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CHOSEN MEASURES FOR PRICING LIQUIDITY

WYBRANE MIARY SZACOWANIA PŁYNNOŚCI

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Summary: The financial crisis of the years 2007-2009 showed that especially liquidity risk was underestimated or was not taken seriously into account. The existing liquidity measures proved to be inadequate or incorrectly used. For this reason, the alternative measures should be considered. The aim of the article is to investigate specific liquidity measures using a sample of daily data. The attention is focused in particular on the yield curve fitting error, precisely on the root mean squared error. The analysis covers the time series of errors calculated from daily WIBOR data and yield curve construction using two types of parametric models – Nelson-Siegel and Svensson. By employing the selected liquidity measures on the Polish financial market, one can find evidence of its changing level in case of market disturbances.

Keywords: liquidity risk, liquidity measures, term structure.

Streszczenie: Kryzys finansowy lat 2007-2009 wykazał, że istotnym czynnikiem jego powstania i eskalacji było niedoszacowanie ryzyka płynności, jego zaniżenie bądź nieuwzględnianie. Istniejące w owym czasie miary płynności okazały się niewystarczające lub były niewłaściwie wykorzystane. Stąd też istotne znaczenie ma konstrukcja i wykorzystanie nowych, alternatywnych miar tego ryzyka. Celem artykułu jest zbadanie konkretnych miar płynności na podstawie rzeczywistych danych dziennych. Szczególną uwagę zwrócono na problem dopasowania krzywej dochodowości, w szczególności na miarę błędu średniokwadratowego. Analiza obejmuje szereg czasowy błędów pozyskanych z krzywych konstruowanych dla danych dziennych na bazie stawek WIBOR przy użyciu dwóch typów modeli parametrycznych – Nelson-Siegela i Svenssona. Dzięki zastosowaniu wybranych miar płynności na polskim rynku finansowym można znaleźć dowody wskazujące na zależność pomiędzy wysokością błędu a poziomem niepewności na rynku międzybankowym.

Słowa kluczowe: miary płynności, struktura terminowa.

1. Introduction

The financial crisis of the years 2007-2009 showed many shortcomings among which one of the most important issues was the underestimation or even omission of liquidity on specific level of its existence. Even more, recent crisis showed that its character was strictly multidimensional, which is why the approach to this case should be multidimensional as well.

A motivation for this study were the well-known problems with liquidity risk on the international, global, macro-level which comes from the lack of mechanisms that coordinate national approaches, greater complexity in the international context, as well as the scarcity of data on the international level.

From the micro-perspective, liquidity risk is the key problem to keep the enterprise healthy. The existing regulations, especially in the banking system, have influenced its profitability and have changed the investment models. The existing literature shows several examples of alternative measures of market liquidity. Duffie and Singleton [1997] showed that the changes in swap spreads are related to the changes in counterparty and liquidity risk, Flood, Liechty and Piontek [2015] showed the behaviour of liquidity measures for equity, corporate bond and futures markets, while van der Merwe [2015] described the measures of market liquidity.

The goal of this research is to investigate a range of liquidity measures with special attention paid to the alternative ones. The main focus is put on the yield curve fitting error, precisely on the root mean squared error. By calculation and analysis of the time series that consist of errors calculated from daily WIBOR data it may be found that there is a strong interrelation between the turmoil in the market and the level of the error. The result was confirmed by two different models used for a yield curve construction: Nelson-Siegel and Svensson.

2. Liquidity and liquidity risk

The problem with liquidity takes place when there is a difficulty to fulfil all payment obligations at time when they mature, to their full amount and in the appropriate currency.

This short description shows that liquidity is a specific attribute of the institution – if the institution has enough liquidity, this could be definitely seen as one of its strengths (in a SWOT analysis of the institution). The characteristic aspect of liquidity is that is must be available all the time – regardless of the situation on the market and even in crisis situations, where the probability of their occurrence is very small.

Economic theory offers at least two different concepts of liquidity [ECB 2007]. One of them is called monetary liquidity and relates to the quantity of liquid assets in the economy, which is related to the level of the interest rates. The second concept is market liquidity, which is generally seen as a measure of the ability of market participants to undertake transactions without the influence on the prices. These two

concepts are quite different and, although there is a relationship between them, they are usually separately evaluated.

Some sources distinguish three types of liquidity [Nikolaou 2009]: funding liquidity connected with cash management framework, market liquidity associated with asset--pricing models and central bank liquidity related to monetary policy context. All these types are strongly bonded to each other by bilateral influence and inter-reactions. Sometimes additional type of liquidity, broader in its meaning, is mentioned [Chorofas 1998] – it is macroeconomic liquidity, which could be considered as the surplus to the needs of the real economy which can influence the market behaviour.

