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CONTENTS

Arkadiusz Kurasz – Distress and Restructuring Risk in Polish Cooperative Banks: Research Gaps and a Framework for Early-Warning Modelling 7

Marlena Grzelczak, **Adrian Apanel** – Short- and Long-Term Returns on Initial Public Offerings (IPOs) in the Polish Capital Market 29

Hanna Kociemska, **Sylwia Frydrych** – Green Bonds as Catalysts for Change: Driving Co_2 Reduction and Sustainable Finance Across Europe 57

Sebastian Łukaszewski – Commercial Banks' Readiness to Provide After-Sales Customer Service 85

Justyna Rybacka – Competitiveness in the Banking Services Sector Today from the Perspective of Generation Z 113

Magdalena Ślebocka, **Marta Szaja**, **Hasibe Aysan**, **Adrianna Ślebocka** – The Impact of Revitalization Activity on the Residential Attractiveness of Selected Cities in Poland and in Turkey 135

Arkadiusz Iwanicki – Transaction Structure and Activity Concentration in the Stellar Blockchain Register 167

Krzysztof Świeszczak – Czynniki ekonomiczne jako determinanty atrakcyjności oferty sektora fintech dla klientów indywidualnych banków 187

Cezary Bolek, **Monika Bolek** – Spready w kursach walutowych CHF/PLN wybranych banków oferujących kredyty hipoteczne w Polsce 211

Krzysztof Kil – Credit Reporting Systems, Credit Risk and Access to Credit: Evidence from European Union Countries 237

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Arkadiusz Kurasz https://orcid.org/0009-0008-3936-8714
Wydział Finansów, Uniwersytet Ekonomiczny w Katowicach, e-mail: arkadiusz.kurasz1980@gmail.com

DISTRESS AND RESTRUCTURING RISK IN POLISH COOPERATIVE BANKS: RESEARCH GAPS AND A FRAMEWORK FOR EARLY-WARNING MODELLING

Abstract

The purpose of the article. The article identifies the research gap caused by the lack of empirically validated early-warning models for distress and restructuring risk in Polish cooperative banks. It argues that models developed for commercial banks or non-financial enterprises cannot be transferred mechanically to cooperative banks because of Poland-specific institutional, regulatory and data constraints, including institutional protection scheme (IPS) membership and local-market exposure.

Methodology. The study applies a scoping review approach (PRISMA-ScR), critical literature analysis, document analysis and regulatory-institutional mapping. The review covers bank failure, distress and restructuring models from 1970 to 2025 and was supplemented by a targeted screening of review studies and empirical comparisons on logit, discriminant analysis, tree-based methods, machine learning and systemic early-warning systems. Evidence from corporate-bankruptcy and general financial-distress literature is used only for method taxonomy and validation criteria, not as direct evidence for bank-specific predictors. The article is exploratory: it does not estimate a final predictive model but defines the data architecture, candidate predictors and validation path required for future empirical research.

Results of the research. The study provides a publishable research agenda for Poland by: (1) updating the description of the cooperative banking sector; (2) distinguishing bank-distress modelling from corporate-bankruptcy prediction; (3) explaining why prudential regulation is not a substitute for statistical prediction; (4) proposing a Poland-specific variable set for an early-warning system; (5) defining a two-layer data blueprint for a bank-year panel combining public and supervisory/IPS data; and (6) translating the verified review literature into method-selection and validation rules, including interpretability, calibration, class imbalance and false-negative costs.

Keywords: cooperative banks; early-warning models; institutional protection schemes; restructuring risk
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Introduction

Bank distress prediction represents one of the key challenges in financial risk management, particularly in a dynamically changing economic and regulatory environment. Bank failures and forced restructuring events have consequences not only for individual institutions but also for depositors, local borrowers, supervisory authorities and the wider financial system (Grossman, 1993; Xu, 2022). Over recent decades, numerous statistical and machine-learning models have been developed to identify deterioration in banks' financial condition before formal insolvency or resolution occurs (Citterio, 2024). However, models developed for large commercial banks cannot be applied mechanically to Polish cooperative banks, because the latter operate under a distinct institutional architecture, different data-access constraints and strong local-market exposure.

In Poland, the banking sector, particularly cooperative banks, plays a significant role in ensuring economic stability, especially in local communities (Pluskota, 2018, pp. 249–261). Cooperative banks have unique characteristics, differing from larger commercial banks in terms of organisational structure and strategic goals. Their operations focus on local communities, with social capital playing a critical role in their functioning, influencing customer relationships and financial stability. Therefore, there is a need to develop dedicated failure prediction models that consider the specific attributes of these institutions.

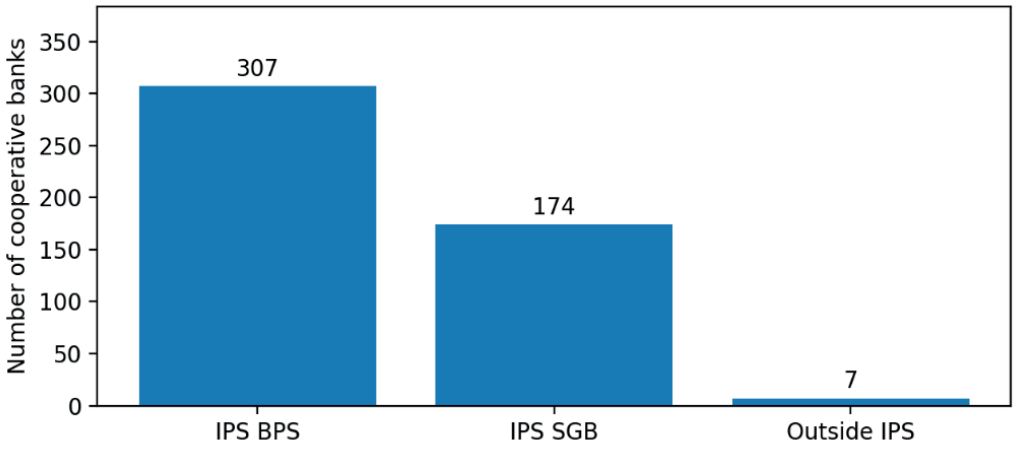
One of the most significant challenges in developing predictive models for Polish cooperative banks is the collection of harmonised bank-level and supervisory data. Compared with commercial banks, cooperative banks are smaller, locally embedded and more dependent on internal capital generation and relationship banking. Publicly available data is useful for a baseline prototype but are insufficient for a supervisory-grade model without confidential COREP/FINREP, SREP, recovery-plan and IPS support information. This constraint is central to the research agenda proposed in the article.

The Polish cooperative banking sector operates within two associating banks: Bank Polskiej Spółdzielczości S.A. (BPS) and SGB-Bank S.A.; and two recognised institutional protection schemes (IPS): IPS BPS and IPS SGB. As of 31 December 2025, 488 cooperative banks and two associating banks operated in Poland. Among cooperative banks, 307 were members of IPS BPS, 174 were members of IPS SGB and seven operated outside an IPS (KNF, 2026).

The current structure explains why a Polish early-warning model cannot be reduced to a generic commercial-bank model. IPS membership affects monitoring, liquidity management and potential support mechanisms; at the same time, it does not eliminate bank-level heterogeneity. KNF data for 2025 shows that cooperative banks remained well capitalised, with a total capital ratio of 29.51% at year-end 2025, while still differing in credit-risk profiles, local exposure and IPS status (KNF, 2026).

Figure 1.

Structure of the Polish cooperative banking sector by IPS membership (December 31, 2025)



Source: Own elaboration based on KNF (2026).

Consequently, adapting existing models or developing new early-warning models for cooperative banks in Poland requires a sector-specific approach: the model must combine bank-level financial ratios, IPS status, supervisory/legal events and local macroeconomic conditions. The research gap is therefore not merely the absence of a model, but the absence of a transparent, empirically testable architecture for such a model.

The aim of this article is to identify this research gap and propose a structured blueprint for future empirical modelling of cooperative-bank distress and restructuring risk in Poland. The article specifies data sources, candidate variables and methodological requirements for a model that could be validated in subsequent quantitative research.

Research Methodology

In line with the article's objective, the following research stages were conducted:

- review of existing bank failure prediction models described in the literature: this phase utilised information on various predictive models (e.g., global bank failure prediction models such as logit, decision trees, and random forests) that have been studied and validated in different countries, with the results published in academic literature. Alongside presenting the characteristics of each model, a preliminary attempt was made to evaluate their applicability to Polish conditions, with a particular focus on cooperative banks in Poland;
- literature analysis to highlight the lack of studies on adapting global predictive models: this stage aimed to demonstrate the absence of research analysing the potential adaptation of global models, such as logit, decision trees, or random forests, to the specific conditions

of the Polish market. It included an assessment of the rationale for applying existing models to the Polish cooperative banking sector, considering both the operational characteristics of these banks and the features of the analysed models;

- demonstrating the need to develop dedicated bank failure prediction models for cooperative banks: this stage focused on emphasising the need for models specifically tailored to cooperative banks due to their unique operational scope compared to commercial banks. The analysis explored various aspects of cooperative banks' operations, such as their operational characteristics, risk specificity, capital resources, organisational structure, and data accessibility. It also highlighted the lack of predictive models for cooperative banks, in contrast to the availability of such models for commercial banks;
- identifying key research needs for developing predictive models: at this stage, specific areas and conditions enabling the adaptation of models to the evolving operational context of cooperative banks in Poland were identified. Additionally, quantitative and qualitative variables (and their accessibility) necessary for constructing failure prediction models for these banks were recognised.

The study is of exploratory nature and therefore, it does not formulate causal hypotheses. It applies critical literature analysis, document analysis (Bowen, 2009), comparative analysis and regulatory-institutional mapping. The exploratory character is treated as a limitation and a research-design choice: the paper builds the architecture of a future model rather than estimating the model itself.

The literature review was designed as a scoping review in line with PRISMA-ScR (Tricco et al., 2018). The review covered bank failure, distress and restructuring models published between 1970 and 2025, with particular attention to logit/panel-logit, decision trees, random forests, survival/hazard models and systemic early-warning systems. Inclusion criteria were: empirical banking samples, transparent predictor reporting and reported diagnostic measures or validation logic. Exclusion criteria were: purely conceptual papers without model specification, studies limited to non-financial firms without banking adaptation, and single-case descriptions without model validation. A supplementary screening of review literature was used to classify sources into three evidence tiers: (1) bank-failure and banking-crisis EWS studies; (2) broader bankruptcy or financial-distress reviews useful for method taxonomy and validation criteria; and (3) lower-transferability material, such as theses or generic data-mining texts, used only to orient the search and not as core evidence. The scoping review is not a meta-analysis; it maps the field and translates the literature into a model-design blueprint for Polish cooperative banks.

