VILIBOR–EURIBOR spread dynamics.

A six-month VILIBOR was chosen as the basic measure representing the Lithuanian interbank interest rates. Although real interbank transactions are usually concluded for shorter periods and are almost non-existent in this maturity, this index represents a very important benchmark used to determine interest rates for housing loans and strongly affects the other retail interest rates. Therefore, it has a very strong effect on the developments in real economy. In addition, this data series should have a less day-to-day volatility than the shorter-maturity interbank interest rates. Specifically, the six-month VILIBOR spread over the six-month EURIBOR (Euro interbank offered rate) was investigated as a dependent variable (further referred to as the VILIBOR spread). The dynamics of VILIBOR spread is shown in Fig. 1.

The potential factors that may have an impact on the level and changes of the VILIBOR spread were chosen based on several criteria. The initial selection of a particular factor was formulated based on the review of literature concerning interbank rate developments during the crisis, with a slight adaptation to Lithuanian regional settings. It should be noted that the aim of this research was to quantify the effect of the chosen factors on the VILIBOR spread. The VILIBOR and EURIBOR relationship was openly discussed in public during this financial crisis, but the statistical effect of this relationship was not tested in academic research. Therefore, for this analysis the EURIBOR was chosen as one of the factors, despite the fact that the EURIBOR itself may be influenced by other independent factors (see Section 2).

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<sup>2</sup> It is worth noting that most of the researchers analysing the possible manipulations of LIBOR rates have concluded that they were set artificially low, citing individual banks' reputation risk and banks' unwillingness to indicate their potential problems as the main factors (see Mollenkamp, Whitehouse, 2009; Hartheiser, Spieser, 2010).

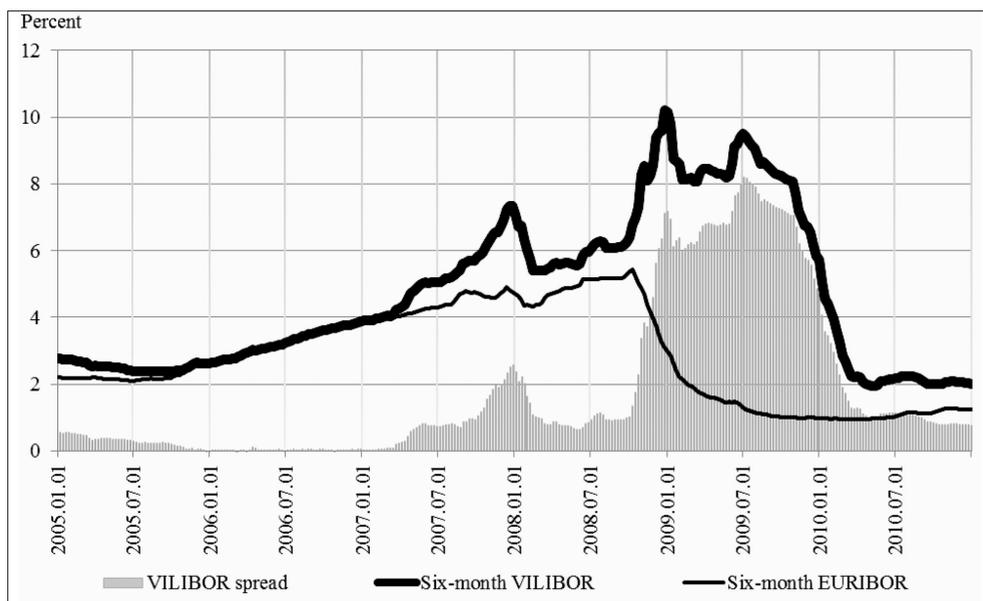


FIG. 1. Dynamics of six-month VILIBOR, EURIBOR and VILIBOR spread

Source: Lietuvos bankas, Bloomberg.

All selected indicators had to have daily values for the full sample from the beginning of 2005 till the end of 2010<sup>3</sup>. In order to avoid duplication, only a single factor out of a group of potentially similar factors was chosen, thus eliminating the interdependence among the data series. The indicators satisfying the above conditions were arbitrarily subdivided into several groups: domestic factors, regional factors and global factors. The independent variables chosen for the initial analysis are listed in Table 1. A more detailed description of the variables is presented in Annex 1.

