NICOLAUS COPERNICUS UNIVERSITY IN TORUŃ

Bulletin of Geography. Socio-economic Series, No. 71 (2026): 165-178
https://doi.org/10.12775/bgss-2026-0010

BULLETIN OF GEOGRAPHY. SOCIO–ECONOMIC SERIES

journal homepages:
https://apcz.umk.pl/BGSS/index
https://www.bulletinofgeography.umk.pl/

Capital at the core: Spatial inequalities in Polish corporate bonds

Paweł Węgrzyn[1, CDFM], **Michał Kruszka**[2, CDMR]

[1]*SGH Warsaw School of Economics*, Department of Economic Geography, Warsaw, Poland, e-mail: pwegrz@sgh.waw.pl (*corresponding author*), https://orcid.org/0000-0001-8963-2765; [2]*University of Warsaw,* Faculty of Management, Warsaw, Poland, e-mail: mkruszka@wz.uw.edu.pl, https://orcid.org/0000-0002-9138-7225

How to cite:
Węgrzyn, P., & Kruszka, M. (2026). Capital at the core: Spatial inequalities in Polish corporate bonds. *Bulletin of Geography. Socio-economic Series,* 71(71): 165-178. DOI: https://doi.org/10.12775/bgss-2026-0010

Abstract. This paper aims to determine whether the regional distribution of corporate bond issuance in Poland is driven by spatial interdependence or by local economic fundamentals. Using a comprehensive dataset of outstanding corporate bonds for year-end 2024 across 73 NUTS-3 regions, the study employs Moran's I statistics and regression models including Ordinary Least Squares (OLS) and Spatial Lag of X (SLX). Results reveal an extreme issuance concentration in the Warsaw region, accounting for 62% of the total. However, no significant spatial autocorrelation was detected, with neither Moran's I nor the SLX specification yielding significant evidence of spatial dependence. The strongest determinants of issuance activity were regional wealth (GDP *per capita*) and innovation capacity (number of filed inventions). By contrast, population density, the number of registered firms, and distance from Warsaw were statistically insignificant. These findings suggest that Poland's corporate bond market is primarily driven by local economic fundamentals, while spatial spillovers do not play a significant role.

Article details:
Received: 15 July 2025
Revised: 22 January 2026
Accepted: 18 February 2026

Key words:
bond market,
corporate bonds,
financial geography,
spatial analysis,
Poland

Contents:

1. Introduction

The development of the corporate bond market in Poland is a crucial aspect of the domestic financial system's functioning and the diversification of corporate financing sources. It can also be seen as a manifestation of the broader financialisation process, where corporate funding increasingly shifts from traditional bank-based financing towards market-based instruments (Bonizzi & Karwowski, 2024). The corporate finance literature identifies several factors that influence companies' decisions to issue bonds. The most important of these factors include the cost of capital and the efficiency and complexity of capital-rising procedures (Bondt, 2005; Rixtel et al., 2015; Tocelovska et al., 2018). Determinants of corporate bond financing also include the specific characteristics of these entities. For example, research consistently shows that larger firms are more likely to issue corporate bonds (Weyzig, 2014; Calomiris et al., 2019; Du, 2024), especially in foreign currencies (Maggiori et al., 2023). This tendency results from both the stringent requirements of the bond market (e.g., the need for adequate credibility, often confirmed by a rating) and the fixed costs of preparing the issue (prospectus, advisors, market organisation), which are disproportionately high for minor issues. Consequently, small companies frequently rely on bank financing rather than public debt markets (Duffee & Hördahl, 2019).

However, most existing studies focus primarily on financial and corporate determinants of bond issuance, largely neglecting the geographical contexts. Despite advancements in digital infrastructure suggesting geographic location should not significantly influence access to financial markets, empirical observations indicate persistent disparities. This paradox highlights the need for a more in-depth examination of regional financial ecosystems and their impact on corporate bond market dynamics. Spatial analyses of corporate bond issuance remain rare despite the fact that they can reveal critical regional variations and spatial dependencies that are difficult to capture through traditional financial methods (Butler, 2008; Francis et al., 2023).

Against this backdrop, this paper aims to analyse the spatial distribution of outstanding corporate bond value in Poland at the level of sub-regions (NUTS-3) and to identify regional determinants of such financial activities. The study consists of three specific objectives: (1) presenting the spatial concentration of bond issuance across sub-regions, with particular emphasis on the extent of dominance of the Warsaw region; (2) evaluating whether the data show spatial autocorrelation, specifically, whether issuance values observed in one region correlate statistically with those in neighbouring regions; (3) evaluating the relationship between the value of outstanding bond issuance and the economic characteristics of the regions, including an assessment of the significance of spatial spillover effects and their impact on issuance inequalities. An additional contribution of the study lies in the unique utilisation of data from the Register of Issuers' Obligations (RIO), which is rarely included in scientific studies on the bond market in Poland. One of the first attempts at using RIO data was provided by Martysz (2020), although without addressing spatial aspects of bond issuance. Therefore, this study addresses this identified research gap directly.

2. Literature review: Spatial dynamics of financial markets

2.1. Financial centres, spatial hierarchies and evolving network logic

Financial geography has traditionally conceptualised the spatial organisation of finance through the lens of core-periphery hierarchies, where financial activity, capital, and decision-making concentrate disproportionately in a few central cities (Kindleberger, 1974; Hryniewicz, 2014). Such models align with broader spatial-economic theories highlighting the uneven distribution of resources and power, often characterised by significant informational asymmetries favouring the core (Aviat & Coeurdacier, 2007). Empirical studies have historically confirmed the dominance of global financial centres like London or New York, underpinned by agglomeration economies that provide scale advantages, knowledge spillovers, and robust institutional infrastructure (Storper, 1997).

However, recent scholarship increasingly emphasises relational and network-based approaches, which challenge the notion of a single dominant core. Instead, financial geography is increasingly seen as a multi-nodal and interconnected network of cities (Coe et al., 2014). Studies such as those from the Globalisation and World Cities (GaWC) research group illustrate how multiple financial centres form complementary and competitive relationships, facilitating capital flows and knowledge diffusion across space. These networks integrate primary hubs (e.g., New York–London axis), secondary financial centres, and regional nodes into global financial circuits,

revealing a more nuanced spatial structure than traditional hierarchies suggest (Wójcik, 2018).

The gravity model - used in both physics and international economics as well - further complements network perspectives by demonstrating that financial interactions depend strongly on economic mass and diminish with distance due primarily to information asymmetries and transaction costs (Portes & Rey, 2005). Despite technological advances enabling instantaneous transactions, geographic proximity still significantly reduces informational frictions, underscoring why finance remains spatially sticky (Butler, 2008).