This distinction is important because not every bankruptcy-prediction source is bank-specific. Reviews of corporate bankruptcy and AI-based financial distress prediction help iden-

tify method families, sampling issues and validation metrics (Alaka et al., 2018; Qu et al., 2019; Kuizinienė et al., 2022; Shetty et al., 2022), whereas bank-failure studies define the relevant failure channels and predictors (Kumar & Ravi, 2007; Liu et al., 2021; Citterio, 2024).

Global Predictive Models for Bank Failure or Restructuring

The screened literature can be organised into four strands: classical statistical models (discriminant analysis, logit/probit), bank-specific probability-of-default and failure models, tree-based or ensemble machine-learning models, and systemic banking-crisis early-warning systems. This distinction matters because individual cooperative-bank distress, corporate bankruptcy and systemic banking crises are related but not identical outcomes.

Logit Model

The logit model, also known as logistic regression, is one of the classical tools for predicting bank failures. It estimates the probability of a binary event, such as distress, failure or supervisory intervention, using explanatory variables. In bank applications, logit models rely on financial indicators such as asset quality, liquidity, profitability and capital adequacy. Meyer and Pifer (1970) and Martin (1977) established the usefulness of early-warning logit approaches for bank supervision. Later research comparing logit with data-mining methods shows that logit remains valuable as a transparent benchmark, even when machine-learning models improve classification in some settings (Jing & Fang, 2018; Citterio, 2024).

In banking applications, logistic regression remains a transparent baseline, but cooperative-bank data requires careful specification. Class imbalance, time-varying covariates and nested structures (bank-year observations within IPS structures) call for panel-logit, Firth-penalised logit or survival/hazard extensions. For the Polish IPS context, validation should be stratified by IPS membership, year and bank size.

Studies of bank probability-of-default models confirm that logit/probit specifications can be strengthened by grouping heterogeneous banks and adding macroeconomic variables (Peresetsky et al., 2004). However, cut-off selection, misclassification costs and out-of-sample validation are decisive, especially because missed failures are more costly than false alarms from a supervisory perspective (Davis & Karim, 2008; Affes & Hentati-Kaffel, 2019).

Decision Trees

Decision trees are another bankruptcy prediction method widely applied in banking risk analysis. This data analysis technique involves step-by-step decision-making based on the values of individual variables. It is particularly useful in cases where data is diverse and difficult to interpret using traditional statistical methods. Research by Citterio (2024) indicates that decision

trees are flexible, allowing for adaptation to the specific characteristics of the banking market, where financial variables are often complex and multidimensional. Internationally, decision trees have been widely applied in the banking sector. For example, in the U.S. banking sector, they are used to analyse both financial and operational data. A key advantage of this method is its intuitive output, which enables managers to make informed decisions. However, in Poland, there is a lack of research on the application of decision trees in banking, including cooperative banks, representing a gap that future studies should address.

Random Forests

Random forest algorithms represent an advanced predictive method based on ensembles of decision trees. They are useful when predictors interact non-linearly and when variable importance must be explored across many financial and non-financial indicators. In banking applications, however, random forests should be treated as complements rather than substitutes for transparent statistical models, because supervisory usefulness depends not only on accuracy but also on calibration, interpretability and false-negative costs (Jing & Fang, 2018; Citterio, 2024). In Poland, this method could be valuable for analysing cooperative banks operating in diverse local markets, provided that data standardisation problems are solved.

The additional review evidence supports using tree-based ensembles as robustness tools rather than as a default black-box solution. ML models may deliver predictive gains in default classification, but their use in regulated finance creates supervisory costs related to explainability, governance and validation (Alonso & Carbó, 2020). On tabular datasets, tree-based models often remain strong benchmarks (Grinsztajn et al., 2022), which justifies testing random forest or gradient boosting against transparent logit/Firth-logit baselines.

Application of Predictive Models in the Polish Market

Although global bank failure prediction models, such as logit, decision trees, and random forests, have been successfully applied in various countries, Poland lacks dedicated predictive solutions tailored to the specific conditions of cooperative banks. Research conducted by Prusak (2005, pp. 1–207) suggests that adapting these tools to the Polish market, where cooperative banks often operate under different conditions than commercial banks, is essential. Prusak (2005, pp. 1–207) also emphasises that the operational specificity of businesses (and by analogy, cooperative banks) necessitates the inclusion of non-financial variables, such as local relationships or levels of social trust, which are critical to the stability of these institutions.

Polish cooperative banks have unique financial structures, and their operations are closely tied to local market conditions. As such, predictive models must incorporate these unique factors, including local economic conditions, customer relationship specifics, and diverse funding

sources. While models like logit could provide a solid foundation, adapting them to local conditions requires further research.

In the context of economic and regulatory changes, the stability of Polish cooperative banks is closely linked to the overall stability of the European financial sector. Gasz (2014, pp. 45–60) highlights that European stability conditions are crucial to the functioning of financial institutions at the national level.

Bank Failure Prediction Versus Bankruptcy Prediction for Non-Financial Enterprises

Predicting bank failure differs materially from predicting bankruptcy of non-financial enterprises. Banks perform maturity transformation, are vulnerable to liquidity shocks and deposit withdrawals, and operate under capital, liquidity, recovery and resolution regimes. Therefore, distress can materialise through channels that are not captured by corporate leverage/profitability models alone.

A bank-specific model should include asset quality (NPL ratio, coverage ratio, cost of risk), liquidity and funding metrics (LCR, NSFR, loan-to-deposit ratio and deposit concentration), solvency indicators (CET1/Tier I and total capital ratio), profitability and efficiency ratios (ROAA, ROAE and C/I), as well as institutional variables such as IPS membership, support availability and supervisory-intervention signals. Corporate bankruptcy models can inspire methodology, but they are not sufficient for cooperative-bank distress modelling.

Broader financial-distress and corporate-bankruptcy reviews therefore serve only a limited role in this paper. They justify a wider methodological menu (e.g., ensemble models, support vector machines, neural networks and resampling approaches), but they do not justify transferring corporate predictors directly to cooperative banks. The proposed Polish EWS must remain bank-specific and institution-specific.

Polish Cooperative Banking Sector: Institutional Specificity, Data Access and Research Gap

Despite the development of the Polish banking sector and the growing literature on bank distress, dedicated early-warning models for cooperative banks in Poland remain scarce. General bank-failure models can provide methodological families, but they do not solve the Poland-specific problem of IPS architecture, local exposure, data fragmentation and legal access to supervisory variables.

In Poland, cooperative banks operate within a legally and institutionally specific architecture: two associating banks (BPS and SGB-Bank) and two IPS arrangements (IPS BPS and IPS SGB). This structure affects liquidity management, risk monitoring, support mechanisms and the interpretation of bank-level ratios.

As of December 31, 2025, 488 cooperative banks operated in Poland; 307 belonged to IPS BPS, 174 to IPS SGB and seven remained outside an IPS. Two associating banks — BPS and SGB-Bank — also operated in the sector (KNF, 2026). This data directly addresses the need to analyse the whole cooperative-banking sector rather than a single associating group.

IPS arrangements should not be treated as consolidated banking groups, but they may influence prudential treatment and risk transmission. The ECB guide defines an IPS as an arrangement that protects member institutions and ensures their liquidity and solvency where necessary; it also indicates that IPS eligibility may affect risk weights, large-exposure treatment and liquidity waivers under the CRR framework (ECB, 2016).

The structure of Polish cooperative banks therefore requires predictors that go beyond standard financial ratios: IPS membership, availability or use of support funds, local credit concentration, exposure to farmers and SMEs, regional macroeconomic indicators, supervisory measures and recovery-plan status should be analysed together with classical ratios such as NPL, coverage, C/I, ROAA, capital adequacy and loan-to-deposit ratio.

The cooperative business model still matters: cooperative banks are not driven solely by profit maximisation but also by the needs of members and local communities (Hesse & Čihák, 2007; Pluskota, 2018). In modelling terms, local relationships, concentration of borrowers and community-level shocks are potential explanatory variables rather than narrative ornaments.

Polish cooperative banks are highly exposed to local economic and social conditions, which may strengthen client loyalty but also creates correlated regional risk. For this reason, public macro data at the poviat or voivodeship level should be linked with bank-level indicators wherever legally and technically feasible.

The literature therefore supports a hybrid research approach combining financial ratios, institutional variables and local socio-economic indicators (Groeneveld & De Vries, 2009; Ayadi et al., 2010). For Poland, IPS variables are the missing hinge in this hybrid architecture.

Concise Comparative Note: IPS-Based Cooperative Systems in Germany and Italy

A concise international comparison confirms that IPS-based cooperative banking systems can support risk monitoring but cannot be copied mechanically. Germany's BVR protection systems and Italy's cooperative banking groups illustrate how network-level monitoring, support mechanisms and more standardised data can strengthen early-warning capacity (ECB, 2016; European Parliament, 2022).

The lesson for Poland is therefore cautious: foreign IPS architectures justify including network-level variables in an EWS model, but Polish model design must reflect the domestic legal framework, the two associating banks, the two IPS structures and local data-access limitations.

This comparison supports the article's central thesis: the research problem is not only methodological but institutional. A model for Polish cooperative banks should combine bank-level indicators with IPS-level and local-economy variables.

Challenges with Data Access in Poland

One of the greatest challenges in predicting cooperative-bank distress in Poland is limited access to harmonised bank-level and supervisory data. Public aggregate data is available from KNF, GUS and NBP; individual banks publish financial statements to varying degrees; and IPS reports provide selected group-level information. However, granular COREP/FINREP, SREP, recovery-plan and supervisory-intervention data are generally not publicly available.

The problem is therefore not the total absence of data, but fragmentation, uneven standardisation and restricted access to the most informative supervisory and IPS variables. A credible research design should explicitly distinguish between a public prototype and an enhanced supervisory/IPS model.

A reasonable database should therefore be built in two layers. The baseline public layer would contain bank-year observations based on annual financial statements, Pillar 3 disclosures, KNF/GUS/NBP sector data and local macroeconomic indicators from Statistics Poland. The enhanced supervisory/IPS layer would add confidential variables such as SREP measures, recovery-plan status, IPS support intensity and granular liquidity/capital reporting.