TABLE 1. Potential factors affecting VILIBOR spread

Area	Name	Short name	Expected impact on VILIBOR spread
Domestic risk factors	VILSE return	VILSE_return	-
	VILSE index volatility	VILSE_vol	+
	Lithuanian 5-y. CDS	LITHUN_cds	+
Regional risk factors	Six-month RIGIBOR	RIGI_6m	+
	EUR / LVL exchange rate	EURLVL	+
Global risk factors	Six-month EURIBOR	EURI_6m	+/-
	Three-month EURIBOR–OIS spread	EUR_OIS	+
	VIX volatility index	VIX	+
	Senior financials 5-y. CDS index (Europe)	SNRFIN_cds	+

Source: compiled by author.

<sup>3</sup> The data for the Lithuanian 5-year. CDS is only available beginning from 12 December 2006, but it was included in the analysis because of the lack of alternative indicators of the Lithuanian credit risk.

The selected indexes represent different regions and have different fixing times; therefore, to decrease the potential timing differences and to smooth out daily volatility, all data series were recalculated to weekly averages which gave 313 data points. The statistics for the selected data series is presented in Table 2. As the levels of all data series varied quite substantially over the period, changes of weekly averages instead of levels were used in most calculations.

TABLE 2. Statistical properties of weekly averages of the selected data series

Name	Average	Min	Max	Standard deviation*
Six-month VILIBOR	4.70	1.94	10.19	0.16
Six-month VILIBOR–EURIBOR spread	1.86	-0.02	8.20	0.17
VILSE return	0.16	-18.08	21.73	3.13
VILSE index volatility	1.07	0.40	5.38	0.28
Lithuanian 5 y CDS	239.54	4.80	834.50	24.56
Six-month RIGIBOR	7.13	1.27	26.04	0.60
EUR/LVL exchange rate	0.70	0.70	0.71	0.17
Six-month EURIBOR	2.84	0.94	5.43	0.06
Three-month EURIBOR–OIS spread	0.35	0.03	1.83	0.05
VIX volatility index	21.60	10.18	72.92	2.68
Senior financials 5y CDS index (Europe)	64.42	7.08	198.72	8.19

\*Standard deviations were calculated using changes in weekly averages.

Source: Bloomberg, Lietuvos bankas, author's calculations.

#### 4. Statistical analysis

As the first step, the relationship between the VILIBOR spread and each data series was evaluated using the correlation analysis of changes in weekly averages, using the same period and one period (one week) lag of the VILIBOR spread. The overall correlation coefficients are not high; only five out of nine original indicators have correlation coefficients statistically different from zero. The direction of the relationship seems to be in line with the expected one. It can be clearly identified that, in most cases, the addition of one period lag gives a stronger relationship. This is particularly true for the Lithuanian CDS where the correlation coefficient increased from 0.07 to 0.26.

TABLE 3. Correlation between VILIBOR spread and independent factors (whole period: 2005–2010)

	VILSE_ return	VILSE_ vol	LITHUN_ cds	SNRFIN_ cds	VIX	EURI_6m	EUR_OIS	RIGI_6m	EURLVL
T+0	-0.223*	0.044	0.070	-0.054	-0.035	-0.297*	0.025	0.353*	-0.087
T-1	-0.255*	0.051	0.259*	0.052	0.035	-0.245*	0.136**	0.387*	-0.046

One or two asterisks denote significance at the 1 and 5 percent confidence level, respectively.

Source: the author's calculations.

It should be noted that during the study period the VILIBOR spread as well as most of the independent data series experienced substantial changes in volatility (see Fig. 1). The period from the beginning of 2005 till the end of 2006 was extremely calm, and most of the data series were relatively stable. From the beginning of 2007, the volatility in all data series started to increase and reached the peak in the last quarter of 2008. Later on, in 2010, volatility and the level of most data series decreased dramatically. This observable change in volatility can have implications for the stability of relationships between the variables. To check the evolution of the relationships over the period, a rolling 26-week (half-year) correlation for the changes in weekly averages of the data series were calculated. The results for the highest and lowest correlation coefficients are presented in Table 4. It can be clearly identified that the relationship was not stable, and in several cases the correlation coefficient moved from significantly positive to significantly negative values.