Thus, contemporary literature views the geography of finance as characterised by persistent hierarchies enriched by relational dynamics, where agglomeration economies coexist with multi-nodal network structures. These spatial logics simultaneously reinforce the dominance of key financial centres and allow for secondary centres to participate in wider capital market activities, raising critical questions regarding whether spatial concentration exacerbates regional inequalities or promotes beneficial diffusion to peripheral regions (Degl'Innocenti et al., 2018; Wei et al., 2024).

2.2. Mechanisms of spatial concentration: Infrastructure, agglomeration, and knowledge embeddedness

The pronounced spatial concentration of financial activity, including corporate bond issuance, stems from several reinforcing mechanisms identified within the literature. Institutional infrastructure plays a fundamental role, as major financial centres typically host essential facilities such as stock exchanges, clearing houses, central securities depositories, and regulatory bodies, creating structural advantages for these locations (Hashimoto & Wójcik, 2021). Kindleberger (1974) historically emphasised how early institutional support and regulatory clustering significantly contributed to financial centre development by reducing transaction costs, attracting skilled labour, and building trust among market participants. Such institutional embeddedness remains pivotal, creating high barriers for peripheral regions where comparable infrastructure and expertise are limited.

Alongside institutional infrastructure, agglomeration economies significantly enhance the attractiveness of established financial centres. Co-location of specialised financial services - such as investment banks, rating agencies, legal consultancies, and market analysts - generates tangible externalities, including labour market pooling and knowledge spillovers (Cook et al., 2007). These agglomerative advantages lower transaction costs, foster informal networks and encourage rapid diffusion of industry-specific knowledge and innovation. Even though urban concentration can incur costs such as congestion or high rents, the net benefits from agglomeration consistently outweigh these drawbacks, reinforcing the dominance of primary financial centres.

A crucial but less tangible mechanism underpinning spatial concentration is the embeddedness of tacit knowledge within dense social and professional networks. Corporate bond issuance, reliant on complex structuring and due diligence, depends heavily on trust and nuanced expertise exchange, which are most effectively transferred through face-to-face interactions and established relational ties (Francis et al., 2023). Physical proximity fosters reputational and relational capital, significantly reducing information asymmetry and enhancing investor confidence. Despite technological advancements enabling remote interactions, recent evidence suggests that high-value tacit knowledge exchanges still benefit disproportionately from physical co-location (Bratton & Wójcik, 2024).

Lastly, regional innovation capacity has emerged as an influential factor enabling broader capital market participation. Regions characterised by strong R&D activities, vibrant entrepreneurial ecosystems, and technological dynamism frequently produce companies with high growth potential that seek external market-based financing (Tocelovska et al., 2023). Such innovative environments tend to attract both investors and issuers, creating conditions conducive to bond market development. Although innovation alone does not guarantee successful capital market engagement, when coupled with strong institutional frameworks and financial infrastructure, it substantially lowers barriers to entry for regional firms.

Collectively, these mechanisms explain the persistent and uneven geographical distribution of financial activities, highlighting why a few well-endowed financial centres dominate bond markets while other regions face structural hurdles in achieving comparable market depth.

2.3. Empirical evidence on spatial concentration

Empirical evidence from a wide range of countries highlights pronounced spatial disparities in corporate bond issuance, consistently favouring economically advanced regions with stronger institutional

infrastructure and connectivity to financial networks. Research across developed economies demonstrates that regional economic strength - reflected primarily by higher GDP per capita and concentrations of larger, financially robust firms - strongly correlates with higher levels of bond issuance. For instance, studies of the Baltic region have shown that the most active corporate bond markets cluster around capital cities and major economic hubs, indicating a clear link between regional economic prosperity and institutional capacity (Tocelovska et al., 2018, 2023). Such findings underscore that regions hosting more substantial, creditworthy enterprises, supported by advanced financial infrastructures, tend to attract greater investor interest and exhibit increased issuance activity. The synergy between innovative business environments and robust financial infrastructures appears particularly decisive, enabling regions to achieve significant engagement with corporate bond markets.

Furthermore, empirical research consistently indicates that greater geographical distance from primary financial centres translates into tangible disadvantages in accessing corporate bond financing. Firms situated far from financial hubs encounter higher informational asymmetries, reduced investor familiarity, and, consequently, increased financing costs. Empirical evidence from the US bond market illustrates that peripheral firms, notably those located in rural or remote areas, typically pay higher yield spreads and face less favourable underwriting terms compared to comparable urban-based enterprises (Arena & Dewally, 2012; Francis et al., 2023). Despite advances in digital technology, proximity continues to offer informational advantages, reflecting the enduring spatial embeddedness of trust and relational networks vital to financial market operations. This pattern underscores a broader phenomenon identified globally as a 'big-city bias', whereby companies based in metropolitan areas consistently report fewer financial constraints compared to their counterparts in smaller towns or rural regions (Lee & Luca, 2019; Kärnä & Stephan, 2022).

In emerging markets, the spatial concentration of corporate bond issuance often appears even more pronounced. Empirical analyses highlight that primary financial centres in developing countries typically dominate corporate bond markets, as exemplified by Johannesburg in South Africa and São Paulo in Brazil (De Carvalho & Marques, 2020; Ahwireng-Obeng & Ahwireng-Obeng, 2022). Such concentration reflects not only the economic scale and institutional sophistication of these cities but also structural weaknesses - such as underdeveloped financial ecosystems, lack of credit ratings, and limited investor exposure - in peripheral regions. Consequently, spatial disparities in bond market access tend to be especially stark in developing economies, reinforcing a rigid core-periphery structure.

Overall, empirical literature consistently underscores persistent spatial unevenness in corporate bond market development. Regions characterised by economic prosperity, innovative capabilities, and strong institutional frameworks continue to dominate issuance activity, benefiting from proximity to major financial centres and the associated relational and informational advantages. Without targeted interventions, these spatial disparities are likely to persist, potentially exacerbating existing regional economic inequalities and limiting financial market development in peripheral areas.

