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Size Matters: Nonlinear Determinants of Sovereign Bond Liquidity in EU Markets*

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Abstract

The purpose of this paper is to investigate the determinants of sovereign bond market liquidity across EU member states, with particular attention to the role of market size. Using panel data for 26 EU countries over the period 2022–2024H1, the analysis applies Hansen's threshold regression methodology to test for non-linearities in the debt–liquidity relationship. The results identify a statistically significant threshold of approximately EUR 92 billion in outstanding debt, above which liquidity dynamics become self-reinforcing, and market size emerges as the dominant driver. Liquidity below this threshold is influenced more by structural and fiscal fundamentals, such as the composition of debt and the quality of sovereign credit. The findings confirm that liquidity is scale-dependent and regime-specific, with important implications for debt management and policy design. The study concludes that strategies to enhance liquidity must be differentiated: large markets rely on sustaining scale, while smaller ones require institutional and structural measures.

Keywords: *sovereign bonds, liquidity, market size, threshold regression*

JEL classification: *E44, G12, G15, H63*

1. Introduction

Liquidity in sovereign bond markets is of fundamental importance for both sovereign debt management and the functioning of the wider financial system. For governments, liquid markets lower borrowing costs by narrowing bid-ask spreads and compressing the liquidity premia demanded by investors. They also ensure a more stable and reliable source of financing during periods of stress by

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enabling a broad and diverse investor base. For investors, liquidity facilitates portfolio adjustments and risk management by allowing large positions to be rebalanced efficiently. At the systemic level, liquid government securities serve as benchmarks for pricing other financial instruments, provide essential collateral in repo and derivatives markets, and constitute the primary channel through which central banks conduct monetary policy operations (International Monetary Fund [IMF], 2012; Organisation for Economic Co-operation and Development [OECD], 2016; Financial Stability Board, 2022). Conversely, illiquid markets heighten refinancing risks, amplify price swings, and may exacerbate the impact of fiscal or macroeconomic shocks. For these reasons, international financial institutions and academic studies alike emphasize the policy relevance of fostering sovereign bond market liquidity, particularly in smaller and emerging economies.

Nevertheless, issuing public debt has been much easier than ensuring its secondary market liquidity. As McCauley and Remolona (2000) already argued, achieving active trading may require a minimum market size, beyond which government bonds can serve as reliable benchmarks and hedging instruments. More recent studies confirm that liquidity is affected not only by the amount of outstanding debt but also by a broad set of factors including issuance practices, investor composition, regulatory and tax frameworks, bonds characteristics, currency denomination, credit rating, the jurisdiction of issuance, and the infrastructure of trading and settlement (Asian Development Bank, 2019; OECD, 2016, 2017, 2018; Fang et al. 2023; Eisl et al. 2020). These insights suggest that while market size may be a necessary condition, it is not sufficient on its own, and understanding how these factors interact remains a crucial task for both academics and policymakers.

The relevance of these issues takes on a distinct character in the European Union. On the one hand, the euro area operates under a common monetary policy, harmonized regulations, and partially integrated settlement infrastructures, which foster cross-border integration. On the other hand, member states outside the euro are issuing debt both in their national currencies and in euros, creating an additional layer of diversity. Yet, as Favero et al. (2010) underline, euro area bonds are not regarded as perfect substitutes by investors. Government securities are issued by multiple sovereigns, each with distinct fiscal positions, credit ratings, issuance practices, and investor bases, while liquidity is provided by common as well as country-specific liquidity providers (Panagiotou et al., 2023). This fragmentation implies that liquidity is uneven across member states, with core issuers such as Germany or France enjoying deep markets, while smaller or peripheral countries face persistent challenges in sustaining secondary market activity.

Market fragmentation creates a unique research challenge. If financial intermediaries, settlement platforms, and monetary policy are largely shared, why do liquidity conditions differ so markedly across countries? One reason lies in country-specific fundamentals. Another lies in the scale of issuance: larger markets naturally facilitate

turnover in ways that smaller markets cannot. Yet the precise point at which market size begins to dominate other factors has not been established empirically. While McCauley and Remolona (2000) suggested that a critical threshold may lie around USD 100–200 billion, no study to date has tested for nonlinearities in this relationship across European sovereign bond markets. Finally, partial currency fragmentation makes the European case especially interesting, as it allows researchers to investigate the extent to which euro area membership itself shapes secondary market liquidity, relative to other structural determinants.

In this paper, we address this gap by focusing on EU sovereign bond markets during 2022–2024. Our central research problem is whether sovereign bond liquidity exhibits a threshold effect with respect to market size, and whether the determinants of liquidity differ systematically between smaller and larger markets. From a policy perspective, identifying a threshold matters because it helps to target efforts more efficiently: if liquidity responds differently above and below a certain size, then policymakers should not apply identical measures across all countries. In fact, larger issuers often have both the resources and the institutional incentives to develop sophisticated market-microstructure tools – such as benchmark programs, securities lending facilities, or enhanced dealer obligations – because even small yield improvements translate into substantial fiscal savings. Smaller issuers, by contrast, face tighter capacity constraints and cannot rely on size alone, making complementary measures – such as diversifying the investor base or incentivizing primary dealers – relatively more important. In this sense, the presence of a threshold informs where reforms are likely to yield the greatest marginal effect, rather than implying that any group of issuers can neglect the issue of liquidity.

Building on the literature and the policy discussion above, this paper advances two related hypotheses:

- H1 – Sovereign bond market liquidity in EU member states exhibits a non-linear relationship with market size.
- H2 – The determinants of liquidity differ systematically between markets below and above the size threshold.

These hypotheses suggest that beyond a certain debt threshold, scale effects dominate, enabling more continuous trading, tighter bid–ask spreads, and resilience in stressed conditions. Below this threshold, liquidity is more fragile and less directly related to market size. For smaller issuers, structural factors such as investor base composition, credit ratings, and issuance practices may play a comparatively greater role, since market size alone is insufficient to generate secondary trading. To the best of our knowledge, this is the first study to estimate an endogenous market-size threshold for sovereign bond liquidity in the EU and to analyse regime-specific liquidity determinants.

Taken together, these hypotheses imply that liquidity policy cannot follow a "one-size-fits-all" template across EU sovereign issuers. Instead, policy priorities should depend on a country's position relative to the critical size threshold; while large issuers may rely primarily on economies of scale complemented by targeted microstructural enhancements, smaller issuers must focus on structural reforms to strengthen liquidity.