This two-layer architecture explains why existing public data is insufficient for a fully validated supervisory-grade model but sufficient for a transparent prototype. The prototype can identify candidate predictors, test baseline logit/ML specifications and indicate which confidential variables materially improve calibration and early-warning usefulness.

The data problem also has a governance dimension: cooperation among cooperative banks, IPS institutions, researchers and supervisors would be necessary to define anonymisation rules, data dictionaries, validation windows and access protocols.

Local macroeconomic variables should be linked to cooperative banks using defensible service-area proxies, such as registered seat, branch network or disclosed credit concentration. This is necessary because regional shocks affecting farmers, SMEs and local governments may affect cooperative banks more strongly than large diversified commercial banks.

Legal and Regulatory Framework: Boundary Conditions and Predictors

Legal regulations are essential for the functioning of cooperative banks, but they should be treated as boundary conditions and sources of predictors rather than as substitutes for statistical prediction. In Poland, the relevant framework includes the Banking Law Act of August 29,

1997, the Act December 7, 2000 on cooperative banks, their associating and associating banks, and the Act of June 10, 2016 on the Bank Guarantee Fund, deposit guarantee scheme and resolution. At the EU level, the CRR framework, including CRR3 (Regulation 2024/1623), defines capital and risk requirements relevant to model variables.

Strict regulation reduces the probability and social cost of bank distress, but it does not predict failure by itself. Regulatory ratios are usually threshold-based and point-in-time; they may not capture local borrower concentration, deterioration in loan quality, profitability erosion, deposit concentration or the timing of IPS support. Prediction requires dynamic statistical modelling of leading indicators.

Accordingly, legal and supervisory variables should be operationalised in the model as observable signals: breach or proximity to capital/liquidity thresholds, recovery-plan status, early--intervention measures, IPS support events, resolution-planning indicators and changes in regulatory buffers. This interpretation answers the regulatory question without treating regulation as a substitute for dynamic prediction.

Specificity of Cooperative Bank Operations and the Need for Dedicated Early-Warning Models

Cooperative banks differ from commercial banks because their operating model is based on member ownership, relationship banking and local-community service. This divergence in governance, objectives and customer relations means that failure prediction models developed for large diversified commercial banks are insufficient for this banking segment without adaptation.

A dedicated model for cooperative banks should therefore include both financial and non-financial variables: local labour-market dynamics, borrower concentration, relationship banking, local government exposure, branch-network changes, operational efficiency and IPS membership. These variables are not decorative; they affect how risk accumulates and how quickly it can be mitigated.

Organisational Structure and Management of Cooperative Banks

One fundamental distinction between cooperative and commercial banks lies in their ownership and organisational structures, rooted in cooperative principles of solidarity and member-based governance. In cooperative banks, the governance model is shaped by member participation and local representation (Act of December 7, 2000; Fonteyne, 2007). This structure fosters long-term relationships with customers and the local community.

This governance structure can support relationship banking, but it may also affect the speed and formality of decision-making. In an EWS model, governance and organisational variables

should therefore be treated as potential contextual predictors rather than as anecdotal background. The key modelling implication is not that cooperative governance is risky per se, but that it changes how risks are monitored, escalated and mitigated.

The Role of Social Capital and Local Relationships

Social capital and local relationships are foundational to the financial stability of cooperative banks. Citterio (2024: 101818) argues that integrating social aspects into predictive models can significantly enhance their effectiveness, especially amid shifting market conditions. Unlike commercial banks, which operate on a broader scale, cooperative banks rely on the trust and long-term relationships of local clients.

In Poland, cooperative banks are deeply integrated into local communities, meaning their financial stability is strongly linked to regional economic health. As noted in the literature (Martin, 1977, pp. 249–276), traditional financial models like logit do not always account for such variables, potentially underestimating risks for cooperative banks. Czechowska and Kuśmierska (2022, pp. 8–27) highlight the importance of social capital and ties in financial decisions made by younger clients, suggesting that incorporating these variables into bankruptcy prediction models could enhance forecast accuracy and stakeholder satisfaction.

Limited Capital Resources and Their Impact on Financial Stability

Compared to large commercial banks, cooperative banks have significantly smaller capital resources. Limited access to capital markets means they rely mainly on member contributions and retained earnings. This reliance makes smaller cooperative banks less able to respond to sudden macroeconomic shocks, increasing the risk of restructuring or, in extreme cases, failure.

Institutional protection schemes provide an important defence mechanism, but they also require predictive risk tools to support timely decisions. In Poland, where cooperative banks play a key role in serving local communities, capital accumulation depends largely on retained earnings and member-related mechanisms. Predictive models should therefore reflect capital buffers, capital erosion, profitability and IPS support capacity when forecasting distress or restructuring risk.

Operational Specificity and Operational Risk

Understanding the impact of technology on risk management is vital when examining the operational specifics of cooperative banks. As digitalisation becomes increasingly widespread, cooperative banks must adapt their strategies to the new market realities, requiring investments in modern information systems. Citterio's (2024) findings indicate that implementing innovative technological solutions, such as artificial intelligence, can enhance these institutions' ability to monitor risks and forecast financial problems.

Furthermore, integrating local data into predictive algorithms could improve crisis forecasting, which is crucial for the stability of banks operating in a volatile economic environment. Analyses by Boos et al. (2024, pp. 497–533) suggest that predictive models must account for operational specifics to accurately forecast failure risks.

The Need to Adapt Models to Cooperative Bank Specifics

In addressing the need to adapt models to cooperative-bank specifics, the key issue is not financial education as a stand-alone topic, but the operationalisation of local and institutional signals. Customer loyalty, member participation, local borrower concentration and branch-network dependence may all affect distress dynamics, but they must be translated into measurable variables before they can enter an EWS model.

Developing educational programmes for members may support long-term financial literacy and trust; however, model design should focus on variables that can be observed, harmonised and validated. This distinction helps maintain empirical testability and model parsimony.

In the Polish context, early warning indicators should be developed for cooperative banks — preferably within existing institutional protection schemes — to more effectively forecast restructuring or bankruptcy risks. Łupiński (2019, pp. 99–113) emphasises the importance of tailoring predictive models to the specifics of this sector.

Creating effective failure prediction models for cooperative banks requires consideration of factors that are not relevant, or are less relevant, for large, diversified institutions. Traditional predictive models based primarily on financial data may fail to account for variables related to local relationships, social capital and operational specificity (Prusak, 2005). International evidence on bank failure prediction shows that advanced models can improve classification, but they must be interpreted with attention to false-negative costs and calibration (Jing & Fang, 2018; Citterio, 2024).

Research Needs: Data, Variables and Model Design

When analysing research needs, it is essential to connect global modelling approaches with the local structure of cooperative banking. Digitalisation, regulatory change and financial-market integration increase the need for advanced risk monitoring, but the empirical specification must still reflect domestic IPS architecture, local exposures and data availability (Citterio, 2024; NBP, 2025).

Collaboration among cooperative banks, IPS institutions, supervisors and research institutions could improve data quality and support anonymised research datasets. Such cooperation is critical for transforming the proposed model architecture into a validated early-warning system.

The review is used to specify a minimum model architecture rather than to rank methods mechanically. Table 1 translates the literature and the Polish institutional setting into a candidate variable dictionary; Table 2 identifies feasible data sources and remaining access gaps.

The literature does not support a simple ranking such as 'machine learning is better than logit'. Some studies report higher discrimination for data-mining or ensemble models, while others stress the value of transparent logit models and the danger of false negatives. Therefore, model choice should be driven by validation design, decision costs and interpretability rather than headline accuracy (Jing & Fang, 2018; Alonso & Carbó, 2020; Liu et al., 2021).

Table 1.

Proposed Poland-specific variable set for a cooperative-bank early-warning system

Variable block	Examples of predictors	Expected role in an EWS
Capital / solvency	CET1/Tier I, total capital ratio, buffer above regulatory minimum, own funds and member-share fund dynamics	Lower buffers and rapid erosion increase distress risk
Asset quality	NPL ratio, coverage ratio, cost of risk, restructuring flow, exposures to farmers/SMEs	Deterioration signals credit-risk stress
Liquidity / funding	LCR, NSFR, loan-to-deposit ratio, non-sticky deposit concentration, IPS versus solo liquidity treatment	Funding stress and liquidity deterioration are leading bank-failure channels
Profitability / efficiency	ROAA, ROAE, net interest margin, C/I, net result dynamics	Weak profitability reduces internal capital generation and shock absorption
Institutional / IPS	IPS membership (BPS/SGB/ outside), IPS support intensity, support-fund use, group monitoring score	Network support may reduce failure probability but can signal hidden distress
Supervisory / legal	Recovery-plan status, early-intervention measures, resolution-planning flags, proximity to regulatory thresholds	Regulatory signals become predictors, not a substitute for prediction
Local macro / market	Poviat unemployment, income, demographic change, agricultural/ SME conditions	Local shocks may affect cooperative banks more strongly than large commercial banks

Source: Own elaboration based on the literature review and institutional/regulatory sources discussed in the article.

Table 2.

Data sources and availability for building a cooperative-bank panel

Data layer	Potential sources	Availability / limitation
Public sector aggregates	KNF quarterly cooperative-bank reports; GUS financial results of banks; NBP Financial Stability Report	Useful for sector context, benchmark ratios and macro-financial environment; not sufficient for bank-level calibration
Bank-level public data	Annual financial statements, Pillar 3 disclosures, commercial registers, bank websites	Feasible for a public prototype; standardisation and missing data are the main obstacles
IPS-level data	IPS BPS and IPS SGB reports, support-fund disclosures, group risk summaries	Important for membership/support variables; detailed support events may require access agreements
Supervisory / confidential data	COREP/FINREP, SREP, recovery plans, early-intervention and resolution data	Needed for enhanced model calibration; requires supervisory or IPS cooperation and strict data governance
Local macro data	GUS Local Data Bank: unemployment, income, demographics, business activity	Public and linkable to bank territories, but geographic mapping of bank exposures is required

Source: Own elaboration based on publicly available institutional data sources and supervisory-reporting frameworks discussed in the article.

Developing effective distress and restructuring-risk models for cooperative banks in Poland requires detailed data and a disciplined variable dictionary. The following subsection identifies the minimum financial, institutional, supervisory and local-macro variables needed for a baseline model.