3. Methods

3.1. Data and scope of the study

The analysis uses cross-sectional data on the value of outstanding corporate bonds from the Central Securities Depository (CSD) official Register of Issuers' Obligations (RIO) (as of the end of 2024), taking into account both public and private issues. The RIO was established following significant disturbances in the domestic corporate bond market, particularly due to the bankruptcy of GetBack, Poland's largest debt collection company, in 2018. This event involved defaulted bonds worth nearly PLN 2,9 billion, resulting in losses for over 9,000 investors. The RIO collects comprehensive data on all non-Treasury bonds issued in Poland, including bonds listed on Catalyst (WSE BondSpot) and private issues registered outside the CSD before RIO's establishment, with historical records subsequently supplemented into the register. This approach ensures a comprehensive and robust dataset of corporate bond issues generated by Polish companies. Thus, information on outstanding corporate bonds as of 31 December 2024 was extracted from the RIO database. Mortgage bonds and issues by local government units and other public financial institutions (e.g., Polish Development Bank and Polish Development Fund) were explicitly excluded to maintain a clear focus solely on corporate bonds. In addition, municipal and communal companies were excluded, so that the analysis covers only strictly commercial enterprises.

Using a unique Legal Entity Identifier (LEI) code, data from RIO was matched with data from the ORBIS database (Bureau van Dijk's Orbis global company database), allowing for the extraction of

the official registered office address of each issuing company. These addresses were geocoded and assigned to the relevant NUTS-3 units (so-called sub-regions). The spatial analysis adopted an administrative division corresponding to the NUTS-3 classification, covering all 73 sub-regions currently recognised in Poland.

In the next step, data on the nominal value of outstanding bonds was aggregated at the level of each NUTS-3 region. To link this data to regional characteristics, selected macroeconomic and demographic variables available at the sub-regional level were included: population density, GDP per capita, number of corporates registered in each region, and the number of inventions filed with the patent office. Throughout this study, the term "corporates" refers specifically to companies whose legal form under Polish law (limited liability companies, joint-stock companies, and simple joint-stock companies) allows them to issue bonds. All regional macroeconomic data was sourced from the Statistics Poland (GUS). It should be noted that while the bond data is for 2024, the most recently available regional macroeconomic data from GUS at the time of analysis pertains to the year 2022. Given the slow-moving nature of these indicators, the 2022 figures are considered a robust proxy for the economic conditions influencing issuance decisions.

Additionally, a variable corresponding to the distance of a given region (in kilometres) from Warsaw (DIST_WAW) was included in the study. This distance was calculated using the geometric centroid of each NUTS-3 region and the reference point in the geographical centre of Warsaw (52.23185°N, 21.01178°E). The coordinates of the centroids were determined based on the official NUTS-3 administrative boundary data. The Haversine formula was applied to compute great-circle distances between the centroids of NUTS-3 regions and Warsaw, thereby accounting for the Earth's curvature. In R, this was implemented using the distHaversine() function from the geosphere package (Hijmans, 2023), which returns distances in metres. Results were converted into kilometres. The obtained variable was subsequently transformed using the logarithmic function log(1 + DIST_WAW) to mitigate the strong rightward skewness of the distribution and to allow the regression coefficient to be interpreted as an approximate elasticity with respect to percentage changes in distance. Based on the literature review presented earlier, it was hypothesised that regions with better economic parameters (higher population density, higher GDP per capita, more registered corporates, and higher innovation activity measured by filed inventions) would exhibit higher bond market activity while greater distance from Warsaw would negatively influence the value of bond issuance.

3.2. Measures of concentration and spatial autocorrelation

After an exploratory analysis of the data to determine the overall degree of regional concentration of bond issuance, the Gini coefficient was calculated to quantify the level of inequality in the distribution of bond issuance values by region (a Gini coefficient of 0 indicates perfectly even dispersion of issuance values, whereas 1 indicates complete concentration in a single region). Additionally, a map was prepared to visualise the regional distribution of outstanding corporate bonds at the end of 2024, categorised by the location of the issuer's registered office within the relevant NUTS-3 sub-region. This map illustrates the sum of issue values (in millions of PLN) per region, allowing for a visual assessment of regional disparities in corporate bond issuance.

The next stage of the analysis was to assess the presence of spatial autocorrelation in bond issuance formally. For this purpose, the global Moran's I statistic was used to determine whether bond issuance values in one region exhibited a statistical correlation with values in neighbouring regions. A matrix of spatial weights was constructed using the queen contiguity criterion, which defines two regions as neighbours if they share either a common boundary or a vertex. This specification was chosen because it provides a more inclusive definition of spatial proximity compared to rook contiguity and is widely applied in studies involving irregular administrative units (Anselin, 1988). The global Moran's I statistic was calculated following the original formulation by Moran (1950):

$$I = \frac{n}{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}} \frac{\sum_{i=1}^{n}\sum_{j=1}^{n} w_{ij}(x_i-\bar{x})(x_j-\bar{x})}{\sum_{i=1}^{n}(x_i-\bar{x})^2}$$

where:

- x_i ix_j denote bond issue values in regions i and j,
- $\bar{x}$ is the average value of bond issues across all regions,
- w_{ij} are elements of the spatial weighting matrix indicating the neighbourhood of the regions (a value of 1 indicates neighbourhood and 0 no neighbourhood),
- n is the total number of regions analysed.

The value of Moran's I statistic approximately falls within the range from -1 (negative spatial

autocorrelation, indicating that regions with different bond issuance values tend to be adjacent) through 0 (absence of significant spatial autocorrelation) to +1 (positive spatial autocorrelation, indicating that regions with similar bond issuance values tend to cluster together). However, the exact range of Moran's measure depends on the spatial structure of the neighbourhood defined in the weight matrix W (de Jong et al., 1984; Boots & Tiefelsdorf, 2000). The statistical significance of Moran's I was assessed using the permutation method, with 999 permutations, with inference based directly on the simulated p-values.

3.3. Spatial econometric modelling

The final element of the methodology was to model the relationship between the scale of bond issuance and regional characteristics while explicitly considering possible spatial effects. Initially, a classical OLS (ordinary least squares) model was estimated. The dependent variable (Y) was the total nominal value of outstanding corporate bonds as of the end of 2024 for each region. The explanatory variables (X) included:

- Regional economic size, measured by (1) population density and (2) GDP per capita (regions with higher population density and higher wealth levels were hypothesised to exhibit greater bond issuance activity).
- Number of corporates registered in the region (specifically, companies legally authorised to issue bonds).
- Regional innovation capacity is measured by the number of inventions filed with the Patent Office (capturing activities aimed at obtaining legal protection for new technologies or innovations).
- Distance to the financial centre, represented by the logarithmic transformation of the distance from Warsaw (in kilometres).