Following the Basel Committee of Banking Supervision, funding liquidity is "the ability to fund increases in assets and meet obligations as they come due, without incurring unacceptable losses" [Committee of European Banking Supervisors 2009, p. 7]. It could be understood as a flow-based concept, where liabilities can be simply financed through different sources and at an acceptable and reasonable price. In other words, the institution is liquid while its inflows exceed the outflows. The risk that is connected with the funding liquidity appears in the situation in which the institution is not able to fulfil its obligations without a delay. Sometimes the sources of the risk are endogenous in nature and come directly from the institution (moral hazard, fraud, etc.), sometimes they are exogenous and depend on the market situation.

Market liquidity, sometimes called trading liquidity, is the ability to trade quickly at a low cost without large changes in prices [O'Hara 1995] and – in its nature – is highly connected with funding liquidity. The main characteristics of a liquid (healthy) market include: narrow bid-ask spreads, low transaction costs and lack of influence of large volumes of transactions (or large number of transactions) on prices. Market liquidity could be divided into several subclasses concerning the asset type, as well as the subsets of whole financial markets (focus on the country, currency, etc.). The market liquidity risk arises while there are problems to obtain a fair price for the asset immediately.

Central bank liquidity means the ability of the central bank to provide the required liquidity to the financial system. As a liquidity provider, the central bank uses its tools to steer the liquidity towards the desired level. Among the popular tools one may find the direct ones: open market operations (OMO), reserve requirements, and those which have an indirect influence on the money in the economy – the short--term interest rate(s) (the target rate), credit requirements, taxes, etc. The central bank liquidity risk appears on the counterparty level, as a consequence of the inappropriate monetary policy or unexpected turmoil.

The last type of liquidity is the macroeconomic one, connected with the whole financial system. This risk is called systemic liquidity risk and is usually associated with a global financial crisis and the effect of contagion. Before this type of risk is measured, there is a need to answer the questions: how to measure liquidity risk globally, whether the feasibility of international regulations is possible, as well as which regulations are universal and which ones should be set individually for different countries.

3. Liquidity measures

The problem of how to measure liquidity has emerged together with financial market operations. The bank managers were obliged to keep money for the expenses and tried to calculate appropriate amount to cover the needs of depositors, as well as the other counterparties. On the other hand, supervisors started to control the system as a whole quite early to omit or at least reduce the risk of contagion.

Considering funding liquidity, the risk is measured at the institutional level and in the case of a bank, the most popular is gap analysis, building the term structure of the expected cash flows and the term structure of the expected cumulated cash flows, as well as the fund transfer pricing policy [Castagna, Fede 2013].

Market liquidity could be measured by [Fleming 2003]:

- the bid-ask spread: calculated as the difference between the bid and ask price to show how much a trader can lose by selling an asset and buying it back right away. The spread usually increases at time of uncertainty;
- market depth: how trading volume is changing over time, trading frequency, it measures the amount that can be traded at a given moment in time as indicated by the trading book;
- price impact, market resilience: how many units the traders can sell or buy at the current bid or ask price without moving the price.

Central bank liquidity risk is usually measured by evaluating the liquidity delivered to the economy by the central bank, in the form of e.g. open market operations.

At the supervisory level, liquidity is measured by the enterprise (e.g. bank) and monitored by the supervisor (central bank). Basel regulations proposed two standards for liquidity risk: liquidity coverage ratio (LCR) and the net stable funding ratio (NSFR); the indicators that allow to measure and monitor the short-term and long-term liquidity.

Apart from the well-known and often used measures there are also some other studies showing alternative liquidity measures. The research of Fleming [Fleming 2000] described the yield curve fitting errors as a measure of market illiquidity. It could be implemented through the noticeable influence of the turbulent market on yields that are modelled with a yield curve. Yield curve fitting errors show a possibility for an alternative income especially for speculators and arbitrageurs.

4. Chosen liquidity measures and their application on to the Polish market

The research shows the deviation between the market yields and those implied by the estimated term structure of interest rates. For a given day the difference between the quoted yield of an asset and the yield implied by term structure model has been calculated. The aim is to show how these deviations are affected by liquidity

considerations, especially in the turmoil time, when the shortage of quotations and wider spread influence the prices.

For the research purposes two models for parametric group of models were taken into account: first one based on four parameters [Nelson, Siegel 1987], and the second one developed by Svensson and based on six parameters [Svensson 1994]. The choice of parametric models was influenced by their role in monetary policy of central banks [BIS 2005]. These two vectors of parameters have been calculated day by day since 2005 by minimizing the mean square errors between the market and theoretical yields:

$$\frac{\sum_{l=1}^{k}(i_l - \bar{i}_l)^2}{k} \rightarrow \min,$$

where: $i_l - \bar{i}_l$ – a yield error of l-th asset; k – number of asset.