TABLE 4. Correlation between independent factors and VILIBOR spread

	VILSE_ return	VILSE_ vol	LITHUN_ cds	SNRFIN_ cds	VIX	EURI_ 6m	EUR_ OIS	RIGI_ 6m	EURLVL
Minimum	-0.73*	-0.53*	-0.32	-0.38	-0.58*	-0.64*	-0.35	-0.23	-0.63*
Maximum	+0.37	+0.80*	+0.85*	+0.46**	+0.83*	+0.62*	+0.80*	+0.92*	+0.43**

One period lag and rolling 26-week periods were used in calculations.

One or two asterisks denote significance at the 1 and 5 percent confidence level, respectively.

Source: author's calculations.

Volatility in data series as well as changes in their statistical properties and interdependence makes the statistical analysis of the relationship very complicated. Indeed, applying the methods of regression analysis in order to check the strength of the relation did not provide any robust statistical results. Using data series in level estimation showed an appropriate determination coefficient (R-squared), but the results were not statistically reliable due to a very strong autocorrelation in the residuals (expressed by low Durbin Watson (DW) statistics). In the case when changes in weekly averages were used instead of the levels, the DW statistics improved, but most of the coefficients were insignificant, and the determination coefficient as well as the overall predictive power were very low.

In general, the analysis performed shows that a recent financial crisis was of tremendous magnitude and had impacted various asset classes and regions, including Lithuanian interbank interest rates. Increased volatility of the financial variables and changes in their interdependences make the statistical analysis very complicated. Therefore, the analysis of the overall period from the beginning of 2005 till the end of 2010 provides only a very weak statistical explanation of the potential factors affecting VILIBOR spread. Most of

the selected independent factors had an unstable effect on the VILIBOR spread and the sufficient statistical relationship could not be established.

### 5. Analysis of increased volatility periods

Considering that most of the data in the analysed series experienced great changes in volatility and in an attempt to localise the periods of increased volatility in the VILIBOR spread, the further analysis was focused on the periods when changes in the VILIBOR spread were largest. For this purpose, only weekly VILIBOR spread changes higher than one standard deviation were analysed. As a result, 48 data points out of the total 313 were chosen. The dynamics of the largest changes of all considered data series is provided in Fig. 2. There were no events of heightened volatility in the stable 2005–2006 period; therefore, only data starting from the beginning of 2007 are presented in the chart.