The explanatory variables were transformed using natural logarithms to reduce skewness and to harmonise their scales, which facilitated comparability of coefficients across variables. Diagnostic tests were then performed to assess spatial autocorrelation in the OLS residuals. Specifically, the global Moran's I statistic and a set of Lagrange Multiplier (LM) and robust LM tests were applied to determine whether a spatial econometric specification was required. If the diagnostics indicated significant endogenous spatial dependence, appropriate models such as the Spatial Autoregressive Model (SAR), the Spatial Error Model (SEM), or the Spatial Durbin Model (SDM) would be considered. In the absence of such evidence, an alternative specification was estimated to account for potential exogenous spillovers in the covariates: the Spatial Lag of X (SLX) model. The SLX incorporates spatially lagged explanatory variables and can formally be expressed as follows:

$$Y = \alpha + X\beta + WX\theta + \varepsilon,$$

Where WX denotes the matrix of spatially lagged explanatory variables, and θ captures their spillover effects from neighbouring regions. Unlike models with endogenous spatial lags of the dependent variable, the SLX focuses solely on exogenous spillover effects in the covariates.

Furthermore, all analyses and visualisations were conducted using the statistical software R. Spatial data were handled with *sf* package (Pebesma, 2018); spatial weights, Moran's I and LM diagnostics were computed with *spdep* (Bivand et al., 2025), the SLX model was estimated with spatialreg (Bivand & Piras, 2015), with regression diagnostics via lmtest (Hothorn et al., 2022) and car (Fox et al., 2024).

4. Results

An analysis of the distribution of corporate bond outstanding values across 73 sub-regions confirmed that the Polish market is extremely spatially concentrated. The dominance of the Warsaw Capital sub-region is particularly striking, as it accounted for nearly 62% of the value of all outstanding corporate bonds at the end of 2024. In comparison, no other single sub-region reached a market share exceeding 5%. Warsaw's share is, therefore, many times greater than that of the second-ranked subregion Lubelski, which accounted for only 4.9% of total bond issuance—nearly ten times less than the capital. Most other regions contributed only marginally to the overall value of bond issuance, with many peripheral areas recording only token issues, representing less than 0.01% of the total outstanding corporate bond issuance. The breakdown of bond issuance values for the largest regions is presented in Table 1.

The Gini coefficient for the distribution of bond issuance values across regions is approximately 0.864, indicating a level of inequality that is exceptionally high, even compared to other economic phenomena. To put this into perspective, this level of regional concentration significantly exceeds typical measures of economic inequality, such as income distribution. For instance, the Gini coefficient for income inequality in Poland stood at 0.300 in 2024, slightly

Table 1. Structure of the face value of outstanding corporate bonds in Poland as of 31 December 2024 by NUTS3 sub-region

No	NUTS3	Region name	Bonds outstanding value [mln PLN]	[%]
1	PL911	Miasto Warszawa	88 231	62,0%
2	PL814	Lubelski	7 033	4,9%
3	PL514	Miasto Wrocław	6 640	4,7%
4	PL415	Miasto Poznań	6 406	4,5%
5	PL923	Płocki	6 273	4,4%
6	PL22A	Katowicki	5 614	3,9%
7	PL516	Legnicko-Głogowski	2 650	1,9%
8	PL432	Zielonogórski	2 640	1,9%
9	PL633	Trójmiejski	2 463	1,7%
10	PL913	Warszawski Zachodni	2 222	1,6%
11	PL721	Kielecki	1 687	1,2%
12	PL213	Miasto Kraków	1 240	0,9%
13	PL244	Częstochowski	1 150	0,8%
14	PL418	Poznański	991	0,7%
15	Others (59 regions)		7 099	5,0%
Total			**142 338**	**100%**

Source: own elaboration

decreasing from 0.314 in 2023. Such a pronounced disparity underscores that access to the corporate bond market is geographically concentrated far beyond what demographic or broader economic indicators would suggest. Consequently, a small number of urban centres dominate nearly the entire bond market, while vast areas of the country remain largely excluded from participation.

These results are clearly illustrated in the reference map (Fig.1), where the Warsaw region distinctly dominates, exhibiting by far the highest bond outstanding values, while activity remains negligible in most regions distant from the capital. Spatial inequalities in bond outstanding value are, therefore, extraordinarily pronounced - the concentration of debt capital in Warsaw is greater than, for example, the regional concentration of population density or GDP observed anywhere else in Poland. Despite the strong dominance of this single financial centre, it is worth investigating whether more nuanced spatial patterns exist within the distribution of bond issuance activity, such as the localised clustering of regions with similar outstanding values.

However, Moran's global I statistic calculated for 2024 was slightly negative ($I = -0.071$) and statistically insignificant ($p = 0.75$), indicating no substantial spatial autocorrelation. This conclusion is further confirmed by the Lagrange Multiplier diagnostics, where both LM-lag ($p = 0.24$) and LM-error ($p = 0.42$), as well as their robust counterparts ($p = 0.36$ and $p = 0.75$), were statistically insignificant. In other words, high or low regional issuance activity does not form extensive clusters, suggesting that interdependence does not arise from simple mimicry between neighbouring regions. Consequently, there was no statistical basis for estimating SAR, SEM, or SDM models. Instead, the analysis proceeds by estimating an Ordinary Least Squares (OLS) specification and, as a robustness check, an alternative Spatial Lag of X (SLX) model. The SLX allows for testing potential spillover effects of neighbouring regions' characteristics, even in the absence of global autocorrelation.

To identify the factors driving regional variation in corporate bond issuance in Poland, both the OLS and the SLX estimations were performed. The results are presented in Table 2.

The results of both models indicate that the key determinant of corporate bond issuance activity in individual regions is the level of economic development, as measured by GDP per capita. Both models consistently identify regional wealth as the most influential factor: in the OLS model ($\beta = 3.744$, $p < 0.001$) and in the SLX model ($\beta = 3.878$, $p < 0.001$). The second statistically significant determinant is the region's level of innovation, represented by the number of patent applications filed. In both models, this effect is positive and statistically significant (OLS: $\beta = 0.468$, $p = 0.0086$; SLX: $\beta = 0.424$, $p = 0.025$). These results confirm that regions with higher