To evaluate these propositions, this paper employs a two-step empirical strategy. First, panel regressions on semi-annual data for 26 EU countries (2022–2024) establish baseline relationships between liquidity and explanatory variables, including market size, debt-to-GDP ratios, credit ratings, euro area membership, and foreign investor participation. Second, Hansen's (2000) threshold regression methodology formally tests for the presence of a market-size threshold and estimates its value. Separate regressions are then conducted for subgroups below and above the threshold to establish whether liquidity drivers differ systematically between regimes.

By empirically testing these hypotheses, our paper contributes to several strands of literature. It extends the early insights of McCauley and Remolona (2000) by providing the first threshold estimate for EU bond markets. It complements studies such as Beber et al. (2009), Favero et al. (2010), and O'Sullivan and Papavassiliou (2020), which emphasize the dual roles of credit quality and liquidity, by showing that these roles are regime-dependent. It also advances the work of Panagiotou et al. (2023) and Richter (2022) on commonality in liquidity by highlighting the conditions under which national factors dominate versus when common effects prevail. Finally, it has direct policy relevance by offering guidance to debt management offices about the conditions under which liquidity-enhancing interventions are most effective.

The remainder of the paper is structured as follows. Section 2 provides an overview of the existing literature and synthesizes previous research on sovereign bond market liquidity. Section 3 presents the methodology, including the use of Hansen's (2000) threshold regression approach. Section 4 introduces the data and presents the empirical results. Section 5 discusses the findings in a broader economic and policy context. Section 6 concludes with key messages and identifies avenues for future research.

2. Literature review

The liquidity of sovereign bond markets has been the subject of sustained academic attention, reflecting both its importance for financial stability and monetary policy. A central debate in the literature concerns whether sovereign bond liquidity is primarily determined by common market-wide forces or by

bond- and country-specific characteristics. Richter (2022), for example, examines liquidity in a panel of developed countries. The study finds that variations in individual bond liquidity are to a large extent explained by common liquidity movements, driven by proxies such as the number of market makers or local bank returns. However, the results also highlight the absence of a true global liquidity factor, with negative cross-market correlations observed during flight-to-safety episodes. This resonates with the findings of O'Sullivan and Papavassiliou (2020), who document significant commonality in liquidity proxies such as spreads and depth. Importantly, they observe that co-movement weakens during crisis periods but remains more pronounced in the periphery than in the core. Similar conclusions are drawn by Panagiotou et al. (2023), who focus on the determinants of commonality in liquidity across European fixed-income markets. Their results suggest that supply-side factors, such as the funding constraints of financial intermediaries, explain much of the time-series variation in commonality, while demand-side proxies play a much more limited role. Clancy et al. (2019) find that significant own- and cross-market effects causing liquidity contractions in the Italian and Spanish bond markets during times of heightened risk are amplified by the German Bund's safe-haven status. Chaumont (2024) emphasizes that the liquidity of the secondary market for bonds is endogenous and varies over the business cycle.

At the same time, an extensive strand of literature emphasizes the role of bond-specific and structural characteristics. McCauley and Remolona (2000) show that larger stocks of outstanding government debt are typically associated with higher turnover and narrower bid-ask spreads, and hypothesize the existence of a market-size threshold, in the order of USD 100–200 billion, above which liquidity improves substantially. Subsequent research has supported this view, with Galliani et al. (2014) demonstrating that bond-level features such as rating, duration, and amount issued play a particularly strong role under stressed conditions. Favero et al. (2010) observe that while yield differentials display a common factor highly correlated with aggregate risk, liquidity differentials – proxied by bid-ask spreads – are more heterogeneous, suggesting that market size and structure explain differences in liquidity.

These findings link closely to the literature disentangling liquidity from credit quality. Beber et al. (2009) argue that during crises, investors tend to prioritize liquidity over credit quality, leading to a negative relation between credit standing and liquidity in sovereign bond markets. Petrella and Resti (2016) show that liquidity dynamics are driven by market-wide factors, such as quality spreads, and by bond-specific characteristics, with stressed conditions amplifying the relevance of the latter. Dell'Erba et al. (2013) complement these results by analyzing the interaction between debt levels, debt composition, and spreads in diverse markets. They find that the correlation between debt levels and spreads is high and

statistically significant in countries with a large share of foreign currency debt or high net foreign liabilities. On the other hand, Pelizzon et al. (2016) investigate the relation between credit risk and liquidity and find a strong positive relationship between credit default swap spreads and bid-ask spreads in the Italian sovereign bond market.

Further perspectives highlight the reinforcing role of funding constraints and fragmentation in European bond markets. Moinas et al. (2018) document two-way feedback between funding liquidity and market liquidity, showing that impairments in one dimension tend to exacerbate problems in the other. Sensoy et al. (2019) observe that after a period of increasing convergence, the European debt crisis reintroduced segmentation, reducing cross-market correlations and dividing euro-area markets. Pozzi and Wolswijk (2012) similarly argue that idiosyncratic factors, driven by fiscal positions, regained importance during and after the financial crisis. Together, these studies illustrate how structural weaknesses, institutional differences, and country-specific fiscal profiles reassert themselves when integration is tested under crisis conditions.

In addition to bond-level and macroeconomic perspectives, several studies rely on high-frequency data from the MTS trading platform to examine microstructure dimensions of sovereign bond liquidity. Menkveld et al. (2004) and Cheung et al. (2005) investigate the link between order flow and yield dynamics. Dunne et al. (2006) use limit order book and transaction data to find that execution quality is closely related to the size of the issuer, the issuance techniques, and the obligations imposed on primary dealers. In a further study, Dunne et al. (2007) study the determinants of benchmark status highlighting that liquidity is generally concentrated on a small number of individual instruments. Dufour and Nguyen (2012) focus on price impact, Caporale and Girardi (2013) analyze price discovery, and Paiardini (2014, 2015) considers the influence of macroeconomic announcements on Italian government bond prices and liquidity. Buis et al. (2020) examine the interaction between the primary and secondary markets for euro area sovereign bonds and find that expected issuance fees are positively related to liquidity. These studies collectively demonstrate that market liquidity is not only shaped by macro-level fundamentals but also by microstructural features of trading platforms, order flows, and dealer incentives.

Despite the breadth of the existing literature, two gaps remain. First, while several authors have hypothesized the existence of market-size thresholds beyond which liquidity improves (McCauley & Remolona, 2000), no study has formally tested this proposition using an endogenous threshold methodology. Existing contributions typically assume linear relationships between issuance volume and liquidity, which risks obscuring non-linearities that may arise once a market surpasses a critical size. Second, while the commonality in liquidity has been well documented, little is known about whether explanatory variables such as debt composition, fiscal

position, or euro-area membership differ in significance across small and large markets. If such regime-dependence exists, the determinants of liquidity in smaller EU sovereign bond markets may diverge substantially from those in larger, more established markets.