The data comes from Polish money market, and includes WIBOR (money market fixing quotations), for maturities from one day to one year (T/N-tomorrow next, 1W-one week, 2W-two weeks, 1M-one month, 3M-three months, 6M-six months, 9M-nine months, 1Y-one year), taken daily between 2005-2012 when the biggest volatility could be observed.

The comparison of the two types of parametric models covers calculation of the mean and standard deviation over a number of days. A low mean value confirms the flexibility of each model and demonstrates its ability to fit the data quite precisely. The level of the standard deviation enables the assessment of the reliability of the entire sample.

In the considered case the RMSE was calculated for the Nelson-Siegel and Svensson parametric model. To obtain the results, two macros were written in VBA code which helped to receive two panel results for daily vectors of parameters (four--parameters vector for Nelson-Siegel model and six-parameters vector for Svensson model). Additionally, two vectors of RMSE were calculated (a goodness of fit statistic is presented in Table 1).

Table 1. Goodness of fit statistics

Model	Nelson-Siegel	Svensson
Observations	1957	1957
Mean	0.00047	0.00032
Standard deviation	0.00096	0.00061

Source: own study.

It is easy to notice that the mean of average price errors is very small, although the Svensson model shows a slightly better result than the Nelson-Siegel model, which appears to be less flexible. The results of the RMSE statistic show that Svens-

son model produces lower mean value of the RMSE, as well as a lower standard deviation.

The plots of errors for the selected methods allow for the analysis of their sensitivity to the disturbances in the market (Fig. 1). From the beginning of the financial crisis the volatility of financial instruments' rates had become very high which caused problems with fitting the data. As the chart shows, the Nelson-Siegel model turned out to be the most resistant to the market disturbances (starting in autumn 2008).

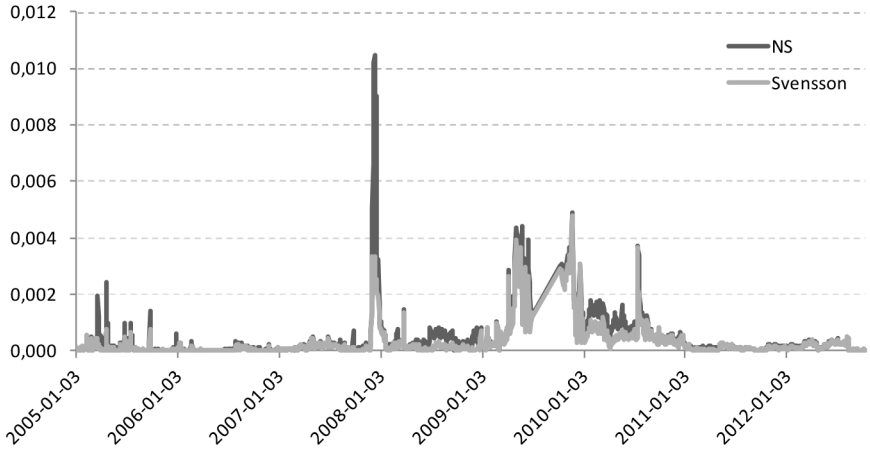

Fig. 1. RMSE errors for the different types of model fitting techniques

Source: own study.

The chosen measure confirms that there is a strong relation between the turmoil in the market and the level of the error. Together with the beginning of market turmoil (IX.2007 – III.2008) the difference between the market and theoretic yields started to increase. The highest level of the error was noticed during last days of November and the beginning of December 2007 regardless of the chosen model.

The volatile period could be also observed during the whole year 2009 – despite the fact that the error was not very high, we have seen increased volatility due to lack of liquidity.

5. Conclusions

Two different models were applied in this work (based on Nelson-Siegel and Svensson research) to show the root mean squared error as a market liquidity measure. The presented summary statistics (represented through a low value for the mean and the standard deviation) allow to assume that both methods are suitable to

analyse liquidity. The chosen measure – the root mean squared error – proved to be sensitive to market turmoil and its level significantly increased in reaction to it (as it was expected).

The most important conclusion from this study is that the goodness of fit criteria vary over time and that this can be an interesting alternative to other measures. Comparing the Basel III liquidity criteria, both related measures (LCR, NSFR) are based on asset-liability situation in the banking sector and are prone to a time-lag for preparation, calculation and delivering of data. In case of the measure proposed here, a current situation in the interbank market could be presented almost at once. In that sense, the proposed measures could be an alternative indicator of market liquidity. Additionally, Polish market, still treated as an emerging one, is sufficiently sensitive to new information to apply these alternative measures of market liquidity to it.

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