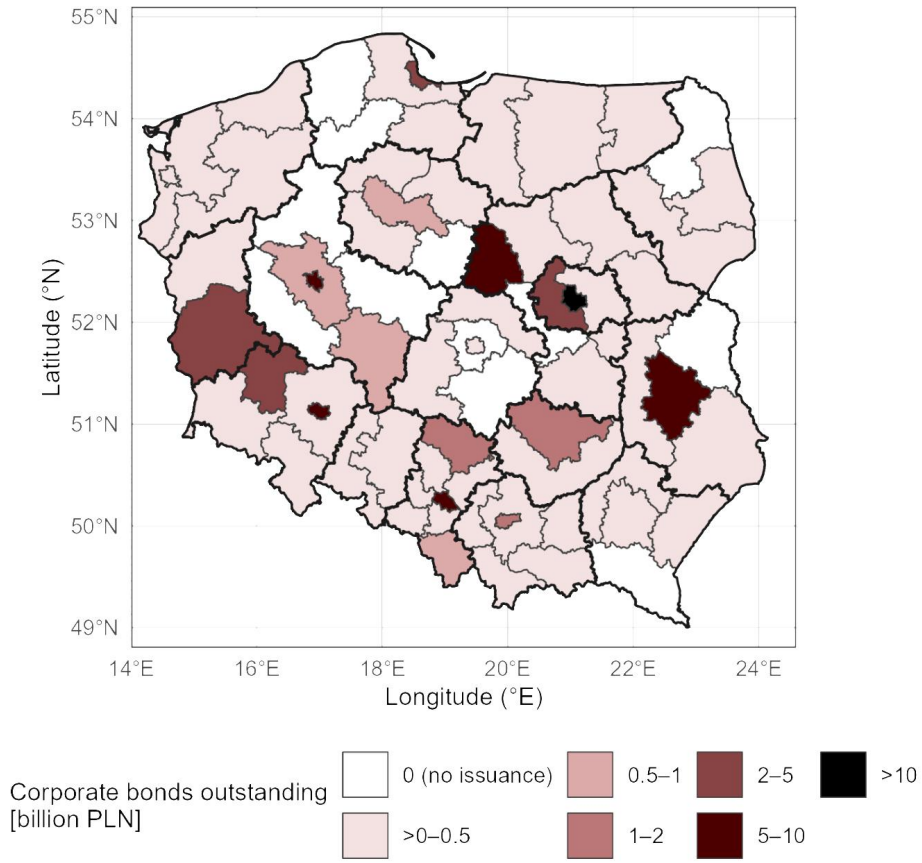

Fig. 1. Graphical presentation of the value of outstanding corporate bonds in Poland as of 31 December 2024 by NUTS3 sub-region
Source: own elaboration in R software, package ggplot2 (Wickham, 2016)

Table 2. Regression Results: Comparison of OLS and SLX models

Variable	OLS estimate	OLS p-value	SLX estimate	SLX p-value
Intercept	-24.393	0.0172*	-12.630	0.4894
GDP per capita	3.744	<0.001***	3.878	<0.001***
Population density	-0.236	0.4346	-0.252	0.4813
Corporates	0.203	0.6316	0.298	0.5169
Inventions	0.468	0.0086**	0.424	0.0250*
Distance to Warsaw	-0.170	0.4896	-0.358	0.7004
Spatial lag [GDP per capita]	-	-	-0.948	0.5828
Spatial lag [Population density]	-	-	0.246	0.6550
Spatial lag [Corporates]	-	-	-0.387	0.6150
Spatial lag [Inventions]	-	-	0.044	0.9085
Spatial lag [Distance to Warsaw]	-	-	0.219	0.8534

Note: ***: $p < 0.001$, **: $p < 0.01$, *: $p < 0.05$.
Source: own elaboration

innovation levels, characterised by increased R&D activity, have greater demand for external capital, including corporate bond issuance.

The remaining variables analysed – population density, number of corporates, and distance from Warsaw - did not exhibit statistical significance in either model. The insignificance of the distance variable, measuring proximity to Warsaw as Poland's primary financial centre, is particularly noteworthy. In the OLS model, the coefficient for this variable was -0.170 (p = 0. 4896), and in the SLX model, it was -0.358 (p = 0.7004), suggesting that geographical distance alone does not substantially affect regional bond issuance activities.

To assess the statistical validity and robustness of both the classical OLS and the SLX model, diagnostic tests specific to each model type were performed. For the OLS model, standard regression checks were conducted, including residual normality (Shapiro–Wilk), homoscedasticity (Breusch–Pagan), and residual spatial autocorrelation (global Moran's I). For the SLX model, we tested the joint significance of the lagged regressors using a Wald test, examined residual spatial autocorrelation with Moran's I, and compared information criteria (AIC) with the OLS benchmark.

Diagnostic results presented in Table 3 confirm that the classical OLS model meets all fundamental regression assumptions, including residual normality (Shapiro-Wilk, p = 0.35), homoscedasticity (Breusch-Pagan, p = 0.29), and critically, the absence of significant spatial autocorrelation in residuals (Moran's I = -0.093, p = 0.75). Additionally, the overall significance of the OLS model is strongly supported by the F-test (F=19.6, p < 0.001), demonstrating robust explanatory power. The lack of spatial autocorrelation in the OLS residuals indicates that the spatial structure of the data is adequately captured by the basic linear specification, implying no inherent necessity for more complex spatial econometric methods. Nevertheless, for the SLX specification, diagnostics similarly indicate no significant residual spatial autocorrelation (Moran's I = –0.096, p = 0.83). However, the joint Wald test for the spatially lagged covariates (W·X) was clearly insignificant (p = 0.94), confirming that contextual spillover effects are weak. Moreover, the Akaike Information Criterion (AIC) does not favour the SLX model (AIC = 258.6) over the OLS benchmark (AIC = 250.1), suggesting no improvement in model fit. Taken together, these results indicate that the classical OLS model remains preferable due to its interpretative clarity, statistical robustness, and the absence of significant residual spatial dependence.

5. Discussion

The empirical findings confirm that the corporate bond market in Poland has a highly spatially concentrated structure. The marked dominance of Warsaw as the primary issuance centre aligns with the classical framework of financial geography, wherein capital market activities commonly centralise in major financial hubs, frequently in the capital city. Kindleberger (1974) had already observed that financial systems organise themselves hierarchically, with a single dominant centre acting as the 'keystone' of the entire structure. Similar phenomena occur internationally; for instance, in the euro area, bond issuance is significantly concentrated in Paris—one of Europe's leading financial centres (Consulat Général de France à Houston, 2013). The strong concentration of bond issuance in the Polish capital is theoretically supported by financial agglomeration effects. Warsaw brings together financial institutions, institutional investors, and highly specialised financial experts, creating favourable conditions for companies located within its proximity to access the bond market. Research on geographical variation in the cost of debt capital confirms that firms based

Table 3. Diagnostic comparison of OLS and SLX models

Diagnostic criterion	OLS model	SLX model
Residual Normality (Shapiro-Wilk)	W = 0.980, p = 0.35	W = 0.980, p = 0.34
Homoscedasticity (Breusch-Pagan)	BP = 6.19, p = 0.29	BP = 12.5, p = 0.25
Residual Spatial Autocorrelation (Moran's I)	I = -0.071, p = 0.75	I = -0.096, p = 0.83
Spatial dependence (Wald test for W·X)	–	F = 0.26, p = 0.94
F-test – overall model significance (OLS)	F = 19.6, p <0.001***	–
Adjusted R^2	0.578	–
Akaike Information Criterion (AIC)	250.08	258.57

Note: ***: p < 0.001, **: p < 0.01, *:p < 0.05
Source: own elaboration

in large metropolitan areas typically obtain more favourable financing terms, such as lower margins on bond issues, due to their proximity to numerous investors and financial intermediaries (Francis et al., 2023). This finding suggests that financial centres maintain significant informational and networking advantages compared to peripheral regions.