The present study seeks to address these gaps by combining panel regression analysis with Hansen's (2000) threshold methodology. This allows for the endogenous determination of thresholds in market size and enables testing whether the elasticity of liquidity with respect to outstanding debt differs across regimes. By doing so, the analysis not only provides new empirical evidence on the role of market size in shaping liquidity but also explores whether secondary determinants – such as foreign currency issuance, foreign investor participation, or euro-area membership – become more or less relevant once markets cross a critical size. In this way, the study extends the literature by identifying regime-specific dynamics in the determinants of sovereign bond liquidity across EU countries.

Beyond addressing these gaps, the novelty of this study lies in the combination of three elements that have not previously been integrated. First, the analysis focuses exclusively on EU sovereign bond markets during the most recent period with systematically reported secondary-market trading volumes, capturing current market structure and regulatory conditions. Second, by pairing these data with endogenous threshold estimation, the paper provides a more accurate characterization of scale effects than linear specifications used to date. Third, the explicit comparison of liquidity determinants across size-based regimes offers policy-relevant insights for European debt managers, whose strategic priorities differ according to market scale. Taken together, these contributions advance the literature by offering a contemporary, empirically grounded framework for differentiating liquidity policies across EU member states.

3. Methodology

The first step in the analysis is to select an appropriate measure of liquidity. In broad terms, liquidity describes the extent to which a financial market can absorb trading volume for a given change in price, and vice versa (European Central Bank [ECB], 2017). The optimal choice of liquidity measure depends on the research focus, as different dimensions of liquidity capture different aspects of market functioning (Galliani et al., 2014).

Liquidity measures for bonds are generally classified into two main categories: order-based and trade-based (Galliani et al. 2014; ECB, 2017). Pre-trade measures rely on information observable before a trade occurs, such as indicative price quotes posted by dealers. Post-trade measures are based on executed transaction prices and volumes. The literature offers numerous specific measures (Schestag

et al., 2016). Studies focusing on yield differentials or crisis-period behaviour often favour granular measures such as bid-ask spreads. For instance, Favero et al. (2010) use bid-ask spreads as a liquidity proxy; Panagiotou et al. (2023) employs quoted spreads, effective spreads, and the Amihud ratio; and O'Sullivan and Papavassiliou (2020) use relative spreads, quoted spreads, and market quality indices. By contrast, research on broader capital market development issues may employ simpler metrics. McCauley and Remolona (2000), for example, use the turnover ratio, defined as annual trading volume divided by volume of debt outstanding.

Accurate liquidity measurement is also complicated by data constraints. Unlike equities, sovereign bonds are primarily traded over the counter (OTC), making precise transaction or quote data difficult to obtain. In the EU, data are fragmented across multiple sources. This reflects, in part, the Approved Publication Arrangement (APA) system under MiFID II, where no consolidated tape provider has emerged. The lack of a consolidated tape – an aggregated, standardised view of post-trade data – remains a central challenge, with information currently dispersed across APAs that often vary in quality and accessibility. As highlighted by International Capital Market Association (ICMA, 2022a), data quality issues, such as incorrect notional amounts and misclassification of bond types further limit usability.

Considering both (i) the alignment of the liquidity measure with the research focus and (ii) the availability of consistent cross-country data, this study follows McCauley and Remolona (2000) in adopting turnover as the liquidity measure.

High-frequency liquidity metrics, such as bid-ask spreads or Amihud price-impact measures, capture microstructural dimensions of trading. However, they are not consistently available across EU sovereign markets in a harmonised format. Additionally, such measures often reflect short-term market dynamics, whereas turnover is more appropriate for examining structural and persistent liquidity drivers such as market size and fiscal fundamentals. For research focused on long-run relationships and cross-country heterogeneity, simpler proxies are therefore preferable (McCauley & Remolona, 2000). Finally, turnover represents the only liquidity metric consistently reported for all EU sovereign issuers over the sample period, making it the most appropriate measure for the present empirical design.

To address the absence of a consolidated tape, the ICMA began publishing semi-annual data on trading volumes in 2022. ICMA estimates that its reports capture over 80% of all secondary market transactions in the EU and UK, though it acknowledges data quality limitations under the current reporting regime (ICMA, 2024b, p. 5). However, it discontinued reporting country-level figures after the first half of 2024, limiting the present study to five semesters of data. This short observation window represents a key limitation of the empirical design, as it may

restrict the detection of longer-run dynamics in liquidity determinants. Nevertheless, the limited variability observed in the country data suggests it remains informative over the available horizon. Importantly, the core relationships continue to hold with strong statistical significance across alternative inference methods and sub-sample specifications, indicating that the key findings are robust despite the short observation window.

The primary empirical framework of the research is a panel regression specified as:

$$ln(Liq_{it}) = \alpha + \beta_1 \ln(Dt_{it}) + \beta_2 FXDt_{it} + \beta_3 FHld\%_{it} + \\ + \beta_4 Dt/GDP_{it} + \beta_5 EurDmy_{it} + \beta_6 RtDmy_{it} + \varepsilon_{it} \quad (1)$$

Where:

- i = country;
- t = semester;
- ln(Liq) = natural logarithm of turnover calculated as trading amount divided by debt securities outstanding;
- ln(Dt) = natural logarithm of government consolidated gross debt outstanding at face value (debt securities). Seen as a proxy for market size, it is expected to correlate positively with liquidity through economies of scale and broader investor participation;
- FXDt = foreign currency debt as percentage of total. It captures currency risk and segmentation effects that may influence the breadth of the investor base and secondary market activity;
- FHld = foreign debt holders as percentage of total. Seen as a proxy for international investor participation, potentially enhancing liquidity by increasing diversity of trading motives;
- Dt/GDP = government consolidated gross debt as percentage of GDP. Reflects perceptions of fiscal sustainability, which can affect sovereign risk premia and market attractiveness;
- EurDmy = dummy variable expressing whether a country is member of the euro area (1) or not (0). Controls for the effects of monetary integration;
- RtDmy = dummy variable expressing whether a member country's S&P long-term debt rating is in the A group of rating (1) or in the B group (0). Accounts for credit quality thresholds that can influence institutional investment mandates and trading patterns;
- ε = error term.