Detailed Financial and Balance-Sheet Data

Data availability and scope consistently form the foundation of any distress or restructuring-risk model. For banks, including the cooperative ones, access to granular data remains limited, presenting a significant challenge for researchers and financial institutions in Poland. Meyer and

Pifer (1970) and Martin (1977) show that bank-level financial indicators are central to early-warning modelling, but the Polish cooperative-banking context also requires institutional, supervisory and local-macro variables.

In Poland, the problem is therefore not only legal access but also standardisation: bank-level data must be harmonised across reporting formats, mergers and IPS status changes. Legislative or sectoral data-sharing arrangements would improve research quality, but a baseline prototype can already be built from public data combined with local macroeconomic indicators.

Identification of Significant Variables in Distress and Restructuring-Risk Prediction

Identifying variables relevant to the prediction of cooperative-bank distress is a key task, because these institutions operate under local conditions that are not fully captured by traditional models. Socio-economic factors such as unemployment, local business activity and agricultural-sector conditions may influence credit quality and funding stability.

Beyond traditional financial indicators such as liquidity, profitability, capital adequacy and asset quality, non-financial and institutional variables may prove crucial. These include IPS membership, support-fund availability, recovery-plan status, branch-network intensity, local borrower concentration and deposit concentration.

Many of these variables are not typically included in corporate bankruptcy models, which limits their usefulness for cooperative banks. Research into Poland-specific predictors is therefore essential, particularly under changing regulatory, competitive and interest-rate conditions.

This article sets out an operational research agenda for a Polish cooperative-bank early-warning system. Its key contribution is the specification of the institutional, regulatory and data conditions that such a model must satisfy.

The analysis shows that a valid model for Poland must include IPS architecture (BPS/SGB/outside IPS), bank-level financial ratios, supervisory and legal events, and local macroeconomic indicators. Foreign models can provide methodological families — logit, panel-logit, decision trees, random forests or survival/hazard models — but not a ready-to-use Polish specification.

The exploratory character of the article is a limitation: it does not estimate and validate a final model. Its practical value lies in defining a publishable empirical next step: a bank-year panel, a transparent variable set and validation metrics such as AUC, Brier score, calibration curves and class-imbalance handling.

The proposed model architecture can support the following practical applications:

- supporting risk-management decisions in cooperative banks by identifying early deterioration in solvency, asset quality, liquidity and profitability;
- prioritising remedial actions and IPS support by distinguishing temporary liquidity pressure from deeper solvency or asset-quality stress;

- strengthening supervisory early-warning systems by combining financial indicators with recovery-plan, IPS and local-macro variables;
- informing regulatory policy by showing which indicators are leading signals and which are merely minimum compliance thresholds;
- expanding future research through comparative validation of panel-logit, Firth-logit, random forest and gradient boosting specifications on the same Polish dataset.

Data Availability and Governance

Challenges related to data availability require stronger cooperation among cooperative banks, IPS institutions, supervisors and research organisations. The aim should be to develop standardised data dictionaries, anonymised access protocols and validation samples that can be used without breaching prudential secrecy or competition-sensitive information.

Local universities and research institutes could support this process by developing prototypes, testing variable definitions and evaluating the predictive usefulness of public data. The broader bankruptcy-prediction literature confirms that access to reliable data is crucial for effective modelling (Shi & Li, 2019), but bank-specific EWS development also requires supervisory and institutional variables.

In Poland, cooperative banks publish financial statements, but they are not required to disclose the full set of granular supervisory variables necessary for a calibrated EWS. Legislative or sectoral data-sharing arrangements would therefore improve research quality and supervisory usefulness.

Model-Selection and Validation Protocol

The proposed empirical stage should compare model families on the same harmonised bank-year panel. A defensible protocol would include: (1) an interpretable baseline (logit/Firth-logit/panel-logit); (2) a time-to-event model; (3) a tree-based ensemble; and (4) sensitivity analysis across IPS strata, bank size and time windows. The aim is not to crown a universal winner, because review evidence shows that no bankruptcy/distress tool dominates all criteria and datasets (Kumar & Ravi, 2007; Alaka et al., 2018).

Validation should use out-of-time tests and report AUC/ROC, precision-recall measures for imbalanced samples, Brier score, calibration curves, false-negative rates and cost-sensitive thresholds. This approach is consistent with bank EWS studies that emphasise the costs of missed distress events and the need for supervisory usefulness rather than accuracy alone (Davis & Karim, 2008; Affes & Hentati-Kaffel, 2019; Wang et al., 2021).

Because cooperative-bank failures or restructuring events are rare, the final model should also document class-imbalance handling, temporal stability and explainability. For machine-learning

specifications, variable-importance and SHAP-type explanations may support interpretability, but they should not replace calibration and economic plausibility checks.

Conclusions

The article identifies a specific and still underdeveloped research gap: the absence of empirically validated early-warning models for distress and restructuring risk in Polish cooperative banks. The gap is not merely technical. It reflects the institutional architecture of the sector, data fragmentation, IPS membership, local-market exposure and limited public access to supervisory variables.

The proposed research contribution is therefore a framework rather than a finished predictive model. It defines: the relevant institutional context; a candidate variable set; a two-layer data architecture; and validation requirements for future empirical work. This is a necessary step before model estimation because importing foreign models without adapting them to IPS status, local exposures and Polish data constraints would lead to model misspecification.

For future empirical research, three model families should be tested on the same bank-year panel: a baseline panel-logit or Firth-logit model, a survival/hazard model for time-to-distress events, and an interpretable tree-based machine-learning model such as random forest or gradient boosting. Model evaluation should report AUC/ROC, precision-recall measures, Brier score, calibration curves, false-negative rates, class-imbalance treatment and cost-sensitive thresholds. This design follows the review literature: predictive accuracy must be assessed together with interpretability and supervisory usefulness.

The practical relevance of the framework lies in its possible use by cooperative banks, IPS institutions and supervisory bodies. A validated EWS could support earlier identification of deteriorating asset quality, liquidity pressure, capital erosion and local macroeconomic stress. Regulations and IPS arrangements provide safeguards, but they do not replace a dynamic prediction.

The main limitation of the article is that it does not estimate a final model. This limitation is deliberate: the article first establishes the data, institutional and methodological preconditions for credible modelling. The next research step should therefore be the construction of a harmonised panel dataset for 2010–2025 and the out-of-sample validation of the proposed model families.

Further research should also test whether IPS membership and IPS support intensity reduce the hazard of distress after controlling for bank size, capital buffers, asset quality, liquidity, profitability and local macroeconomic conditions. This would transform the current research-needs analysis into a directly testable empirical contribution.

Disclosure Statement

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Marlena Grzelczak https://orcid.org/0000-0002-3653-3920
PhD, Faculty of Economics and Sociology, Department of Corporate Finance, University of Lodz, POW3/5, 90-255 Lodz, e-mail: marlena.grzelczak@eksoc.uni.lodz.pl

Adrian Apanel https://orcid.org/0009-0006-9920-2324
MA, Faculty of Economics and Sociology, University of Lodz, POW3/5, 90-255 Lodz, e-mail: adrian.apanel@edu.uni.lodz.pl

SHORT- AND LONG-TERM RETURNS ON INITIAL PUBLIC OFFERINGS (IPOS) IN THE POLISH CAPITAL MARKET

Abstract

The purpose of the article. The purpose of the study was to examine how the returns on shares of companies entering the Warsaw Stock Exchange as part of initial public offerings (IPOs) evolve, both in the short and long term. The study aimed to verify the hypothesis of the existence of anomalies on the main market of the WSE, consisting in the underpricing of shares in the short term and their overpricing in the medium and long term.

Methodology. The basis of the study was the analysis of historical data on returns on shares issued in initial public offerings. The evaluation of the phenomenon of undervaluation of share prices from IPOs was conducted using the immediate return (IR) index and its adjusted version (AIR). In turn, simple rates of return (BHR) and abnormal rates of return (BHAR) were used to assess the overvaluation of share prices over the longer term.

Results of the research. The study confirmed the occurrence of share price undervaluation during IPOs on the Polish capital market in the years 2010–2024, as evidenced by an average immediate return (IR) of 9.73%. The highest average returns in the short term were recorded in 2020, exceeding 40%, mainly due to debuts of companies from the computer games sector. In contrast, in the long term, the weakest performance, characterized by negative average returns (BHARs) in all periods studied, took place between 2019 and 2024, associated with the economic difficulties following the pandemic and the preponderance of companies making losses.

Keywords: undervaluation, overvaluation, IPO, public offering, BHR, BHAR, IR, AIR
JEL Class: G12, G14, G24

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Introduction

The term "initial public offering" is defined quite broadly in the literature and can be interpreted in various ways (Sobotnik, 2009, pp. 268–269). It most often refers to a situation where a company offers its shares to a wide range of investors for the first time, which is tantamount to its IPO (Siwek, 2005, pp. 12–13). An IPO may include both the issue of new shares to be traded on the public market (first subscription) and the sale of existing shares by existing shareholders, offered for the first time on the public market (first sale) (*Act of 29 July 2005*…, Article 4(5); Siwek, 2005, p. 13). Under national and EU law, a public offer of securities means a communication, in whatever form and by whatever means, which contains sufficient information about the terms of the offer and the securities offered to enable an investor to decide to purchase or subscribe to them (*Regulation (EU) 2017/1129*…, Article 2(d)). As of July 21, 2019, communication addressed to at least two persons is considered a public offer, whereas previously the threshold was 150 persons (FSC, 2025).

A stock market debut in the form of an initial public offering (IPO) is often associated with a rapid increase in the value of shares, especially on the first day of trading, which is known in the literature as *underpricing*. In contrast, in the longer term, a decline in the value of the shares can usually be observed, known as *underperformance* (Lizińska, 2014, p. 384). The phenomenon of underpricing of shares in IPOs is commonly present in global capital markets, although its magnitude depends on the specifics of the market in question, the period analyzed or the phase of the economic cycle (Ibbotson & Ritter, 1995, pp. 994–996). *Underperformance*, on the other hand, means that, over the long term, stock returns are lower than those of the broad market as measured, for example, by the WIG index or relative to companies with a similar profile that did not IPO at the same time (Wieczorek, 2020, p. 359).

Taking up the research topic in this study is due to noticeable research gaps in the existing academic literature and the specificity of the Polish capital market. There is still a lack of up-to-date and detailed analyses of undervaluation and overvaluation of shares on the WSE. Studies to date in Poland have been limited to shorter time frames, usually covering two or three years, which is in contrast to multi-year, comprehensive analyses conducted on developed markets, such as J.R. Ritter's research on the USA. In addition, most of the available studies are based on data prior to 2016, thus failing to take into account current capital market trends and developments.