Conversely, the lack of significant spatial autocorrelation in bond outstanding value (reflected by a low and statistically insignificant Moran's I) warrants further discussion. This result indicates that intense issuance activity in one region does not significantly influence adjacent regions, contrasting with literature demonstrating clear regional financial clustering elsewhere. For instance, existing research from China has identified positive spatial autocorrelation of regional financial efficiency, manifested through spatial clustering of high financial development across neighbouring provinces (Chang et al., 2022). In Poland, however, such regional clustering of bond issuance activity was not observed. Outside of Warsaw, Polish regions fail to form coherent clusters, instead showing a pattern characterised by a single dominant financial centre surrounded by a largely dispersed peripheral landscape. This asymmetry can be interpreted in the context of financial centre theory and the 'centre-periphery effect' (Hryniewicz, 2014; Lux, 2015). A financial centre (in this case, Warsaw) attracts a significant amount of market activity, while other regional centres do not demonstrate reciprocal or complementary interactions. The geography of finance literature consistently highlights that peripheral regions are often subordinated to dominant financial hubs (Węgrzyn, 2025). Our results (indicating the absence of spatial autocorrelation) are consistent with this interpretation: the Polish periphery does not form its own 'mini-centres' of bond issuance but rather issues bonds independently of issuance activity levels in neighbouring regions. This can also be explained by the fact that the corporate bond market is relatively narrow and selective - only a few regions (primarily Warsaw and a handful of major urban centres) meet conditions conducive to issuance, thus precluding a continuous spatial diffusion of financial activity.

Additionally, existing literature points out that modern telecommunications infrastructure and the centralisation of financial markets have enabled firms located outside primary financial centres to remotely access financial services, potentially reducing the significance of geographical proximity. However, it is worth noting that research on SME financing continues to identify locational advantages for large cities; even in the digital age, businesses far from financial centres still experience limitations in accessing finance (Kärnä & Stephan, 2022).

In this context, our finding - the insignificant impact of distance from Warsaw - should be interpreted cautiously. This could be because corporate bond issuance is predominantly pursued by larger, financially mature firms capable of overcoming geographical barriers through established financial networks and relationships. Such companies typically rely on Warsaw-based financial intermediaries (e.g., major banks and investment firms), irrespective of the physical location of their headquarters or operations, thus mitigating the importance of geographic proximity. Consequently, while the 'distance barrier' theory remains relevant in numerous financial contexts (e.g., cost of capital or SME finance access) (Butler, 2008; Francis et al., 2023), in the case of the Polish corporate bond market, geographical distance from the primary financial centre did not emerge as a significant constraint on bond issuance activity.

With regard to economic determinants, the analysis demonstrated that regional wealth (as measured by GDP per capita) and innovation (as represented by the number of patent applications) are key factors influencing corporate bond issuance. This finding is strongly corroborated by international literature, which consistently shows that economically developed and wealthier regions tend to have larger and more active corporate bond markets. For instance, a study by Tocelovska et al. (2018) on the Latvian market revealed that higher GDP per capita significantly enhances corporate bond issuance activity. A more prosperous region typically features larger companies, more robust financial infrastructure, and more sophisticated investor demand, collectively increasing the propensity of firms to issue debt securities. Regional innovation operates similarly: regions characterised by higher levels of R&D activity, patent filings, and a dynamic technology sector typically host more competitive firms, which in turn are more likely to seek capital market financing. While existing literature offers limited direct evidence explicitly linking regional innovation indicators to corporate bond issuance, broader insights from the geography of innovation and finance provide support for this relationship. Regions identified as technological “growth poles” generally attract investment capital (Brown et al., 2009; Chen et al., 2010). Consequently, a region's high level of innovation can serve as an indirect indicator of the presence of firms possessing strong growth potential and reputational characteristics (such as sufficient operational scale, financial transparency, and robust creditworthiness), thereby meeting key criteria for successful bond issuance.

In contrast to the above factors, the region's population density and the number of corporates registered proved statistically insignificant. Initially, this result might appear counterintuitive, as a high population density or a high concentration of firms would typically imply a larger pool of potential issuers. However, this finding aligns with observations from other studies, suggesting that bond market development relies less on the sheer quantity of firms and more significantly on their quality, maturity, and structural characteristics. Corporate bond markets are generally dominated by larger, financially sound companies that possess sufficient scale and creditworthiness (Du, 2024; Thia & Kong, 2024). Thus, even in densely populated regions with a large number of incorporated entities, bond issuance activity may remain limited or involve smaller transaction volumes if the region lacks prominent, financially robust corporations capable of consistently issuing significant bonds.

It is worth emphasising that the study is subject to certain limitations. First, the analysis relies on cross-sectional data from a single year (2024), limiting its ability to adequately capture the dynamics and evolution of the corporate bond market in Poland. A more comprehensive understanding would necessitate analysis over an extended period, allowing for the identification of long-term trends and shifts related to cyclical economic factors, such as monetary policy changes, phases of the business cycle, or evolving market conditions. Indeed, existing economic literature suggests that bond markets often experience substantial fluctuations linked to macroeconomic conditions, including interest rates and overall economic health (Du, 2024; Thia & Kong, 2024). The second major limitation is the absence of an in-depth analysis of the bond market's demand side, specifically the structural characteristics and investment preferences of bond investors. The geographical aspects of corporate bond markets encompass not only issuer locations but also investor locations and behaviours, which may be influenced by local investment preferences, institutional policies, information accessibility, or varying degrees of risk aversion (Francis et al., 2023).

Additionally, a promising direction for further research would be to conduct a comparative spatial analysis of the Polish bond market alongside other Central and Eastern European (CEE) countries. Future studies could investigate whether comparable patterns of bond issuance concentration exist in regional financial hubs such as Prague, Bratislava, or Budapest. Such comparative research would place the Polish case within a broader European context, clarifying whether the observed spatial phenomena reflect unique national circumstances or align with broader regional trends characterising financial markets in the CEE region.