Since non-investment grade ratings apply only to Greece, we depart from the usual segregation between investment and non-investment grade and adopt a breakdown based on A ratings and B ratings.

Liquidity and outstanding debt are transformed into natural logarithms to reduce skewness and linearise the relationship between outstanding debt and liquidity. This improved model fit, raising the adjusted R^2 from 0.63 to 0.72.

Before proceeding to the estimation of pooled and sub-sample regressions, we conduct standard diagnostic tests in R software to assess multicollinearity, heteroskedasticity, serial correlation and cross-sectional dependence. Summary results are displayed in Table 1.

Multicollinearity is assessed using tolerance and Variance Inflation Factor (VIF) statistics for all explanatory variables, including the two dummy variables. Tolerance values range from 0.31 to 0.58, corresponding to VIF values between 1.73 and 3.18, suggesting no problematic collinearity.

We then test the assumptions underlying pooled panel OLS. The Breusch-Pagan LM test ($p = 7.1 \times 10^{-7}$) and the Koenker variant ($p = 0.0012$) strongly reject homoskedasticity, indicating that heteroskedasticity-robust inference is required. Pesaran's CD test also rejects the null of cross-sectional independence ($p = 2.6 \times 10^{-10}$), consistent with common shocks across EU sovereign bond markets. The Wooldridge test for serial correlation does not reject the null ($p = 0.155$), suggesting that autocorrelation is less of a concern in this specification. Taken together, these diagnostics motivate the use of Driscoll–Kraay standard errors, which are robust to heteroskedasticity and cross-sectional dependence, as our primary inference method. Cluster-robust (by country) results are reported as a robustness check.

Table 1: Diagnostics tests

Test	Statistic	p-value	Interpretation
VIF (mean)	2.63	-	No serious multicollinearity
Breusch-Pagan LM	22.12	7.06e-07	Rejects homoskedasticity
Koenker	-	0.001153	Heteroskedasticity (robust variant)
Pesaran CD	-	2.57e-10	Strong cross-sectional dependence
Woolridge (AR1)	-	0.155	No evidence of serial correlation

Source: Author's calculations

While the presence of heteroskedasticity is addressed by applying robust inference methods, these corrections do not capture the possibility that the relationship between liquidity and its determinants may not be fully captured by a linear specification. To account for this, we further test for structural thresholds using Hansen's methodology. While the regression initially included a broader set of explanatory variables, only debt outstanding proved consistently significant across

robust inference methods and aligns most directly with theoretical expectations regarding market size effects on secondary market liquidity. The threshold analysis was therefore specified as a univariate model relating liquidity to debt outstanding.

Following Hansen (2000), a panel threshold regression is applied to examine whether the relationship between liquidity and outstanding debt changes once outstanding debt exceeds a certain level. Unlike an arbitrary cutoff, Hansen's method endogenously determines the threshold value γ at which the slope of the debt-liquidity relationship changes. The model can be expressed as:

$$\ln(Liq_{it}) = \alpha + \beta_1 \ln(Dt_{it}) * 1(\ln(Dt_{it}) \leq \gamma) + \beta_2 \ln(Dt_{it}) * 1(\ln(Dt_{it}) > \gamma) + \varepsilon_{it} \quad (2)$$

Where γ is the endogenously estimated threshold, and 1() is the indicator function, equal to 1 if the condition inside the parentheses is true and 0 otherwise. This specification permits different slopes (β_1 and β_2) for the ln(DebtOut), depending on whether the debt outstanding is below or above the threshold γ.

Estimation proceeds by searching over candidate γ to find $\hat{\gamma}$ that minimizes the residual sum of squares (RSS), yielding regime-specific elasticities β_1 and β_2. The null hypothesis H_0:$\beta_1 = \beta_2$ implies no threshold effect.

The supLR statistic compares the threshold and linear models by taking the maximum likelihood ratio across γ:

$$supLR = sup_{\gamma \in \Gamma} \frac{RSS_0 - RSS_1(\gamma)}{\hat{\sigma}^2} \quad (3)$$

Because its distribution under H_0 is non-standard, inference is based on bootstrap replications. Here, 500 bootstrap replications generate the empirical distribution and p-values. In practical terms, the test examines whether allowing different slopes across regimes improves explanatory power compared to a single slope.

Finally, to explore whether other explanatory variables affect liquidity differently across regimes, separate panel regressions were estimated for the subsets of countries below and above the estimated threshold. This allows a comparison of the drivers of liquidity in smaller versus larger markets, complementing the threshold regression and providing further policy-relevant insights.

4. Empirical data and analysis

The analysis covers all EU member states except Malta, which lacks a functional sovereign debt market. Trading volume data is drawn from ICMA publications; all other variables, except ratings, come from Eurostat. The dataset is semi-

annual, spanning five periods (2022-2024) across 26 countries, for a total of 130 observations (ICMA, 2022a; 2022b; 2023a; 2023b; 2024a; 2024b). Where Eurostat does not provide semi-annual series, values are linearly interpolated to retain a balanced panel. Although some variables are officially reported only at annual frequency, their underlying economic evolution typically follows a gradual, trend-like pattern. Linear interpolation, therefore, offers a reasonable approximation over a short sample horizon and avoids creating artificial volatility in the explanatory variables.

Some data gaps required approximation. Missing values for foreign-currency debt (Denmark, Finland, Greece) and foreign holders (Greece, Germany) were replaced with cross-country averages. Estonia's reported EUR 11 billion trading volume in H2022 was treated as an outlier and replaced by the average of adjacent periods. Cross-country means provide a conservative approximation that avoids introducing country-specific biases, particularly as the variables concerned change slowly. To address the robustness of the results to these imputations, we re-estimated both the pooled and sub-sample regressions, excluding all observations in which values were imputed or adjusted. Coefficients on market size and the key structural variables remain qualitatively unchanged, and the significance of the threshold effect is preserved. These checks indicate that the main findings are not driven by data adjustments but instead reflect stable underlying relationships.

The dependent variable, liquidity, is defined as trading volume (ICMA) divided by debt outstanding (Eurostat). Table 2 shows a wide variation, from 11.43% on average in Lithuania to 202.71% in Italy. Debt levels are relatively stable with an upward trend. Composition shifts are evident in Croatia, where euro adoption in 2023 reduced the foreign currency share from 73.8% to just 0.1%. Ratings were mostly stable, with Portugal the only country upgraded from the B segment into the A segment.