Although the WSE's main market plays an important role in raising capital for companies, previous analyses have mainly focused on the long-term effectiveness of IPOs on the world's largest markets, such as the US, Germany or China. There is a lack of comprehensive research relating to the Polish market. Studies in emerging markets have tended to focus on selected industries, such as the computer games sector, which does not allow general trends to be captured.

Therefore, a thorough analysis of the Polish IPO market is justified and necessary. This market requires systematic observation and research, given its importance in corporate financing. A comprehensive study of the long-term effectiveness of IPOs on the WSE, which overcomes previous methodological and time constraints, can fill gaps in the literature and provide valuable information for capital market participants.

The main objective of this study was to assess changes in short-term and long-term returns on IPOs on the Warsaw Stock Exchange. The research hypothesis was that there are price anomalies on the WSE's main market — in the short term, the shares of new companies are undervalued, while in the medium and long term they are overvalued.

The study formulated two main questions:

1. What were the short-term returns (IR and AIR) for companies debuting on the WSE between 2010 and 2024, particularly on the day of their debut, and was there any undervaluation of share prices at that time?
2. What were the medium- and long-term returns (BHR and BHAR) for companies listing on the WSE during this period, depending on the investment horizon (from 1 to 72 months after listing) and was there *an underperformance* relative to the broad market?

A Review of the Literature on First-Issue Stock Returns

Short-Term Stock Returns – Insights from Foreign and Domestic Studies

In the short term, and especially on the day of the IPO, it is typical for there to be *underpricing* of shares. This means that the closing price of the shares on the day of the debut is usually higher than the issue price (Wieczorek, 2020, p. 359). Miller and Reilly (1987) pointed out that on this day the market valuation of shares is often inadequate. Paleari and Vismara (2007), on the other hand, noted that newly debuting companies are sometimes deliberately priced high by issuers and analysts, which helps build a positive image of the company and increases investor confidence.

The results of empirical studies both on foreign markets and in Poland confirm the existence of *underpricing*. In their 1994 analysis, Ibbotson, Sindelar, and Ritter showed that the average level of underpricing of shares of debuting companies varied across successive periods, reaching 21.3% in the 1960s and 10.9% in the early 1990s. Loughran, Ritter and Rydqvist (2020), analyzing data from 54 countries, found that the average returns on the first day of the debut were usually in the range of a few to several percent. For example, in the US (1960–2019) they were 16.9 per cent, in Germany (1978–2014) they were 23 per cent and in the UK (1959–2016) they were 15.8 per cent. Perz (2025) noted that the magnitude of undervaluation tended to be greater in emerging markets than in mature markets, e.g., in China between 1989 and 1996 it

averaged 388 per cent, compared to 15.8 per cent in the US between 1960 and 1996. The most recent study by Ritter (2025) for the US between 1980 and 2023 showed that the highest average immediate returns occurred between 2019 and 2023 (158%), as well as between 1998 and 2000 (149.4%).

In the Polish and Hungarian markets between 1991 and 1998, according to a study by Lyn and Zychowicz (2003), the average adjusted first-day return in Poland was 15.1%. Czapiewski and co-authors (2014) showed that in Poland the scale of undervaluation decreased with the development of the capital market – in 1991–2000 it was 34.1%, and in 2001–2011 it decreased to 13.6%. Pomykalski and Domagalski (2015) reported an average undervaluation of 11.89% between 2005 and 2013.

Trąpczyński (2017) found that for 200 IPOs between 2007 and 2016, the average *underpricing* was 7.89%, which was a decrease compared to earlier periods, such as 19.8% between 1991 and 1997. Lizińska and Czapiewski (2014) research for 2004–2009 found an average first-day return of 10.98%, and that higher *underpricing* was associated with better pre-issue company financial performance.

Sukacz (2005), analyzing 185 IPOs from 1991 to 2002, showed an average undervaluation of 26%, while pointing to high returns on debut day in sectors such as construction, media, electrical machinery and IT. In contrast, research by Podedworna-Tarnowska and Kiełpsz (2024) found that between 2017 and 2021, the average first-day return was higher for small listings (22.9%) than for large listings (13.68%), with particularly high performance in the gaming industry.

Aziewicz and Dobrowolski (2014) highlighted the high volatility of debut day returns between 2005 and 2013, which made it difficult to develop an effective investment strategy for the long term. Frydrych (2022) noted that between 2007 and 2020, the majority of companies (60.22%) had a higher closing price than the issue price at the end of the first day of their debut, and debuts of so-called 'penny companies' (with a price below PLN 1) were significant.

In summary, undervaluation in the short term is a common phenomenon worldwide, and its intensity is greater in emerging markets. Polish research confirms its occurrence and indicates that the scale of this phenomenon has decreased as the domestic capital market has matured.

Long-Term Stock Returns – Rresults from Domestic and International Studies

Over the long term, the share price of newly listed companies on the main market often shows a downward trend. This phenomenon is called *long-run underperformanc*e and means that investors typically receive lower returns on such investments compared to the broad market or other listed companies. This problem has been extensively described by, among others, Ritter (2025), who, analyzing data from the US market from 1980 to 2023, found that average adjust-

ed 3-year returns (BHARs) were generally negative over this period – for the entire sample they were around −20.20%, and fell as low as −296.40% from 2019 to 2023. These results show that emerging market equities did not deliver sustainable, above-average returns over the long term. Similar results – negative 3-year returns ranging from −12% to −42% – have been reported in markets such as Spain, Sweden and Switzerland (Schuster, 2003).

The results of international studies confirm that the strategy of buying shares in an IPO and holding them for three years generally did not yield satisfactory results – the prices of these shares often underperformed the benchmark indices. Some exceptions were the markets of Sweden (+1.20%) and Korea (+2.0%), where positive relative returns over the long term were achieved (Sehgal, Singh, 2007). Goergen, Khurshed and Mudambi (2007) pointed out that lower long-term returns were characteristic of companies with higher pre-IPO profitability and with a highly diluted ownership structure after the IPO. In contrast, better results were recorded for larger companies.

In Poland, it has also been shown that returns on investments in IPO shares, in the medium and long term, were clearly lower than the returns obtained on the day of the IPO, and were similar to the performance observed in developed markets. Sieradzki (2013) noted that holding IPO stocks one year yielded an average negative adjusted return of −4.2% relative to the WIG index. Zieliński (2013), analyzing the period 1994–2016, indicated that the 3-year adjusted BHAR ranged from −14% to −28.6%. Rzewuska and Wrzesinski (2016) noted that investments in shares of 2006 IPO companies underperformed the index by 9% after two years and by as much as 26% after three years. Kwit (2006), on the other hand, estimated that holding shares acquired during the IPO for three years resulted in a 17% lower rate of return compared to other companies listed on the WSE market.

Research by Kochalski and Ratajczak (2025) found that the average return on IPOs from 2009 to 2011 showed a downward trend until the 370th day of listing and reached −19.35%. Aziewicz and Dobrowolski (2014) observed that the above-average results obtained 12 months after the IPO were not sustainable, and that declines in returns were particularly pronounced after three years. An interesting conclusion was provided by Wieczorek (2020) study using 29 gaming companies as an example, which pointed to the possibility of achieving positive average BHARs over the long term, which calls into question the universality of the *underperformance* phenomenon.

In summary, most studies – both domestic and foreign – show that investors who kept shares of debut companies in their portfolios for an extended period of time underperformed the market. Although overvaluation over the long term is a common phenomenon, it did not always occur in a systematic way and returns varied depending on the period and market analyzed.

Survey Methodology

The analysis of the occurrence of undervaluation of the share prices of companies entering the stock market was conducted using *the* indicator of the immediate *return* (*IR*) and the adjusted *initial* return (*AIR*). The method of calculating the immediate return is presented in the following formula (cf. Trąpczyński, 2017, p. 150; Wieczorek, 2019, p. 88; Wieczorek, 2020, pp. 367–368):

$$\mathrm{IR} = \frac{(\mathrm{P_i} - \mathrm{E_i})}{\mathrm{E_i}} \times 100\% \tag{1}$$

where:

IR_i – the immediate return on investment in the company's shares *and* offered in the IPO on the first day of trading;

P_i – the closing price of the company's shares (or rights to shares) *and* at the close of trading on the day of the IPO;

E_i – the price of the shares offered by the company *i* (issue price or reference price).

The main advantage of the simple rate of return is that it is the only such a rate whose use in portfolio theory is mathematically justified (Piasecki & Tomasik, 2013, p. 31). Calculating the rate of return on the basis of the presented formula allows us to assess the profitability of investing in the shares of a given company at the time of the IPO.

In order to draw inferences for the groups of companies that debuted on the WSE and were distinguished within the research sample, the rates of return calculated for individual companies on specific trading days can be aggregated and averaged across firms within a given group. This approach enables the estimation of the average adjusted initial return. The formula for the average immediate rate of return on the day of debut is as follows (Siwek, 2005, p. 146):

$$\overline{\mathrm{IR}} = \frac{1}{\mathrm{N}} \sum_{\mathrm{i}=1}^{\mathrm{N}} \mathrm{IR_i} \tag{2}$$

where:

$\overline{IR}$ – average immediate rate of return;

N – total number of companies surveyed.

Research papers also use the adjusted immediate rate of return for the relative change in the stock market index (AIR). This rate takes into account the change in the broad market, which allows an analysis of the profitability of the investment relative to the overall market. In the empirical part, the WIG index was taken as the benchmark for stock returns reflecting the efficiency of investments in the broad stock market due to the fact that it is considered the primary

barometer of the Polish stock market (Zimny, 2017, p. 114). The formula for the immediate adjusted rate of return was as follows (Podedworna-Tarnowska & Kiełpsz, 2024, p. 56; Wieczorek, 2019, p. 88; Wieczorek 2020, p. 368):

$$\mathrm{AIR_i} = \frac{(\mathrm{P_i} - \mathrm{E_i})}{\mathrm{E_i}} - \frac{(\mathrm{M_i} - \mathrm{M_o})}{\mathrm{M_o}} \times 100\% \tag{3}$$

where:
AIR_i – the immediate return on investment in the company's shares *and* IPO offerings adjusted for the relative change in the stock market index;
P_i – the closing price of the company's shares *and* on the first day of trading;
E_i – the price of the shares offered by the company (issue price or reference price).
M_i – value of the stock exchange index on the first day of trading of the company I;
M_0 – value of the stock market index on the date of allotment of the company's shares i.