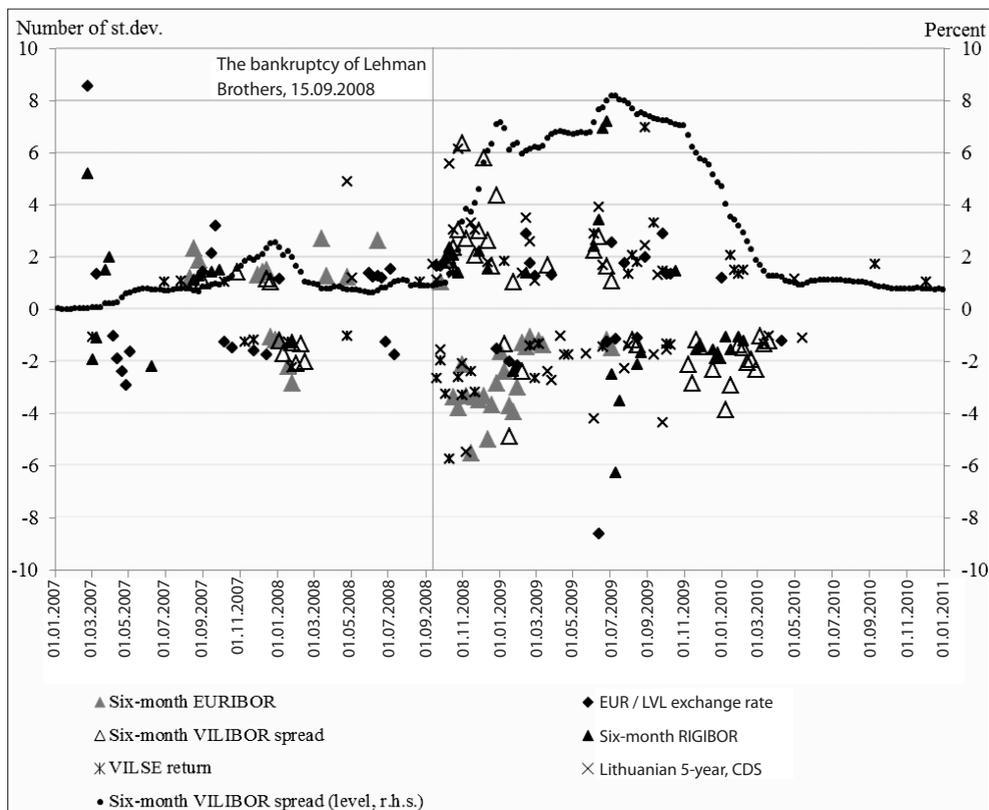


FIG. 2. Dynamics of major changes\* in the selected data series

\* Changes in weekly averages higher than one standard deviation.

Source: Bloomberg, "Lietuvos bankas", the author's calculations.

A closer look at Fig. 2 reveals several periods of increased volatility in the indexes, which in most cases corresponded to the increase in VILIBOR spread volatility. A brief discussion of the major events during these specific periods is provided in the following sections.

The initial market disruptions were experienced in Latvia in the week of 19–25 February 2007.<sup>4</sup> The second round of increase in RIGIBOR occurred in August–October 2007. The Lithuanian interbank interest rates did not react to the initial increase in RIGIBOR, but a visible increase in VILIBOR spread was experienced starting from October 2007. At that time, RIGIBOR was already 613 basis points above the VILIBOR rate (while in normal conditions, in January 2007, the average spread was less than 75 b.p.). Apparently tensions in the Latvian financial market started pass to its closest neighbour Lithuania. In addition, global interbank tensions emerged after mid-October 2007, as indicated by an increase in the Senior Financial CDS index. The negative developments in the domestic and international interbank markets were immediately echoed by other domestic indicators<sup>5</sup>. The VILIBOR spread increased even further due to the end-of-the-year effect, reflecting the general interbank market trends represented by the increasing EURIBOR-OIS spread. Later, in the period from the beginning of 2008, the VILIBOR spread decreased and normalized in February 2008, in line with the RIGIBOR decrease.

Another substantial increase in the VILIBOR spread was observed at the beginning of October 2008. Tensions in the international money market greatly increased on 15 September 2008 when Lehman Brothers filed for Chapter 11 bankruptcy protection. A considerable immediate spike was observed in EURIBOR-OIS spread, in VIX, as well as in Lithuanian indicators (VILSE return and the Lithuanian CDS index). The interbank interest rates increased only with some lag: the RIGIBOR started to increase with a 2-week lag, while VILIBOR and VILIBOR spread experienced a noticeable increase only after 8 October 2008 (almost a three-week lag). The VILIBOR spread continued increasing even after the international markets had shown the signs of stabilization. This further increase coincided with the sharp decrease in the EURIBOR and was the result of an abrupt VILIBOR and EURIBOR divergence. The main cause of this divergence of interbank interest rates was the change in the ECB monetary policy implementation. In the reaction to the international financial crisis the ECB Governing Council, among other measures, introduced the unlimited amount in its open market operations, which led to a substantial increase in the euro system excess reserves and a consequent decrease in interest rates<sup>6</sup>. Since the ECB liquidity operations were available only to the

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<sup>4</sup> Weekly average of six-month RIGIBOR jumped by 3.12 percentage points and EURLVL exchange rate increased by 1.43%, almost reaching the upper fluctuation margin.

<sup>5</sup> For example, VILSE return was negative for the period starting from mid-October till the end of 2007.

