# ARTICLE IN PRESS

International Review of Economics and Finance xxx (2017) 1-9



Contents lists available at ScienceDirect

# International Review of Economics and Finance

journal homepage: www.elsevier.com/locate/iref



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#### ARTICLE INFO

Keywords: Liquidity Market microstructure High-frequency data Sovereign bonds LCR

JEL classification: C58 G12 G28

## 1. Introduction

## ABSTRACT

We examine effective measures of liquidity in the context of EU sovereign bonds and the Basel III regulatory framework. We observe that the empirical correlations between benchmarks and proxies are typically very low and in general become weaker as the frequency over which these relationships are examined becomes higher, and that the relative strength of the various proxies may change with the frequency considered. The main implications of our results for the EU sovereign bond market are (i) the use of liquidity proxies may lead to erroneous conclusions; (ii) any liquidity measure needs to be assessed against the relevant timeframe for conversion into cash; and (iii) the end-of-day spread is the best performing proxy across different frequencies.

The 2007–2009 financial crisis has triggered renewed interest in liquidity measures. Financial institutions with insufficient liquid assets were forced to sell assets quickly at fire-sale prices or suspend operations, putting strain on the broader financial system. In December 2010, the Basel Committee on Banking Supervision (BCBS) announced the introduction of a Liquidity Coverage Ratio (LCR) into the new Basel III regulatory framework. The main objective of the LCR is to enhance the short-term resilience of banks in the event of a severe liquidity stress scenario. The LCR requires banks to hold sufficient unencumbered high-quality liquid assets (HQLA) to meet the bank's liquidity needs for 30 calendar days in a significant stress scenario.<sup>1</sup> Effective application of the LCR requires liquidity measures that adequately reflect the ability to convert HQLA into cash within days including in times of market stress.

Liquidity of an asset in general refers to how quickly and cheaply it can be converted into cash, or it is "the degree to which an asset or security can quickly be bought or sold in the market without affecting the asset's price." <sup>2</sup> There is a large literature on liquidity measures, translating the general definitions of liquidity into concrete and quantitative concepts based on market data.<sup>3</sup> There is however no consensus on a best measure.

Liquidity measures can be categorized based on the type of data used: high-frequency (intra-day) versus low-frequency data. As the more accurate and complete high-frequency data are expensive, not always available, and difficult to handle due to size and irregular-

https://doi.org/10.1016/j.iref.2017.11.002

Received 23 June 2015; Received in revised form 25 October 2017; Accepted 12 November 2017

Available online xxxx

Please cite this article in press as: Langedijk, S., et al., Benchmarking liquidity proxies: The case of EU sovereign bonds, International Review of Economics and Finance (2017), https://doi.org/10.1016/j.iref.2017.11.002

<sup>\*</sup> The content of this study does not reflect the official opinion of the European Commission. Responsibility for the information and views expressed in the study lies entirely with the authors. The work for this study was done before George Monokroussos joined Amazon.

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<sup>&</sup>lt;sup>1</sup> The LCR rules apply to about 10% of banks' balance sheets (EBA, 2013a).

<sup>&</sup>lt;sup>2</sup> This is a standard definition in the literature. See, for instance, Earne and Sherk (2013).

<sup>&</sup>lt;sup>3</sup> For example Goyenko et al. (2009) provide an overview of measures.

<sup>1059-0560/</sup> $\odot$  2017 Published by Elsevier Inc.

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frequency issues, low-cost so-called liquidity proxies are often preferred. These liquidity proxies are constructed using low-frequency (daily) data.

Recent literature improves upon such common practices identifying the best proxies using time-series and cross-sectional correlations of proxies and so-called benchmarks based on high-frequency data. See, *inter alia*, Goyenko, Holden, and Trzcinka (2009), Fong, Holden, and Trzcinka (2017), and Marshall, Nguyen, and Visaltanachoti (2013) on stocks and Schestag, Schuster, and Uhrig-Homburg (2016) on U.S. corporate bonds. Correlating benchmarks and proxies faces a double challenge: both mixed frequencies (high and low) and irregularly-spaced variables. These problems are dealt with by resorting to the aggregation of both proxies and benchmarks to annual, quarterly, monthly, or daily averages. Based on such aggregation and correlation exercises, this literature typically provides substantial evidence that empirically justifies the use of proxies. For instance, Goyenko et al. (2009) state, "*the evidence is overwhelming that both monthly and annual low-frequency measures capture high-frequency measures of transaction costs. Indeed in many applications the correlations are high and the mean square errors low enough that the effort of using high-frequency measures is simply not worth the cost.*" A similar approach that focuses on low-frequency statistics of liquidity measures seems to be influential with policy authorities which are tasked with implementing the Basel III/LCR regulatory framework.<sup>4</sup>

In this study, we investigate this influential practice of identifying the best liquidity measures by correlating monthly (or even quarterly or cross-sectional) aggregates of benchmarks and proxies, when this practice is extended to sovereign bonds.