The following formula (Siwek, 2005, p. 155) was used to calculate the average adjusted immediate stock return of all companies for a given time interval:

$$\overline{\mathrm{AIR}} = \frac{1}{\mathrm{N}} \sum_{\mathrm{i}=1}^{\mathrm{N}} \mathrm{AIR_i} \tag{4}$$

The average adjusted immediate return indicates what the abnormal return was in each of the consecutive quotations considered.

With regard to the immediate adjusted stock return in the empirical part, a verification of statistical significance was also carried out. Accordingly, two research hypotheses were formulated:

$$\begin{aligned} \mathrm{H_0} &: \mathrm{AIR_i} = 0 \\ \mathrm{H_1} &: \mathrm{AIR_i} > 0 \end{aligned} \tag{5}$$

A parametric test t_{stat} for the sample mean value with a one-sided rejection area, based on the Student's t-statistic, which is determined according to the following formula, was used to verify the hypotheses:

$$\mathrm{t_{stat}} = \frac{\mathrm{AIR_i}}{\widehat{\mathrm{S}}(\overline{\mathrm{AIR_i}})} \sqrt{\mathrm{n}} \tag{6}$$

where:
$\widehat{\mathrm{S}}(\overline{\mathrm{AIR_i}})$ – the standard deviation of the adjusted stock return on the first day of trading.

Under the assumption that the instantaneous rates of return have a normal distribution and the statistical hypothesis H_0 is true, the test statistic t_{stat} has a Student's t-distribution with n-1 degrees of freedom. If the decision is made to reject the null hypothesis, the instantaneous rate of return will differ from zero and the result obtained will be statistically significant. For specific rates of return, the value of the test statistic t_{stat} was determined together with the critical probability (Sosnowski, 2014, p. 201).

In order to calculate returns over longer time intervals, the BHR '*buy-and-hold*' (BHR) approach is used in the literature to verify the occurrence of overvaluation of share prices over the longer term. This assumption is based on the fact that the investor will hold the purchased shares in the portfolio at the time of the IPO until the exit (Wieczorek, 2020, p. 368). The timing of the sale in the empirical part was denoted as 1M/3M/6M/12M/24M/48M/60M/72M, respectively, where *M* refers to the number of months since the IPO for each time interval *t*. The return on BHR shares was calculated as follows (Podedworna-Tarnowska & Kiełpsz, 2024, p. 56; Wieczorek, 2020, p. 368):

$$\mathrm{BHR}_{\mathrm{i,T}}^{\mathrm{IP0}} = \frac{\mathrm{P_{it}} - \mathrm{P_{i1}}}{\mathrm{P_{i1}}} \times 100\% \tag{7}$$

where:
$\mathrm{BHR}_{\mathrm{i,T}}^{\mathrm{IP0}}$ – simple rate of return on investment in company *i* shares at date *t*;
P_{it} – the closing price of *i*'s shares on the day of quotation *t*;
P_{i1} – the allotment price of the company's *i* shares on the allotment date $t = 1$.

The following formula was used to calculate the average stock return of all companies (BHR) for a given time interval:

$$\overline{\mathrm{BHR}}_{\mathrm{\iota,T}}^{\mathrm{IPO}} = \frac{1}{\mathrm{N}} \sum_{\mathrm{n=1}}^{\mathrm{N}} \mathrm{BHR}_{\mathrm{i,T}}^{\mathrm{IPO}} \tag{8}$$

where:
N – total number of companies surveyed.

On the other hand, if the rate of return on specific financial instruments is compared to the returns on the benchmark portfolio, then the so-called *abnormal* return, BHAR (*buy and hold abnormal return*), is determined. In order to calculate the BHAR, the simple rate of return on the shares of company *i* for quotation *t* $\left(\mathrm{BHR}_{\mathrm{i,T}}^{\mathrm{IPO}}\right)$ should be adjusted by the hypothetical rate of return on the WIG income index, which is calculated according to the following formula (Kochalski, Ratajczak, p. 137):

$$\mathrm{BHR}_{\mathrm{i,T}}^{\mathrm{WIG}} = \frac{\mathrm{I}_{\mathrm{i,t}} - \mathrm{I}_{\mathrm{i,1}}}{\mathrm{I}_{\mathrm{i,1}}} \times 100\% \tag{9}$$

where:

$I_{n,T}$ – the closing price of the WIG index corresponding to quotation t for company i,

$I_{i,1}$ – the closing price of the WIG index on the date of allotment of $t = 1$ share in company i.

The abnormal rate of return for each company on successive trading days was determined according to the following formula (Kochalski & Ratajczak, p. 369):

$$\mathrm{BHAR}_{\mathrm{T}}^{\mathrm{i}} = \mathrm{BHR}_{\mathrm{i,T}}^{\mathrm{IPO}} - \mathrm{BHR}_{\mathrm{i,T}}^{\mathrm{WIG}} \tag{10}$$

In order to calculate the abnormal return of all companies considered under the time criterion, the equation for the average abnormal return was used (Podedworna-Tarnowska & Kiełpsz, 2024, p. 56):

$$\overline{\mathrm{BHAR}}_{\mathrm{T}} = \frac{1}{\mathrm{N}} \sum_{\mathrm{i=1}}^{\mathrm{N}} \mathrm{BHAR}_{\mathrm{T}}^{\mathrm{i}} \tag{11}$$

As for instantaneous returns, two statistical hypotheses were also formulated for the returns resulting from the implementation of the buy-and-hold strategy (Sosnowski, 2014, p. 224):

$$\begin{aligned} \mathrm{H}_0 &: \mathrm{BHAR}_{\mathrm{T}} = 0 \\ \mathrm{H}_1 &: \mathrm{BHAR}_{\mathrm{T}} < 0 \end{aligned} \tag{12}$$

A parametric test with a one-sided rejection area was used to verify the hypotheses, whose Student's t-statistic was determined according to the following formula (Sosnowski, 2014, p. 224):

$$\mathrm{t}_{\mathrm{stat}} = \frac{\mathrm{BHAR}_{\mathrm{T}}}{\widehat{\mathrm{S}}(\overline{\mathrm{BHAR}}_{\mathrm{T}})} \sqrt{\mathrm{n}} \tag{13}$$

where:

$\widehat{\mathrm{S}}(\overline{\mathrm{BHAR}}_{\mathrm{T}})$ – standard deviation of the BHAR return.

Assuming a normal distribution for BHAR returns and the truth of the statistical hypothesis H_0, the test statistic t_{stat} has a Student's t-distribution with n-1 degrees of freedom. Rejecting the null hypothesis will mean that the BHAR return rate is significantly different from zero and the result obtained is statistically significant.

Short- and Long-Term Stock Returns in the Light of Own Research

Survey Design and Sampling

Secondary data was used to analyze returns on shares debuted on the main market, which came from the official website of the WSE (issue price data) and the website stooq.pl (closing quotations of shares and the WIG stock market index). The advantage of data from this source is the inclusion of operations such as (Stooq):

- dividends;
- subscription rights;
- acquisition rights;
- rights of coverage;
- share splits;
- denominations of stock market indices.

All the events mentioned have been included in the historical share prices of the companies by converting them with the appropriate divisor value, so that they did not distort the rates of return for the periods in which they occurred.

The research sample was purposively selected based on the following criteria:

1. The analysis includes companies that conducted an initial public offering (IPO) on the Warsaw Stock Exchange between 2010 and 2024 and were listed on 31.12.2024. Entities debuting on the alternative market – NewConnect – were excluded from the research sample.
2. Companies which, although they debuted on the main market, had a transition from the NewConnect market were omitted, as well as those with so-called *cross-listing*, i.e., those which were listed simultaneously on several stock exchange floors.
3. Entities that did not have a classic IPO on the WSE were excluded, such as companies with *dual listings* such as Sopharma AD, Eurohold Bulgaria, Tatry Mountain Resorts, AB Inter Rao, City Service and Marvipol Development.
4. Companies for which the initial price (issue price, offer price) was known at the time of the IPO on the Warsaw Stock Exchange were qualified for the study.
5. Companies for which the closing price of the shares was known on the first day of trading on the Warsaw Stock Exchange were included.

In addition, it should be emphasized that, as in the research of T. Sosnowski (2014, pp. 197–198), in the case of a rights issue (RBO), the RBO price was treated on a par with the share price. On the other hand, if both types of securities were listed on the day of the debut, then the closing price of the shares was taken into account.

In the end, the research sample comprised 90 companies. Stock returns were analyzed depending on the investment horizon adopted from the date of the IPO. It was assumed that investors follow a passive investment strategy of holding the purchased shares for a certain period of time regardless of the economic situation in the country or market developments.

Taking into account the investment horizon, an immediate return (IR) and an adjusted immediate return (AIR) were calculated for each company in the sample, as well as a simple return (BHR) and a rate relative to the WIG (BHAR) over longer periods, assuming the following investment horizons:

a) 1 month (21 trading sessions);
b) 3 months (63 trading sessions);
c) 6 months (126 trading sessions);
d) 12 months (252 trading sessions);
e) 24 months (504 trading sessions);
f) 36 months (756 trading sessions);
g) 48 months (1008 trading sessions);
h) 60 months (1260 trading sessions);
i) 72 months (1512 trading sessions).

Rates of return were determined for each company involved in the IPO, and then mean, median and standard deviation values were calculated for the four periods:

- 2010–2012;
- 2013–2015;
- 2016–2018;
- 2019–2024.

This division made it possible to ensure a comparable number of companies in each time interval, which increases the reliability of statistical analyses. In addition, this solution made it possible to capture the different phases of the business cycle and the specific macroeconomic and market conditions in Poland and Europe at the analyzed time, facilitating comparisons of the rates of return of debuting companies under different market conditions.

Characteristics of the Research Sample

Table 1 presents the number of companies that debuted on the WSE's main market (excluding NewConnect) between 2010 and 2024, the number of entities active on the WSE as at December 31, 2024, included in the research sample, as well as the percentage share of active companies in the total number of debutants in each year.

Table 1.