6. Conclusions

A spatial analysis of corporate bond issuance in Poland has highlighted significant regional disparities in the development of the domestic capital market, characterised by an exceptionally strong concentration of financial activity in Warsaw. The capital region accounts for approximately 62% of the total value of outstanding corporate bonds, confirming its central position as the dominant financial hub in the country. The results align with classical financial geography theories, clearly reflecting a spatial hierarchy in capital markets, with a single dominant metropolitan centre surrounded by significantly weaker peripheral regions.

Despite this marked concentration, the analysis did not identify statistically significant spatial autocorrelation effects, indicating an absence of regional clusters of issuance activity outside Warsaw. This finding implies that high issuance levels in the capital region do not lead to increased corporate bond issuance in adjacent or nearby regions. The key determinants of regional corporate bond issuance identified were regional economic wealth (GDP per capita) and innovation capacity (number of patent filings). Conversely, factors such as population density, the number of corporates legally authorised to issue bonds, and geographical distance from Warsaw did not exhibit statistical significance. This pattern highlights the predominance of local economic and technological foundations over purely spatial considerations in determining bond market activity.

The results have substantial implications for economic and regional policy. To achieve greater geographic diversification of the corporate bond market and promote balanced economic development, it is essential to strategically invest in regional economic growth and innovation. This should be accompanied by targeted measures facilitating access to capital market opportunities for firms located outside primary financial centres. Without such interventions, the existing tendency towards financial centralisation may persist, further reinforcing Warsaw's competitive advantage as the dominant financial hub while leaving regional economic potential underutilised and perpetuating geographic disparities across Poland.

References.

Ahwireng-Obeng, A.S., & Ahwireng-Obeng, F. (2022). Corporate Bond Issuance Behaviour in African Emerging Markets. *Journal of African Business*, 23(1): 126–145. https://doi.org/10.1080/15228916.2020.1826853

Anselin, L. (1988). *Spatial Econometrics: Methods and Models* (Vol. 4). Springer Netherlands. https://doi.org/10.1007/978-94-015-7799-1

Arena, M.P., & Dewally, M. (2012). Firm location and corporate debt. *Journal of Banking & Finance*, 36(4): 1079–1092. https://doi.org/10.1016/j.jbankfin.2011.11.003

Aviat, A., & Coeurdacier, N. (2007). The geography of trade in goods and asset holdings. *Journal of International Economics*, 71(1): 22–51.

Bivand, R., Altman, M., Anselin, L., Assunção, R., Bera, A., Berke, O., Blanchet, F.G., Carvalho, M., Christensen, B., Chun, Y., Dormann, C., Dray, S., Dunnington, D., Gómez-Rubio, V., Koley, M., Kossowski, T., Krainski, E., Legendre, P., Lewin-Koh, N., … Yu, D. (2025). *spdep: Spatial Dependence: Weighting Schemes, Statistics* (Version 1.4-1). Computer software. Available at: https://cran.r-project.org/web/packages/spdep/index.html

Bivand, R., & Piras, G. (2015). Comparing Implementations of Estimation Methods for Spatial Econometrics. *Journal of Statistical Software*, 63: 1–36. https://doi.org/10.18637/jss.v063.i18

Bondt, G.D. (2005). Determinants of corporate debt securities in the Euro area. *The European Journal of Finance*, 11(6): 493–509. https://doi.org/10.1080/1351847042000255661

Bonizzi, B., & Karwowski, E. (2024). Commonality without convergence: An analytical framework Accounting for variegated financialisation in emerging economies. *Competition & Change*, 28(2): 293–317. https://doi.org/10.1177/10245294231209276

Boots, B., & Tiefelsdorf, M. (2000). Global and local spatial autocorrelation in bounded regular tessellations. *Journal of Geographical Systems*, 2(4): 319–348. https://doi.org/10.1007/PL00011461

Bratton, W., & Wójcik, D. (2024). Acute proximity and the acquisition of specialised financial knowledge: Evidence from sell-side equity research and the impact of the COVID-19 pandemic. *Finance and Space*, 1(1): 104–120. https://doi.org/10.1080/2833115X.2024.2315983

Brown, J.R., Fazzari, S.M., & Petersen, B.C. (2009). Financing Innovation and Growth: Cash Flow, External Equity, and the 1990s R&D Boom. *The Journal of Finance*, 64(1): 151–185. https://doi.org/10.1111/j.1540-6261.2008.01431.x

Butler, A.W. (2008). Distance Still Matters: Evidence from Municipal Bond Underwriting. *Review of Financial Studies*, 21(2): 763–784. https://doi.org/10.1093/rfs/hhn002

Calomiris, C.W., Larrain, M., Schmukler, S.L., & Williams, T. (2019). *Search for Yield in Large International Corporate Bonds: Investor Behavior and Firm Responses* (Working Paper No. 25979). National Bureau of Economic Research. https://doi.org/10.3386/w25979

Chang, K., Li, Z., & Long, Y. (2022). Spatial Spillover Transmission Effects of Financial Development on Economic-Zone Financial Efficiency in China. *Discrete Dynamics in Nature and Society*, 2022(1): 6183764. https://doi.org/10.1155/2022/6183764.

Chen, H., Gompers, P., Kovner, A., & Lerner, J. (2010). Buy local? The geography of venture capital. *Journal of Urban Economics*, 67(1): 90–102. https://doi.org/10.1016/j.jue.2009.09.013

Coe, N.M., Lai, K.P.Y., & Wójcik, D. (2014). Integrating Finance into Global Production Networks. *Regional Studies*, 48(5): 761–777. https://doi.org/10.1080/00343404.2014.886772

Consulat Général de France à Houston. (2013). *Paris, the Euro Area's leading financial centre*. Consulat Général de France à Houston. Available at: https://houston.consulfrance.org/paris-the-euro-area-s-leading-financial-centre

Cook, G.A.S., Pandit, N.R., Beaverstock, J.V., Taylor, P.J., & Pain, K. (2007). The Role of Location in Knowledge Creation and Diffusion: Evidence of Centripetal and Centrifugal Forces in the City of London Financial Services Agglomeration. *Environment and Planning A: Economy and Space*, 39(6): 1325–1345. https://doi.org/10.1068/a37380

De Carvalho, A., & Marques, F. (2020). The Microstructure of the Brazilian Market for Corporate Bonds. *Review of Business Management*, 22: 482–500. https://doi.org/10.7819/rbgn.v22i0.4061

de Jong, P., Sprenger, C., & van Veen, F. (1984). On Extreme Values of Moran's I and Geary's c. *Ge-*

ographical Analysis, 16(1): 17–24. https://doi.org/10.1111/j.1538-4632.1984.tb00797.x

Degl'Innocenti, M., Matousek, R., & Tzeremes, N.G. (2018). Financial centres' competitiveness and economic convergence: Evidence from the European Union regions. *Environment and Planning A: Economy and Space*, 50(1): 133–156. https://doi.org/10.1177/0308518X17740894

Du, X. (2024). The Bond Market: A Pillar of Risk Management and Economic Stability. *Highlights in Business, Economics and Management*, 41: 354–363. https://doi.org/10.54097/wwcmfh44

Duffee, G., & Hördahl, P. (2019). Corporate bond use in Asia and the United States. *BIS Papers Chapters*, 102: 97–107.