Table 2: Descriptive statistics of sovereign bond markets in EU member states (2022-2024)

Country	Liq (%)	Dbt (EUR bn)	FXDt (%)	FHld (%)	Dt/GDP (%)	EurDmy	RtDmy
Austria	53.02	319	0.25	56.25	80.18	1	1
Belgium	90.94	511	0.00	50.75	104.56	1	1
Bulgaria	22.52	17	73.20	32.55	21.20	0	0
Croatia	17.27	33	44.01	16.93	65.80	0/1	0
Cyprus	13.93	14	0.00	57.08	79.00	1	0
Czechia	41.64	113	8.79	20.08	42.42	0	1
Denmark	28.42	115	11.00	26.25	34.36	0	1
Estonia	23.44	4	0.00	38.50	19.94	1	1
Finland	68.41	150	11.00	44.95	75.86	1	1
France	99.04	2,710	0.00	46.80	111.58	1	1
Germany	181.75	2,029	1.35	36.42	63.98	1	1
Greece	33.64	89	11.00	36.42	171.90	1	0
Hungary	57.48	115	28.51	27.11	74.86	0	0
Ireland	32.35	149	0.00	33.74	44.08	1	1
Italy	202.71	2,346	0.05	22.92	138.32	1	0
Latvia	17.66	14	0.00	55.06	44.42	1	1
Lithuania	11.43	22	0.00	45.53	37.92	1	1
Luxembourg	16.07	17	0.00	49.83	26.10	1	1
Netherlands	119.42	406	0.00	36.96	46.20	1	1
Poland	62.18	276	24.30	21.00	49.98	0	1
Portugal	54.38	156	0.00	20.75	107.96	1	0/1
Romania	47.44	123	52.76	40.25	49.02	0	0
Slovakia	19.26	59	0.00	40.67	58.46	1	1
Slovenia	39.02	37	0.10	45.55	71.24	1	1
Spain	84.90	1,359	0.00	36.50	108.34	1	1
Sweden	38.74	103	7.79	13.35	32.36	0	1

Source: Author's calculations based on ICMA (2022a, 2022b, 2023a, 2023b, 2024a and 2024b) and Eurostat (2022-2024) data

Diagnostic tests indicated heteroskedasticity and cross-country correlation. Regressions were therefore estimated with robust inference. The baseline uses Driscoll–Kraay errors, appropriate for EU bond markets where shocks spill across borders.

The pooled regression results for the sample of 26 EU member countries are shown in Table 3.

Table 3: Pooled regressions (Driscoll-Kraay standard error)

Variable	Coefficient	Standard error	p-value
lnDt	0.431	0.0217	3.38e-40
FHld	-0.285	0.1342	0.036
EurDmy	0.104	0.0361	0.0045
Other regressors	-	-	ns

Source: Author's calculations

The pooled regression expressed in Equation (4) finds debt outstanding highly significant with elasticity estimated at 0.43 (SE = 0.022, $p < 0.001$).

$$\ln(Liq_{it}) = -5.81 + 0.43 * \ln(Dt_{it}) + 0.22 * FXDt_{it} - 0.28 * FHld\%_{it} - \\ - 0.11 * Dt/GDP_{it} + 0.1 * EurDmy_{it} - 0.05 * RtDmy_{it} + \varepsilon_{it} \quad (4)$$

This implies that a 10% increase in debt outstanding raises turnover by roughly 4.3%. In addition, two other variables reach statistical significance: the share of foreign holders (coeff. = -0.28, p = 0.036) and euro area membership (coeff. = 0.10, p = 0.0045). The model accounts for a substantial portion of liquidity variation, with an adjusted R^2 of 0.72 under standard OLS approximation.

For comparison, Table 4 reports results using cluster-robust standard errors by country. This adjustment accounts for serial correlation and heteroskedasticity within each country but ignores cross-country linkages. In this specification, only debt outstanding remains statistically significant.

Table 4: Pooled regressions (Cluster-robust standard errors, by country)

Variable	Coefficient	Standard error	p-value
lnDt	0.431	0.0650	8.99e-10
Other regressors	-	-	ns

Source: Author's calculations

To test for nonlinearities, Hansen's threshold regression was applied to debt size. Results (Table 5) identify a statistically significant threshold at lnDt = 11.43, or roughly EUR 92 billion of debt outstanding. Below the threshold, elasticity is 0.25; above, 0.30. The model fits better than a linear alternative (RSS falls from 24.28 to 21.37; supLR = 14.27, p = 0.012).

Table 5: Hansen threshold regression results (log-log specification)

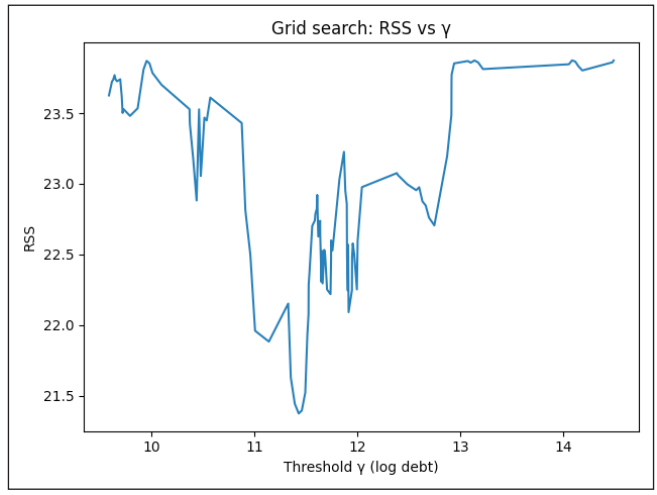
Item	Estimate	Notes
Estimated threshold, $\hat{\gamma}$ (lnDt)	11.43	
Implied threshold (EUR bn)	92.04	Level of debt outstanding at which elasticity shifts
Elasticity below $\hat{\gamma}$	0.25	β_1 (slope on lnDt)
Elasticity above $\hat{\gamma}$	0.30	β_2 (slope on lnDt)
Null model (linear) RSS	24.28	From pooled regression
Threshold model RSS	21.37	At $\hat{\gamma}$
supLR statistic	14.27	Test of threshold effect
Bootstrap p-value	0.012	Based on 500 replications
95% CI for $\hat{\gamma}$ (log debt)	[9.61; 14.48]	Percentile bootstrap
95% CI for $\hat{\gamma}$ (EUR mn)	[14.97; 1,947.42]	Converted to EUR bn

Source: Author's calculations

This indicates that once markets exceed EUR 92 billion, incremental issuance yields disproportionately higher liquidity, consistent with scale economies and broader investor bases.