A key concern associated with averaging the liquidity benchmarks at a low frequency is that it may fail to reflect the ability (or lack thereof) of investors to transact immediately and the cost associated with this. As averaging removes the extra information that come at the higher frequency, short-term, high-frequency movements of liquidity are ignored, possibly resulting in erroneous assessments and conclusions.<sup>5</sup> The extent to which results from low-frequency analyses could lead to such erroneous conclusions is an empirical matter. Our contribution consists of shedding light on this empirical matter, and doing so in a robust way.

We investigate the above through a series of exercises. We compute and contrast daily and monthly correlations for various proxies and benchmarks, for a series of sovereign bonds coming from both "core" and "periphery" EU countries. Our focus on sovereign bonds reflects the emphasis on sovereign debt for the calibration of the Basel III LCR numerator (e.g., see Basel Committee on Banking Supervision, 2013). Following literature, we use time-series, cross-sectional and portfolio analysis. Our findings provide empirical support to the concerns outlined above; for example, correlations between benchmarks and proxies tend to become substantially weaker when examined at higher frequencies, and the relative performance of proxies may change with the frequency considered.

The remainder of this paper is structured as follows: Section 2 discusses the liquidity measures and the data we use, Section 3 provides the details of our methodology and results, as well as the policy implications of our results, and Section 4 concludes.

### 2. Liquidity measures and data

We use sovereign bond data,<sup>6</sup> combining two MTS (Mercato Telematico dei Titoli di Stato) datasets: a low-frequency daily and a high-frequency intra-day dataset. MTS is the major wholesale market<sup>7</sup> for fixed income securities in Europe. All major international financial institutions participate in MTS. EuroMTS is the reference pan-European electronic market for Euro benchmark bonds, or bonds with an outstanding value of at least  $\varepsilon$ 5 billion. The MTS platform liquidity is guaranteed by quoting requirements for market makers with minimum quote sizes varying between EUR 2.5 million and EUR 10 million. Participants can join the MTS markets either as a market maker or market taker and are subject to minimum capital requirements, as well as trading requirements.<sup>8</sup>

We consider 4 sovereigns: Germany, Finland, Italy and Portugal, to have a mix of large and small markets, with high and lower credit quality. The dataset covers two calendar years: 2011–2012. This time period reflects a wide range of market circumstances and covers the Eurozone sovereign debt crisis. Our sample is composed of 95 unique bond codes (ISINs): 46 for Italy, 29 for Germany, 8 for Finland and 12 for Portugal.

The low-frequency MTS daily data contains daily traded volume, bid-ask spread, closing price, closing mid-quote, yield to maturity, modified duration, convexity, bond type, issue date, issuer name, maturity date, coupon. The high-frequency data provides for every trade the size, price, millisecond time stamps, direction of the trade (buy or sell) and yield. It also provides the pricing of the order book with three levels of depth throughout the day, resulting in a very large dataset with up to 1000 quotes per bond per day on average for the most traded bonds. For example, in our sample the number of quotes amounts to more than 25 million across the four countries, the total number of trades is more than 100,000 and the total traded volume across the sample considered is more than EUR 500 billion. The trading activity is unevenly spread across bonds, with trading activity limited to a few trades per month in a sizable share of bonds.

We select a number of commonly used proxies and benchmarks to contrast their daily and monthly correlations. The literature

<sup>&</sup>lt;sup>4</sup> In the context of categorizing assets of high and extremely high liquidity for the implementation of the LCR in the European Union, the European Banking Authority notes in EBA (2013b): "Monthly price impact measures are defined by taking the monthly median of the daily measure for each asset. When making cross asset class analysis, the average value across the relevant assets of the monthly medians has been taken."

<sup>&</sup>lt;sup>5</sup> For volatility of equity returns (which is strongly related to market liquidity), Dobrev and Szerzen (2010) find that model inference without high-frequency data takes insufficient account of skewness and kurtosis, underestimating risk during bad times and overestimating risk during good times.

<sup>&</sup>lt;sup>6</sup> Globally, sovereign debt securities make up between 15 and 20% of the total stock of debt and equity outstanding, and are the second category of market assets behind equities. Sovereign bonds are considered as assets of extremely high liquidity and credit quality in the LCR framework (EBA, 2013b).

<sup>&</sup>lt;sup>7</sup> Pelizzon, Subrahmanyam, Tomio, and Uno (2013) report for instance that the MTS market share of interdealer transactions in Italian sovereign bonds ranges between 80 and 85%.

<sup>&</sup>lt;sup>8</sup> For the EuroMTS market, market makers need to have a net worth of at least EUR 375 million. All market makers must commit to providing two-way quotes for the securities assigned to them and display them for all bonds at least five hours per day. For sovereign bonds, proposals must be formulated for a minimum quantity equal to EUR 10 million, EUR 5 million, EUR 2.5 million depending on the MTS market and instrument (bucket of maturity, liquid/benchmark security).

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