Fox, J., Weisberg, S., Price, B., Adler, D., Bates, D., Baud-Bovy, G., Bolker, B., Ellison, S., Firth, D., Friendly, M., Gorjanc, G., Graves, S., Heiberger, R., Krivitsky, P., Laboissiere, R., Maechler, M., Monette, G., Murdoch, D., Nilsson, H., … R-Core. (2024). *car: Companion to Applied Regression* (Version 3.1-3) .Computer software. Available at: https://cran.r-project.org/web/packages/car/index.html

Francis, B., Hasan, I., & Waisman, M. (2023). The geography of information: Evidence from the public debt market. *Journal of Economic Geography*, 23(1): 91–138. https://doi.org/10.1093/jeg/lbac002

Hashimoto, T., & Wójcik, D. (2021). The geography of financial and business services in Poland: Stable concentration and a growing division of labour. *European Urban and Regional Studies*, 28(2): 85–91. https://doi.org/10.1177/0969776420943664

Hijmans, R. J. (2023). *Geosphere: Spherical Trigonometry* (Version version 1.5-18) R; R package. Available at: https://CRAN.R-project.org/package=geosphere

Hothorn, T., Zeileis, A., Farebrother (pan.f): R. W., Cummins (pan.f): C., Millo, G., & Mitchell, D. (2022). *lmtest: Testing Linear Regression Models* (Version 0.9-40). Computer software. Available at: https://cran.r-project.org/web/packages/lmtest/index.html

Hryniewicz, J. T. (2014). Core-Periphery – An Old Theory in New Times. *European Political Science*, 13(3): 235–250. https://doi.org/10.1057/eps.2014.5

Kärnä, A., & Stephan, A. (2022). Do firms in rural regions lack access to credit? Local variation in small business loans and firm growth. *Regional Studies*, *56*(11): 1919–1933. https://doi.org/10.1080/00343404.2021.2016681

Kindleberger, C.P. (1974). *The Formation of Financial Centers: A Study in Comparative Economic History* (First Edition). Princeton University Press.

Lee, N., & Luca, D. (2019). The big-city bias in access to finance: Evidence from firm perceptions in almost 100 countries. *Journal of Economic Geography*, 19(1): 199–224. https://doi.org/10.1093/jeg/lbx047

Lux, T. (2015). Emergence of a core-periphery structure in a simple dynamic model of the interbank market. *Journal of Economic Dynamics and Control*, 52: A11–A23. https://doi.org/10.1016/j.jedc.2014.09.038

Maggiori, M., Neiman, B., & Schreger, J. (2023). *Corporate Debt Structure with Home and International Currency Bias* (SSRN Scholarly Paper 4645063). Social Science Research Network. Available at: https://papers.ssrn.com/abstract=4645063

Martysz, C.B. (2020). Polski rynek obligacji nieskarbowych—Nowe zasady rejestracji obligacji oraz analiza rejestru zobowiązań emitentów (Polish non-treasury bond market—New rules for bond registration and analysis of the register of issuers' liabilities – in Polish). *Journal of Finance and Financial Law*, 3(27): 91–107.

Moran, P.A.P. (1950). Notes on continuous stochastic phenomena. *Biometrika*, 37(1–2): 17–23. https://doi.org/10.1093/biomet/37.1-2.17

Pebesma, E. (2018). Simple features for r: Standardized support for spatial vector data. *The R Journal*, 10(1): 439–446.

Portes, R., & Rey, H. (2005). The determinants of cross-border equity flows. *Journal of International Economics*, 65(2): 269–296. https://doi.org/10.1016/j.jinteco.2004.05.002

Rixtel, A.V., Romo, L., & Yang, J. (2015). *The Determinants of Long-Term Debt Issuance by European Banks: Evidence of Two Crises* (SSRN Scholarly Paper 2668175). Social Science Research Network. Available at: https://papers.ssrn.com/abstract=2668175

Storper, M. (1997). *The regional world: Territorial development in a global economy*. Guilford Press.

Thia, J.P., & Kong, X. (2024). Firms' Bond Market Access and Impact on Bank Borrowing Costs. *Journal of Financial Services Research,* 68(1): 51-74. https://doi.org/10.1007/s10693-024-00424-y

Tocelovska, N., Sloka, B., & Arfejevs, I. (2018). Determinants of the Development of the Corporate Bond Market in Latvia. *European Integration Studies*, 12: 12. https://doi.org/10.5755/j01.eis.0.12.21875

Tocelovska, N., Vainovskis, O., & Lenerts, T. (2023). Going Global or Staying Local: Determinants of Domestic and International Corporate Bond Issues in the Baltics. *European Integration Studies*, 1(17): 141–152. https://doi.org/10.5755/j01.eis.1.17.34041

Węgrzyn, P. (2025). Towards understanding financial geography: A systematic literature review. *Finance and Space*, 2(1): 23–41. https://doi.org/10.1080/2833115X.2024.2445514

Wei, Y., Wang, M., Wei, X., Yuan, F., Fan, J., & Ba, S. (2024). Spatial patterns and influencing factors of financial agglomeration in Guangdong-Hong Kong-Macao Greater Bay Area. *PLOS ONE*, 19(8): e0306301. https://doi.org/10.1371/journal.pone.0306301

Weyzig, F. (2014). The Capital Structure of Large Firms and the Use of Dutch Financing Entities. *Fiscal Studies*, 35(2): 139–164. https://doi.org/10.1111/j.1475-5890.2014.12026.x

Wickham, H. (2016). *ggplot2: Elegant Graphics for Data Analysis*. Springer. Available at: https://ggplot2.tidyverse.org

Wójcik, D. (2018). Rethinking global financial networks: China, politics, and complexity. *Dialogues in Human Geography*, 8(3): 272–275. https://doi.org/10.1177/2043820618797743