<sup>6</sup> The ECB press release, 8 October 2008. Available at: [http://www.ecb.int/press/pr/date/2008/html/pr081008\\_2.en.html](http://www.ecb.int/press/pr/date/2008/html/pr081008_2.en.html).

eurozone banks, these operations did not impact any Lithuanian bank rates; as a result, the VILIBOR spread remained on the increasing trend until the end of the year. The RIGIBOR decreased slightly in the period from the last week of 2008 and later, because tensions in the Latvian financial markets decreased at the end of December 2008 when the Latvian government was able to secure international financial support in the amount of 7.5 billion euro<sup>7</sup>. All risk indicators decreased at the beginning of 2009. The latest VILIBOR spread correction was not significant, and the VILIBOR spread remained well above the 600 basis points.

An additional increase in the VILIBOR spread started at the beginning of June 2009, after a jump in the RIGIBOR rates. At that time, tensions in the Latvian financial system increased again after the IMF had delayed one of its planned loan instalments, citing insufficient effort by the government to rein spending<sup>8</sup>. At the same time, the general discussions on the sustainability of currency pegs intensified. Finally, an agreement with the IMF was reached at the end of July, which led to the abatement of tensions in Latvia, a sharp downward correction in the RIGIBOR and a smaller correction in the VILIBOR spread. The VILIBOR spread remained on the downtrend during the rest of the period.

The last episode, related to a sharp decrease in the VILIBOR spread, started at the beginning of November 2009. Once again, the decrease in the RIGIBOR was much stronger and started two weeks in advance. Over the period from October 2009 till March 2010, the VILIBOR spread decreased by more than 600 basis points and remained relatively stable through the rest of the year 2010.

This brief discussion of market developments seems to reveal similarities in changes of the selected variables. In many cases, the VILIBOR spread changes coincided with the RIGIBOR changes and with domestic risk indicators (e.g., the VILSE return and the Lithuanian CDS). To check whether this relationship could have the statistical backing, the correlation and regression analysis procedures similar to those used for the whole sample were applied to a restricted data sample containing only the largest VILIBOR spread changes. Out of the whole sample, only the weeks when the VILIBOR spread change had been higher than one standard deviation were chosen. The correlation coefficients for the restricted number of data points for the same week, one-week and two-week lags are presented in Table 5. As one can see, the correlation coefficients have nominally increased as compared with the whole sample (see Table 3). It should be noted that the results for the restricted sample are statistically not very different from the overall results, since the decrease in the number of data points from 313 to 48 leads to an increase in the minimum threshold of the statistical significance of the correlation coefficient.

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<sup>7</sup> Joint statement by the Presidency of the Ecofin Council and the Commission on providing the EU medium-term financial assistance to Latvia. Available at: <http://europa.eu/rapid/pressReleasesAction.do?reference=IP/08/2045&format=HTML&aged=0&language=EN&guiLanguage=en>.

<sup>8</sup> <http://www.eubusiness.com/news-eu/1238688122.05>

TABLE 5. Correlation coefficients for greater than one standard deviation changes of VILIBOR spread

Lag	VILSE_ return	VILSE_ vol	LITHUN_ cds	SNRFIN_ cds	VIX	EURI_6m	EUR_OIS	RIGI_6m	EURLVL
T-0	-0.34	0.05	0.09	-0.14	-0.05	-0.46*	0.07	0.50*	-0.12
T-1	-0.40*	0.08	0.37**	0.13	0.02	-0.38*	0.17	0.51*	-0.07
T-2	-0.38*	0.14	0.41*	-0.04	0.19	-0.32**	0.19	0.07	-0.08

One or two asterisks denote significance at the 1 and 5 percent confidence level, respectively.

Source: the authors' calculations.