Data on the number of companies on the WSE included in the sample and the share of the sample companies in the number of IPOs on the WSE between 2010 and 2024

Year of the company's debut	Number of companies newly listed on the WSE (excluding NewConnect)	Number of companies in the research sample (companies active on the WSE as at 31.12.2024)	Share of companies in the sample in the total number of companies newly listed on the WSE
1	2	3	4 = (col. 3/col. 2) × 100
2010	27	14	52%
2011	32	13	41%
2012	17	6	35%
2013	16	9	56%
2014	18	7	39%
2015	17	9	53%
2016	12	6	50%
2017	8	3	38%
2018	5	4	80%
2019	1	1	100%
2020	5	5	100%
2021	12	11	92%
2022	0	0	–
2023	1	1	100%
2024	1	1	100%
total	172	90	52%

Source: Own study.

As can be seen from the data presented in Table 1, at the end of 2024, 52% of the companies that debuted between 2010 and 2024 remained listed on the WSE's main market. It is worth noting that of the 172 companies that debuted in the analyzed period, 82 companies were not included in the research sample, which was due to, among other things, merger, acquisition, bankruptcy or delisting processes. Between 2010 and 2016, the percentage of companies included in the survey ranged from 35% to 56%. In contrast, in years when the number of IPOs was very low (2018–2021, 2023–2024), the percentage of companies in the sample was very high, often reaching 100%. The year 2017 stood out with a low number of IPOs (8) and at the same time a relatively low proportion of companies that were in the sample (38%).

In the following part of the analysis, basic descriptive statistics – arithmetic mean, standard deviation and coefficient of variation – were calculated for the IPOs included in the study. Due to the wide scope of the analyzed period, these values referred to aggregate data for the years 2010–2024. The results of these calculations are presented in Table 2.

Table 2.
Selected descriptive statistics on the number of IPOs included in the sample for the period 2010 to 2024

Statistics	Average	Standard deviation	Coefficient of variation
Value	6.00	4.49	74.80%

Source: own study.

The data in Table 2 shows that the average number of IPOs on the WSE during the period under study was six per year. The standard deviation, which illustrates the dispersion of the results around the average, reached a value of 4.49, indicating significant variation in the number of debuts in individual years. This variation may have been the result of macroeconomic, political or other external factors. A coefficient of variation of around 75% indicates a high volatility in the number of IPOs relative to the average. This level of volatility suggests difficulties in predicting the number of IPOs in subsequent years.

Characteristics of the Research Sample

Short-term Stock Returns – Results of the Analysis

Table 3 (p. 42) provides a summary of the companies from each year of the period under review (2010–2024) for which there was an increase in price relative to the issue price, a decrease in price or no change in closing price relative to the IPO issue price on the IPO date.

An analysis of the annual data shows that the majority of companies that proceeded with an IPO recorded an increase in price on their debut day. Particularly noteworthy is 2015, when only 33.33% of companies recorded an increase in share price, indicating a weaker performance compared to the other years. In 2018–2019, all IPO companies ended the first day of trading with a price higher than the issue price. The year 2015 also stood out for having the highest share of companies whose shares lost value at the close of the session on the debut day (55.56%), which may indicate unfavorable market conditions for new issuers. During the period under review, seven years saw IPOs where the issue price was equal to the closing price on

the day of listing. It is also worth noting that there were no IPOs in 2022, which may indicate a decline in interest in IPOs. The last years covered by the analysis (2023–2024) show limited activity in the IPO market.

Table 3.

Number of companies with upside, downside and no volatility in closing price relative to issue price between 2010 and 2024

Year	N	Price increase on debut		Price drop on debut		Issue price = closing price on debut	
		n	%	n	%	n	%
2010	14	11	78.57	3	21.43	0	–
2011	13	8	61.54	4	30.77	1	7.69
2012	6	5	83.33	1	16.67	0	–
2013	9	6	66.67	2	22.22	1	11.11
2014	7	6	85.71	0	0.00	1	14.29
2015	9	3	33.33	5	55.56	1	11.11
2016	6	3	50.00	2	33.33	1	16.67
2017	3	2	66.67	1	33.33	0	–
2018	4	4	100.00	0	0.00	0	–
2019	1	1	100.00	0	0.00	0	–
2020	5	4	80.00	0	0.00	1	20.00
2021	11	5	45.45	6	54.55	0	–
2022	0	0	–	0	–	0	–
2023	1	1	100.00	0	0.00	0	0.00
2024	1	0	0.00	0	0.00	1	100.00
total	90	59	–	24	–	7	–

Source: Own study.

Table 4 presents the results of the analysis with immediate returns (IR) and returns adjusted for the change in the broad market, as expressed by the WIG index (AIR).

The average immediate rate of return (IR) from 2010 to 2024 was 9.73%, with the median value slightly lower at 8.69%. The adjusted immediate rate of return (AIR) reached a similar level of 9.60%, with a median of 8.65%. As in other empirical analyses, the differences between pre- and post-adjusted returns proved to be small. The highest IR and AIR values were achieved by in 2020, at 43.88% and 40.92% respectively, which was largely due to two companies from the gaming sector – GAMES OPERATORS and PCF GROUP, for which IR and AIR were

around 100% (90.80%) and 49.96% (46.95%) respectively. High returns were also achieved by ALLEGRO, where IR reached 62.79% and AIR reached 64.94%. In contrast, the lowest average returns occurred in 2015 and amounted to 0.62% (IR) and 2.90% (AIR), as a result of the negative performance of four companies: ATAL, DEKPOL, KGL CORPORATION, KRYNICA VITAMIN. These results confirm the phenomenon of stock undervaluation during IPOs in the sample.

Table 4.

Immediate unadjusted (IR) and adjusted (AIR) returns from 2010 to 2024

Year	N	Average	Median	Standard deviation	Average	Median	Standard deviation	*T-statistics* for AIR	The *p-value*
		Immediate rate of return (IR)			Adjusted immediate rate of return (AIR)				
2010	14	8.48%	7.07%	8.81%	7.06%	5.17%	8.33%	3.17	0.36%
2011	13	2.32%	1.52%	11.73%	5.94%	5.00%	12.21%	1.75	9.94%
2012	6	17.42%	7.68%	25.48%	16.89%	6.02%	23.16%	1.79	6.67%
2013	9	10.56%	18.59%	13.20%	9.44%	14.91%	14.91%	1.90	4.70%
2014	7	1.44%	1.72%	0.85%	2.33%	2.09%	1.59%	3.88	0.41%
2015	9	0.62%	−1.29%	4.70%	2.90%	2.90%	5.09%	1.71	6.28%
2016	6	4.32%	2.39%	7.75%	5.03%	2.89%	9.34%	1.32	12.20%
2017	3	2.83%	1.82%	7.06%	2.19%	2.05%	7.35%	0.52	32.74%
2018	4	10.83%	3.53%	13.86%	9.60%	4.61%	15.92%	1.21	15.65%
2019	1	14.74%	14.74%	–	17.57%	17.57%	–	–	–
2020	5	43.88%	49.96%	41.40%	40.92%	46.95%	35.51%	2.58	3.07%
2021	11	4.84%	−0.01%	12.04%	3.98%	0.34%	11.15%	1.19	13.08%
2022	0	–	–	–	–	–	–	n.a.	n.a.
2023	1	13.94%	13.94%	–	8.97%	8.97%	–	–	–
2024	1	0.00%	0.00%	–	1.62%	1.62%	–	–	–
average	90	9.73%	8.69%	13.35%	9.60%	8.65%	13.14%	–	–

Source: Own study.

Due to the fact that the average adjusted rates of return, calculated separately for the individual years covered by the study, turned out to be statistically insignificant in most cases, it was decided to determine their value after the first day of trading in time intervals selected so as to

include a comparable number of companies in each of them. A division into three groups was adopted: companies for which the issue price was lower than the closing price on the debut day, companies for which the issue price exceeded the closing price and companies for which the closing price at the end of the first trading day was equal to the issue price. The results of these calculations are shown in Table 5.

Table 5.

Immediate unadjusted (IR) and adjusted (AIR) return rates over several year intervals from 2010 to 2024

Year	N	Average	Median	Standard deviation	Average	Median	Standard deviation	*T-statistics* for AIR	The *p-value*
		IR			AIR				
2010–2012									
total	33	7.68%	3.86%	14.42%	8.41%	5.00%	14.14%	3.42	0.09%
issue price < closing price	24	12.07%	7.14%	13.95%	11.97%	7.10%	13.91%	4.22	0.02%
issue price > closing price	8	−4.52%	−1.49%	7.69%	−1.30%	−0.13%	10.21%	−0.36	63.53%
issue price = closing price	1	0.00%	0.00%	0.00%	0.58%	0.58%	–	–	–
2013–2015									
total	25	4.43%	1.72%	9.42%	5.09%	2.90%	8.97%	2.84	0.45%
issue price < closing price	15	9.46%	6.82%	8.47%	10.00%	8.48%	7.69%	5.03	0.00%
issue price > closing price	7	−4.44%	−4.11%	3.26%	−3.13%	−2.92%	5.07%	−1.64	92.39%
issue price = closing price	3	0.00%	0.00%	0.00%	−0.23%	0.21%	2.75%	−0.14	54.93%

Year	N	Average	Median	Standard deviation	Average	Median	Standard deviation	*T-statistics* for AIR	The *p-value*
		IR			AIR				
2016–2018									
total	13	5.98%	2.94%	10.45%	5.78%	3.79%	10.59%	1.97	3.62%
issue price < closing price	9	9.90%	4.78%	10.30%	9.87%	6.23%	25.78%	1.15	14.17%
issue price > closing price	3	−3.78%	−3.85%	1.24%	−3.65%	−3.74%	2.57%	−2.46	93.35%
issue price = closing price	1	0.00%	0.00%	0.00%	−2.82%	−2.82%	–	–	–
2019–2024									
total	19	15.86%	8.00%	27.11%	14.56%	14.56%	14.56%	**4.36**	**0.02%**
issue price < closing price	11	29.69%	14.74%	12.38%	27.78%	27.78%	27.78%	3.32	0.39%
issue price > closing price	6	−4.21%	−1.21%	6.15%	−4.94%	−4.94%	−4.94%	2.45	2.90%
issue price = closing price	2	0.00%	0.00%	0.00%	0.32%	0.32%	1.30%	0.35	39.28%

Source: Own study.