Figure 1 plots the residual sum of squares (RSS) across candidate thresholds for lnDt. The RSS attains its minimum at $\hat{\gamma}$ = 11.43 (EUR 92 billion), with the sharp decline around the minimum confirming that the identified threshold improves model fit relative to linear alternatives.

Figure 1: Residual sum of squares (RSS) across candidate thresholds



Source: Author's calculations

Having established, through Hansen's methodology, the existence of a statistically significant threshold around EUR 92 billion of outstanding debt, the analysis proceeds with separate regressions for the two groups of countries.

Sub-sample regressions confirm diverging dynamics. For larger markets (16 countries), the model achieves strong explanatory power (Adjusted R^2 = 0.70). As reported in Table 6, debt outstanding remains the strongest determinant of liquidity (coeff. = 0.42; $p < 0.001$), with additional effects from foreign currency denominated debt (coeff. = 0.93; $p < 0.001$), and euro area membership (coeff. = 0.43; $p < 0.001$). Stronger credit ratings (coeff. = –0.17; $p < 0.001$) and foreign investor participation exerts a negative effect (coeff. = -0.76, p = 0.004), while debt-to-GDP shows a marginally negative coefficient (coeff. = -0.19, p = 0.080).

Table 6: Sub-sample regression for large issuers (Driscoll-Kraay standard error)

Variable	Coefficient	Standard error	p-value
lnDt	0.416	0.02	9.16e-32
FXDt	0.932	0.153	4.48e-08
FHld	-0.759	0.257	0.0043
Dt/GDP	-0.195	0.110	0.080
EurDmy	0.433	0.104	8.90e-05
RtDmy	-0.169	0.037	1.57e-05

Source: Author's calculations

The corresponding regression equation is:

$$\ln(Liq_{it}) = -5.54 + 0.42 * \ln(Dt_{it}) + 0.93 * FXDt_{it} - 0.76 * FHld\%_{it} - \\ - 0.19 * Dt/GDP_{it} + 0.43 * EurDmy_{it} - 0.17 * RtDmy_{it} + \varepsilon_{it} \quad (5)$$

For comparison, cluster-robust standard errors by country (Table 7) yield more conservative inference: only debt outstanding remains statistically significant.

Table 7: Sub-sample regression for large issuers (Cluster-robust standard errors, by country)

Variable	Coefficient	Standard error	p-value
lnDt	0.416	0.082	3.0e-06
others	ns	-	-

Source: Author's calculations

For smaller markets (10 countries), explanatory power is considerably weaker (Adjusted $R^2 = 0.13$). As reported in Table 8, debt outstanding is not significant (coeff. = –0.08; p = 0.32). Instead, liquidity is associated with structural features: higher shares of foreign-currency debt (coeff. = 0.69; $p < 0.001$), higher debt-to-GDP ratios (coeff. = 0.93; $p< 0.001$), and stronger credit ratings (coeff. = 0.59; $p < 0.001$).

Table 8: Sub-sample regressions for small issuers (Driscoll-Kraay standard error)

Variable	Coefficient	Standard error	p-value
lnDt	-0.076	0.0753	0.316
FXDt	0.687	0.155	6.26e-05
Dt/GDP	0.932	0.178	4.56e-06
RtDmy	0.587	0.171	0.0013

Source: Author's calculations

The regression equation is:

$$\ln(Liq_{it}) = -1.59 - 0.07 * \ln(Dt_{it}) + 0.69 * FXDt_{it} - 0.24 * FHld\%_{it} + \\ + 0.93 * Dt/GDP_{it} - 0.25 * EurDmy_{it} + 0.59 * RtDmy_{it} + \varepsilon_{it} \quad (6)$$

Cluster-robust results (Table 9) confirm the same set of significant variables for small issuers.

Table 9: Sub-sample regressions for small issuers (Cluster-robust standard errors, by country)

Variable	Coefficient	Standard error	p-value
lnDt	-0.076	0.094	0.420
FXDt	0.687	0.186	0.001
Dt/GDP	0.932	0.270	0.001
RtDmy	0.587	0.257	0.027

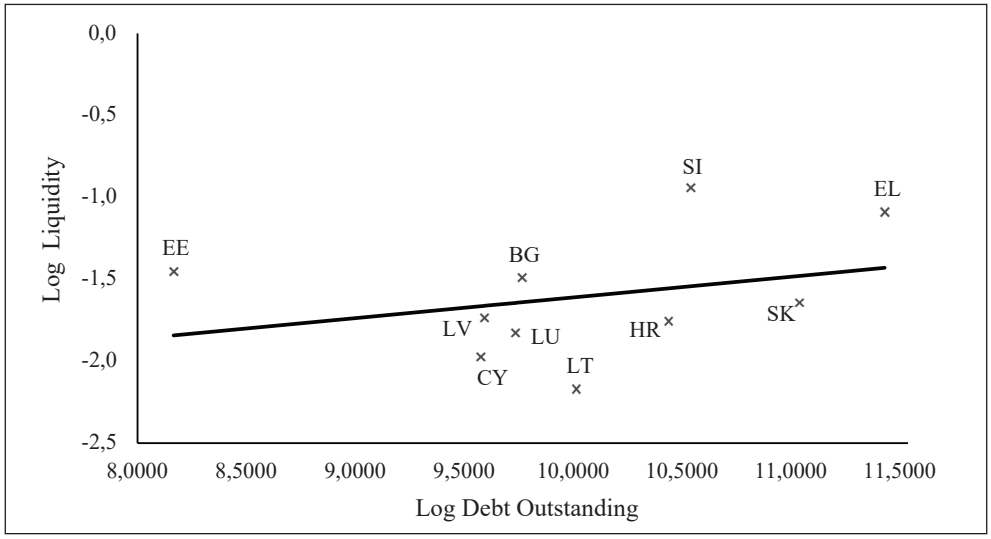
Source: Author's calculations

To complement the regression analysis, fitted plots illustrate how liquidity relates to debt outstanding in the two regimes. Country-level averages (Table 2) are used to enhance interpretability.