In the further analysis, the relationships were tested using multiple regression methods. Contrary to the case of the overall data series, the regression analysis performed on the restricted data sample, including only days when changes of the VILIBOR spread were largest resulted in statistically robust results. Testing different lags and independent factors, the best estimate of the VILIBOR spread was obtained by using six-month RIGIBOR (T+0), six-month EURIBOR (T-1)<sup>9</sup> and 5-year. Lithuanian CDS (T-2) as independent factors. The standard statistical estimation output is presented in Table 6. The determination coefficient is not very high (adjusted R-squared is 0.41) but sufficient, having in mind that changes of the factors were estimated. All three coefficients are statistically significant as indicated by a high t-statistics. The signs of all coefficients are the same as expected.

TABLE 6. Estimation results for largest VILIBOR spread changes

Dependent variable: VILI\_EURI6M

Method: Least Squares

Included observations: 48

Variable	Coefficient	Std. error	t-Statistic	Prob.
RIGI6M_0	0.166992	0.050251	3.323166	0.0018
LITHUNCDS5Y_2	0.002669	0.001110	2.404787	0.0205
EUR006M_102	-1.746087	0.536903	-3.252148	0.0022
C	-0.094277	0.056180	-1.678132	0.1004
R-squared	0.446825	Mean dependent var.		-0.000375
Adjusted R-squared	0.409109	S.D. dependent var.		0.426582
S.E. of regression	0.327911	Akaike info criterion		0.687508
Sum squared resid.	4.731135	Schwarz criterion		0.843441
Log likelihood	-12.50019	Hannan–Quinn criter.		0.746435
F-statistic	11.84695	Durbin–Watson stat.		1.951128
Prob(F-statistic)	0.000008			

Source: the author's calculations, Eviews software.

<sup>9</sup> The EURIBOR as an explanatory factor has changed the sign from positive to negative since October 2008; therefore, in this regression equation, only the EURIBOR changes after October 2008 were included, while all the preceding values of the EURIBOR changes were set to 0.

To summarize, an additional analysis was carried out, based on the restricted data points comprising only the largest changes in the VILIBOR spread. This restriction decreased the number of data points from 313 to 48, but the statistical properties were more stable for these large changes in the VILIBOR spread. These changes were found to correspond to the international or regional events reflecting changes in the risk attitude. The largest part of the high VILIBOR spread may be attributed to the dramatic drop in the EURIBOR rates when the ECB started providing unlimited financing to the eurozone banks and to negative Latvian economic developments (represented by high RIGIBOR rates). The use of statistical methods (correlation and regression analysis) does give some proof that the largest VILIBOR spread changes were preceded by changes in the independent factors and can be partly explained by them. The factors that have the strongest effect represent international (six-month EURIBOR), regional (six-month RIGIBOR) and domestic (5-year. Lithuanian CDS) indicators reflecting overall risk levels. These factors, with minimal corrections, could explain more than 40 per cent of the VILIBOR spread volatility. The other part remains unexplained by the statistical factors, which may indicate that banks had some discretion in setting the VILIBOR interest rates independently from the EURIBOR movements.

To conclude, it was in possible to find a proper statistical relationship for the whole period, but the analysis of the restricted data series allowed to determine the main factors explaining the greatest changes in the VILIBOR spread; however, this became possible only upon introducing several restrictions. It should be admitted that a number of economic events and policy changes internationally can be easily identified. These developments transformed the interdependences among the different asset classes and markets during the study period. In this environment, a plain statistical relationship could not be easily established, but as long as these changes in the relationship can have a proper theoretical backing, statements concerning the poor functioning of the financial market cannot be proven.

## **6. Conclusions**

The period under analysis (2005–2010) may be subdivided into several sub-periods which can be clearly identified depending on a particular VILIBOR spread trend. Unstable statistical properties of the analysed data series and changes in their interdependence make a uniform statistical analysis of the potential relationship very complicated.

Admittedly, the statistical analysis methods applied to the overall data set in order to check the strength of the relationships has not yielded any statistically robust results. Correlation coefficients statistically different from zero are observable between the VILIBOR spread and several factors, but this statistical relationship did not remain stable over the period. The existence of a statistical relationship could not be backed by the regression analysis.

Taking into account that most of the analysed series experienced substantial changes in their statistical properties during the study period and while attempting to localise only the greatest movements in the VILIBOR spread, a further analysis was carried out specifically for the VILIBOR spread changes higher than one standard deviation.