For smaller markets (Figure 2), the fitted regression line is relatively flat, indicating limited elasticity of liquidity with respect to outstanding debt. This suggests that

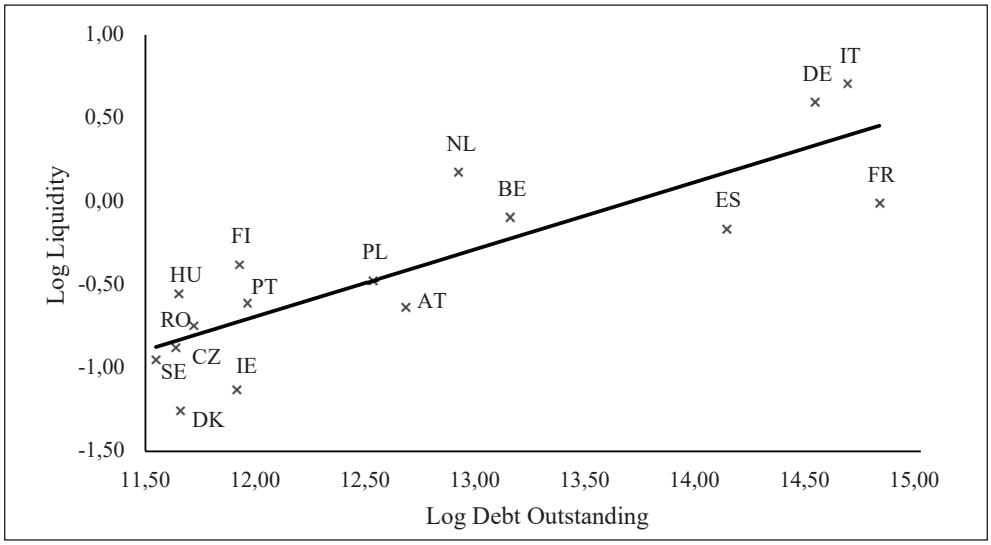
increases in debt outstanding do not yield proportionally large improvements in turnover. Within this group, notable deviations occur: Slovenia's observed liquidity (39,02%) substantially exceed the 22,4% predicted by Equation (6), marking it as an interesting case for further investigation.

Figure 2: Liquidity vs. Debt Outstanding (log-log) – Countries below the threshold



Source: Author's calculations

Figure 3: Liquidity vs. Debt Outstanding (log-log) – Countries above the threshold



Source: Author's calculations

For larger markets (Figure 3), the slope of the fitted regression line is steeper, confirming the stronger scale elasticity highlighted in the threshold analysis. Nonetheless, heterogeneity persists. The Netherlands and Finland lie above the fitted line, exhibiting higher liquidity than predicted, whereas Denmark, France and Ireland fall below it, with observed liquidity lower than expected given their market size.

5. Results and discussion

A central finding of the analysis is that liquidity is not a simple linear function of market size but exhibits a clear threshold effect. Hansen's methodology confirms that once a sovereign bond market surpasses a critical scale – around EUR 92 billion of debt outstanding – liquidity dynamics become self-reinforcing, with market size itself emerging as the dominant driver. Subsample regressions reveal a sharp divergence across regimes: in large markets, outstanding debt is the most powerful determinant of liquidity, while in smaller markets, liquidity is not explained by size but by fiscal and structural fundamentals. This result is broadly consistent with McCauley and Remolona's (2000) conjecture that government bond markets require a critical mass – around USD 100-200 billion – to function as deep and liquid benchmarks.

The subsample evidence also helps reconcile findings from the pooled regressions. At the pooled level, debt outstanding was the only consistently robust determinant of liquidity across inference methods, while other factors (such as foreign holdings or euro area membership) lost their significance when clustered errors were taken into account. The threshold analysis clarifies why: in aggregate, the dominant effect of market size masks the heterogeneity of other determinants, which only become visible once countries are segmented into small and large markets.

Beyond market size, other determinants emerge, and their effects differ across regimes. Some variables exert consistent influence, while others display sign reversals depending on market scale.

A higher share of foreign-currency-denominated debt is positively correlated with liquidity in both groups. This feature is almost exclusively observed in non-Euro area countries, where limited domestic markets and a lack of international investors willing to hold local-currency debt encourage governments to issue in major reserve currencies. One plausible explanation is that such issuance enables smaller sovereigns to tap global institutional investors who are unwilling or unable to hold local-currency risk. In addition, issuance in foreign currencies typically supports inclusion in larger and more standardised benchmarks, increasing visibility and trading interest. Broader participation also increases the diversity of trading motives, which may translate into more active secondary trading. The finding suggests that while foreign-currency issuance is often regarded as a vulnerability,

it can also connect sovereigns to deeper pools of liquidity and thereby support secondary trading activity.

By contrast, the share of foreign investors is consistently negatively associated with liquidity, with a particularly significant effect in large markets. This may indicate that foreign investors often adopt "buy-and-hold" strategies.

Euro area membership operates asymmetrically. Mechanically, it should support liquidity by eliminating exchange-rate risk and integrating sovereign bonds into a common trading, clearing, and settlement infrastructure, which broadens the investor base and facilitates cross-border market making. Harmonised repo and collateral frameworks further increase the usability of these bonds in secured funding markets, strengthening two-way trading and reducing liquidity premia. These mechanisms appear most effective in larger markets, where euro area membership is associated with higher liquidity. In smaller markets, however, euro membership is insignificant – and even weakly negative. This highlights that euro accession alone does not guarantee liquid markets. It may also indicate that in some non-Euro area countries, relatively siloed markets develop in local currency, sheltered by regulations, positive interest rate differentials, or home-bias effects. Croatia provides a telling example. Despite joining the euro area in 2023, its liquidity remains below that of smaller euro area peers such as Slovenia or Slovakia. Structural impediments clearly play a role, but microstructural features may also be relevant: Croatia is the only country in the sample without a formal primary dealer system, limiting incentives for active market-making and hindering secondary-market depth. Moreover, Croatia has by far the lowest share of foreign holdings in its debt stock, which – though theoretically favourable given the negative coefficient for foreign holdings – appears in practice to limit market liquidity. This illustrates that institutional design and market microstructure critically condition the benefits of euro area membership.

Fiscal fundamentals also display divergent effects. In large markets, the debt-to-GDP ratio is moderately negatively related to liquidity, consistent with the interpretation that weaker fiscal positions deter investors' interest. In smaller markets, however, the relationship reverses: higher debt-to-GDP ratios are strongly and positively associated with turnover. One possible explanation is that fiscal vulnerabilities attract speculative or hedging activity. Credit ratings present the mirror image: in small markets, stronger ratings are positively correlated with liquidity, while they are negatively correlated in larger markets. The coexistence of these results, while seemingly contradictory, points to the fact that investor behaviour and motivations differ systematically across market size segments.

At the same time, several countries deviate notably from values predicted by regressions. Slovenia, for example, displays much higher liquidity than its small size and other regressors would suggest, likely reflecting supportive microstructural features such as primary dealer obligations or an active domestic investor base.

Taken together, the evidence highlights a dual structure of liquidity determinants. In large markets, liquidity is scale-driven: once critical mass is achieved, issuance volumes and integration within the euro area suffice to sustain turnover. In small markets, liquidity is shaped more by fundamentals such as debt composition and credit quality. This duality carries important policy implications.

For larger issuers, the priority is to maintain transparency and stability in issuance, ensure integration with EU financial infrastructures, and preserve the scale that underpins liquidity. For smaller issuers, policy efforts should focus on fiscal credibility, sustaining investment-grade ratings, and developing market microstructure.

Several findings align with the existing literature. Consistent with McCauley and Remolona (2000), market size remains the primary structural determinant of liquidity, with larger issuance volumes associated with significantly higher turnover. Likewise, credit quality continues to play a liquidity-enhancing role, confirming the view that perceived sovereign risk shapes secondary-market activity. However, two results deviate from standard expectations. First, the negative relationship between foreign holdings and liquidity suggests that a more internationally dispersed investor base does not necessarily translate into more active secondary trading in the EU context. Second, euro-area membership does not universally improve liquidity: while it strengthens liquidity in large markets, its effects are negligible in smaller markets, implying that monetary integration alone is insufficient. These differences underscore the importance of market scale and institutional features in shaping liquidity outcomes.

From a broader perspective, these findings refine the understanding of liquidity determinants by showing that debt size effects are contingent on market regime, and that certain variables – most notably ratings – operate differently across contexts. The study thus contributes to the literature by providing empirical evidence of threshold effects, sign reversals, and institutional contingencies, underscoring the need for differentiated policy approaches to the structural realities of individual markets.

These findings suggest clear and differentiated implications for sovereign debt management. For large issuers that have already surpassed the estimated liquidity threshold, maintaining size is crucial to preserving scale effects. Complementary tools – such as regular issuance calendars, securities lending programs, active buybacks, and incentives for primary dealers – may further enhance market depth by strengthening two-way trading. For smaller issuers, by contrast, increasing issuance volumes alone is insufficient. Policy priorities should focus on strengthening fiscal credibility, sustaining investment-grade ratings, improving secondary-market infrastructure, and broadening the investor base, including through selective use of hard-currency issues where appropriate. Countries can also benefit from aligning issuance practices with best international standards and enhancing market-making obligations, ensuring that

liquidity gains from integration are fully realised. Together, these measures offer a practical roadmap for tailoring liquidity-enhancing policies to market scale.

6. Conclusions

This study examined the determinants of sovereign bond market liquidity in EU countries, aiming to test two hypotheses: H1 – that liquidity exhibits a non-linear relationship with market size, and H2 – that the determinants of liquidity differ systematically between markets below and above a size threshold. Both hypotheses are supported. Using Hansen's methodology, a statistically significant threshold of approximately EUR 92 billion in outstanding debt was identified, beyond which liquidity becomes self-reinforcing and market size emerges as the dominant driver. This confirms the long-assumed presence of scale effects (McCauley & Remolona, 2000) and provides empirical evidence of regime-dependence in EU sovereign bond markets. Subsample regressions show that in large markets, liquidity is overwhelmingly scale-driven, complemented by euro area membership, while in small markets, liquidity is not explained by issuance volume but by fundamentals such as debt composition and credit quality. Importantly, some variables not only differ in magnitude across regimes but also change sign: higher debt-to-GDP ratios are negatively correlated with liquidity in large markets but positively in small ones; credit ratings display the opposite pattern, positively correlated with liquidity in small issuers yet negatively in large ones. These reversals highlight the role of investor behaviour and caution against uniform policy prescriptions. The results thus make a dual contribution: empirically establishing a market-size threshold and showing that the determinants of liquidity are regime-specific. Policy implications follow directly. The liquidity threshold estimated in this paper implies that strategies must be tailored to market scale. For large issuers, the key requirement is to preserve scale advantages through maintaining issued volume, transparency, and integration into euro area infrastructures. For smaller issuers, however, increasing issuance volumes alone is insufficient. Instead, efforts should focus on preserving fiscal credibility and sustaining investment-grade ratings. Results further demonstrate that deviations from predicted lines are shaped not only by fundamentals but also by institutional arrangements, suggesting that smaller issuers can outperform their size if supported by appropriate design, while large issuers cannot assume liquidity is automatic. The analysis is limited by the short time horizon (2022–2024H1), the use of turnover ratios as the sole liquidity proxy, and the exclusion of microstructural indicators such as bid–ask spreads. Future research should extend the time series, incorporate richer liquidity measures, and explore qualitative determinants such as investor segmentation, primary dealers' incentives, or case studies of outlier countries.

Overall, the findings contribute to economic science by demonstrating that sovereign bond market liquidity in the EU is shaped by a non-linear scale effect

and by regime-dependent determinants, providing new evidence for differentiated policy approaches between large and small issuers. In doing so, this paper delivers the first empirical estimate of a market-size liquidity threshold for EU sovereign bonds using recent trading data and shows that liquidity determinants are regime-specific, thereby contributing novel evidence to the academic and policy debate.

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Veličina je važna: Nelinearne determinante likvidnosti državnih obveznica na tržištima EU

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Sažetak

Svrha je ovog članka ispitati determinante likvidnosti tržišta državnih obveznica u državama članicama EU, s posebnim naglaskom na ulogu veličine tržišta. Korištenjem panel-podataka za 26 zemalja EU u razdoblju 2022.–2024H1, analiza primjenjuje Hansenovu metodologiju pragovne regresije kako bi testirala postojanje nelinearnosti u odnosu između duga i likvidnosti. Rezultati upućuju na statistički značajan prag od približno 92 milijarde eura izdanog duga, iznad kojega dinamika likvidnosti postaje samoodrživa te veličina tržišta izrasta u dominantan čimbenik. Ispod tog praga, likvidnost ovisi ponajprije o strukturnim i fiskalnim fundamentima poput sastava duga i kreditne kvalitete države. Nalazi potvrđuju da je likvidnost ovisna o veličini i specifična po režimima, što ima važne implikacije za upravljanje dugom i oblikovanje politika. Istraživanje zaključuje da strategije za jačanje likvidnosti moraju biti diferencirane: velika tržišta oslanjaju se na održavanje obujma, dok manja zahtijevaju institucionalne i strukturne mjere.

Ključne riječi*: državne obveznice, likvidnost, veličina tržišta, pragovna regresija*

JEL klasifikacija*:E44, G12, G15, H63*

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