The brief discussion about market developments over the periods of an increased VILIBOR spread volatility seems to give proof of some similarities in trends of the selected variables. In many cases, VILIBOR spread changes corresponded to the RIGIBOR, EURIBOR and domestic risk indicators (VILSE return and Lithuanian CDS).

The statistical methods of correlation and regression analysis give some proof that the largest VILIBOR spread changes were preceded and can be partly explained by independent factors. The factors that have the strongest relationship represent international (six-month EURIBOR), regional (six-month RIGIBOR) and domestic (5-year Lithuanian CDS) indicators reflecting the corresponding risk levels. These factors, after minimal corrections, could explain more than 40 per cent of the VILIBOR volatility.

The other part remains unexplained by the selected factors. This may indicate that banks had some discretion in setting the VILIBOR interest rates independently of the EURIBOR and international developments. At the same time, it should be admitted that many economic and policy changes internationally (specifically in the euro zone and Latvia) had transformed the interdependences between different asset classes and markets during the under analysis. In this environment, a plain statistical relationship could not be easily established, but as long as these changes in the relationship can have a theoretical backing, statements concerning the poor functioning of the financial market cannot be proven.

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## ANNEX 1

### Description of the analysed data series

Region	Name	Description
Domestic risk factors	Six-month VILIBOR	VILIBOR is the Vilnius Interbank Offered Rate. A six-month segment was chosen as having potentially the strongest impact on retail loan and deposit rates and, consequently, on real economy; in addition, six-month segment induces less day-to-day volatility.
	Six-month VILIBOR–EURIBOR spread	The difference between the six-month VILIBOR and six-month EURIBOR.
	VILSE return (-)	VILSE index–OMX Vilnius is a total return index which includes all shares listed in the Main & Secondary lists on the Vilnius Stock Exchange.
	VILSE index volatility (+)	VILSE index volatility, expressed as standard deviation of VILSE index changes over rolling 30-day period.
	Lithuanian 5 y CDS (+)	5-y. tenor Lithuanian Credit Default Swap.
Regional risk factors	Six-month RIGIBOR (+)	RIGIBOR – the Riga Interbank Offered Rate.
	EUR LVL exchange rate	EUR LVL exchange rate. Since January 1, 2005, the lats has been pegged to the euro (at the rate 1 EUR = 0.702804 LVL). The normal fluctuation margins around the fixed peg rate are +/-1%. In the case of market turmoil, the demand for foreign currency grows and the prices go up. In view of this, the exchange rate offered by the central bank for euro cash transactions, combined with the unlimited euro supply, acts as a stabilising factor.
Global risk factors	Six-month EURIBOR (+/-)	EURIBOR is the Euro Interbank Offered Rate.
	Three-month EONIA swap (OIS)	EONIA SWAP INDEX is the average rate at which a representative panel of prime banks provides daily quotes that each Panel Bank believes is the mid-market rate of EONIA swap quotations between prime banks. An “EONIA swap” is an interest rate swap transaction, where one party agrees to receive/pay a fixed rate to another party, against paying/receiving a floating rate named EONIA.
	Three-month EURIBOR–OIS spread (+)	Three-month EURIBOR–OIS spread is the spread between unsecured (three-month EURIBOR) and secured (three-month EONIA swap) euro interbank market rates.
	VIX volatility index (+)	The CBOE Volatility Index® is a key measure of market expectations of near-term volatility conveyed by S&P 500 stock index option prices. VIX has been considered by many to be the world’s premier barometer of investor sentiment and market volatility.
	Senior financials 5-y. CDS index (Europe) (+)	Senior financials 5-y. CDS index (Europe) – CDS index for senior debt of 25 European financial corporations.

Source: Bloomberg, Lietuvos bankas, Latvijas Banka, <http://www.euribor-ebf.eu/eoniaswap-org/about-eoniaswap.html>, [http://www.markit.com/assets/en/docs/fact-sheets/uk/FS\\_Credit\\_Indices\\_A4.pdf](http://www.markit.com/assets/en/docs/fact-sheets/uk/FS_Credit_Indices_A4.pdf)