The data presented in Table 5 shows that the highest average IR returns were recorded between 2019 and 2024, reaching 15.86%. The adjusted AIR return over this period was 14.56%. Performance varied by a group of companies (where the issue price was lower, higher or equal to the closing price). For companies where the issue price was lower than the closing price, the average IR between 2019 and 2024 was 29.69%, while AIR was lower at 27.78%. In contrast, for companies where the issue price exceeded the closing price at the end of the first day of trading, both IR and AIR took on negative values, indicating a loss for investors realizing a gain on the day of the debut. The average adjusted returns were statistically significant for companies with an undervalued share price in 2010–2012, 2013–2015, as well as for all companies

debuting in 2019–2024. This period was characterized by strong capital market growth, which supported higher returns. The positive performance was influenced by expansionary monetary policy and the recovery of the economy after the pandemic crisis (in 2019–2021).

Long-term stock returns – results of the analysis

Considering 3-year periods (for the period 2010–2018) and 5-year periods for the period 2019 to 2024, the levels of unadjusted and adjusted stock returns over a longer time horizon than one day from the IPO date are shown in Table 6. The returns at different exit points – after 1, 3, 6, 12, 24, 36, 48, 60 and 72 months from the IPO date – are analyzed.

Table 6.

Unadjusted (BHR) and adjusted returns (BHAR) on first issue shares by investment horizon from the date of listing (in months) over the period 2010–2024

Year	N	Average	Median	Standard deviation	Average	Median	Standard deviation	Statistics *t* for BHAR	The *p-value*
			BHR 1M				**BHAR 1M**		
2010–2012	33	2.78%	0.38%	15.42%	2.03%	1.17%	15.67%	0.74	23.23%
2013–2015	25	2.16%	0.23%	8.12%	2.85%	3.07%	7.17%	1.99	2.90%
2016–2018	13	5.00%	0.00%	11.65%	3.79%	−0.72%	13.42%	1.02	16.39%
2019–2024	19	−1.20%	−3.15%	11.96%	−3.20%	−2.62%	11.65%	−1.20	87.72%
Return on shares			**BHR 3M**				**BHAR 3M**		
2010–2012	33	7.75%	0.94%	39.33%	7.46%	3.07%	38.29%	1.12	13.55%
2013–2015	25	5.11%	4.34%	13.78%	4.49%	5.93%	13.43%	1.67	5.40%
2016–2018	13	11.48%	−2.86%	24.91%	8.46%	4.46%	26.48%	1.15	13.63%
2019–2024	19	−1.23%	2.43%	16.85%	−4.79%	−1.74%	15.00%	−1.39	90.93%
Return on shares			**BHR 6M**				**BHAR 6M**		
2010–2012	33	1.68%	−5.06%	35.71%	0.97%	−4.30%	34.04%	0.16	43.69%
2013–2015	25	19.64%	13.77%	36.20%	19.17%	17.07%	31.70%	3.02	0.30%
2016–2018	13	13.55%	1.10%	46.33%	7.10%	−2.82%	46.16%	0.55	29.62%
2019–2024	19	−10.52%	−7.70%	24.05%	−18.87%	−15.40%	26.52%	−3.10	99.69%
Return on shares			**BHR 12M**				**BHAR 12M**		
2010–2012	33	−3.25%	−10.32%	66.01%	0.01%	−3.71%	63.42%	0.00	50.00%
2013–2015	25	19.33%	14.12%	34.80%	18.71%	11.53%	32.84%	2.85	0.44%

Year	N	Average	Median	Standard deviation	Average	Median	Standard deviation	Statistics *t* for BHAR	The *p-value*
2016–2018	13	16.45%	−18.69%	69.04%	2.79%	−17.02%	68.05%	0.15	44.16%
2019–2024	18	−23.98%	−16.47%	23.20%	−25.83%	−20.27%	34.50%	−3.18	99.73%
Return on shares			**BHR 24M**				**BHAR 24M**		
2010–2012	33	−2.45%	−27.60%	81.96%	−5.19%	−21.94%	79.09%	−0.38	64.68%
2013–2015	25	30.44%	23.99%	43.90%	23.13%	21.52%	47.72%	2.42	1.17%
2016–2018	13	54.17%	18.98%	149.83%	48.03%	−11.11%	154.14%	1.12	14.23%
2019–2024	17	−29.04%	−26.68%	28.43%	−32.01%	−21.01%	33.61%	−3.93	99.94%
Return on shares			**BHR 36M**				**BHAR 36M**		
2010–2012	33	11.31%	−10.99%	92.32%	−2.17%	−25.47%	91.43%	−0.14	55.52%
2013–2015	25	38.68%	26.98%	62.42%	29.38%	27.54%	60.68%	2.42	1.17%
2016–2018	13	123.86%	61.11%	238.26%	117.18%	71.42%	241.16%	1.75	5.28%
2019–2024	17	−28.56%	−39.18%	42.87%	−53.08%	−66.09%	45.25%	−4.84	99.99%
Return on shares			**BHR 48M**				**BHAR 48M**		
2010–2012	33	5.28%	−15.17%	86.15%	−11.40%	−31.72%	85.78%	−0.76	77.36%
2013–2015	25	48.34%	7.10%	91.59%	29.57%	−10.27%	92.04%	1.61	6.02%
2016–2018	13	144.21%	69.65%	287.80%	140.45%	51.98%	287.07%	1.76	5.19%
2019–2024	11	−16.26%	0.00%	46.76%	−43.86%	−27.34%	58.38%	−2.49	98.40%
Return on shares			**BHR 60M**				**BHAR 60M**		
2010–2012	33	29.96%	−21.01%	130.38%	13.74%	−28.26%	135.76%	0.58	28.30%
2013–2015	25	40.83%	1.52%	95.10%	30.00%	15.26%	96.45%	1.56	6.59%
2016–2018	13	171.87%	111.05%	300.38%	155.00%	65.46%	292.18%	1.91	4.02%
2019–2024	2	−5.30%	0.00%	15.70%	−13.09%	0.00%	40.02%	−0.46	63.72%
Return on shares			**BHR 72M**				**BHAR 72M**		
2010–2012	33	43.74%	−21.61%	176.12%	23.48%	−28.20%	177.39%	0.76	22.64%
2013–2015	25	37.05%	15.40%	84.79%	20.89%	21.93%	79.88%	1.31	10.13%
2016–2018	13	165.58%	50.13%	318.73%	140.47%	−0.63%	321.67%	1.57	7.12%
2019–2024	1	−2.89%	0.00%	12.28%	−6.28%	0.00%	26.65%	–	–

Source: Own study.

The results obtained show the volatility of unadjusted returns, as well as those adjusted for the WIG index, depending on the time horizon adopted, calculated from the date of debut. Between 2010 and 2012, stock returns (BHARs) were generally positive, with the exception

of the 24M, 36M and 48M time intervals. It is worth noting that the overstatement of average returns from the third month to three years after the debut was influenced by the high stock returns (even more than 200% increase relative to the issue price) of PCC EXOL. From one year after the debut to five years, significant returns (100–200%) were also achieved by the company ZAMET INDUSTRY. Good results in this period, especially after two years since the debut, were recorded for the companies: EUROPEAN CENTRUM ODSZKODOWAŃ, BENEFIT SYSTEMS, KRUK and AC.

Over the 2013–2015 period, BHR and BHAR returns were positive and statistically significant for the time intervals: 1M, 6M, 12M, 24M, 36M. Particularly high returns, often exceeding 100% three years after listing, were recorded for companies: MFO, ATAL, ENTER AIR. The years 2016–2018 were characterized by on average higher returns for BHR and BHAR, especially after three years from the debut, thanks to the solid performance of companies such as AUTO PARTNER, DINO POLSKA, TEN SQUARE GAMES, ML SYSTEM. During this period, the BHAR return for the horizon of 60 months after the debut was statistically significant. On the other hand, the lack of statistical significance for longer time intervals was due to the decreasing number of companies in the sample, which affected the calculation of the arithmetic mean.

The worst performance, reflected in the negative returns of the BHR and BHAR in all the time intervals analyzed, was recorded between 2019 and 2024. This situation can be explained by the economic problems after the pandemic, which translated into negative investment performance. The median returns also took negative values during this period.

In order to better illustrate the number of companies with positive and negative adjusted returns over the analyzed period, the results of the analysis are summarized in Table 7.

Table 7.

Number of companies with negative and positive average BHAR returns sampled in time intervals from 1M to 72 M after listing from 2010 to 2024

Period	Description	BHAR 1M	BHAR 3M	BHAR 6M	BHAR 12M	BHAR 24M	BHAR 36M	BHAR 48M	BHAR 60M	BHAR 72M
2010–2012	negative	14	13	19	19	22	21	22	21	23
	positive	19	20	14	14	11	12	11	12	10
2013–2015	negative	8	10	5	6	7	9	14	12	11
	positive	17	15	20	19	18	16	11	13	14
2016–2018	negative	7	5	7	8	7	6	6	5	7
	positive	6	8	6	5	6	7	7	8	6
2019–2024	negative	12	11	16	13	16	16	10	2	1
	positive	7	8	3	5	1	1	1	0	0

Source: Own study.

Analysis of the data presented in Table 7 shows changes in the number of companies generating positive and negative average BHAR returns with different investment horizons between 2010 and 2024. In the period 2010–2012, holding shares of debuting companies for up to 3 months usually yielded positive returns, while as the investment period was extended to at least 6 months, the number of companies generating negative returns clearly increased. In subsequent years, between 2013 and 2015, the situation improved in favor of investors – the number of companies generating positive BHAR returns significantly exceeded the number of those generating losses, indicating favorable market conditions for new issuers. A gradual decline in the number of companies generating positive returns was observed in subsequent time frames (2016–2018 and 2019–2024). In particular, in the years 2019–2024, companies with negative abnormal returns prevailed in all the investment horizons analyzed.

Discussion

The analysis of short-term rates of return in our own research confirmed the existence of the phenomenon of undervaluation of share prices in IPOs on the Polish capital market during the analyzed period. The average immediate rate of return (IR) between 2010 and 2024 was 9.73%, while its adjusted value (AIR) was slightly lower at 9.60%. These results are similar to those obtained in other studies on the Polish market, suggesting a continuing trend of a decrease in the scale of undervaluation compared to the 1990s and early 2000s. For example, Czapiewski et al. (2014) showed an average adjusted IR of 34.1% for 1991–2011 and 13.6% for 2001–2011, while Trąpczyński (2017) recorded a level of 7.89% for 2007–2016, which was lower than 19.8% for 1991–1997. Similar results were obtained by Lizińska and Czapiewski (2014) for 2004–2009 (10.89%) and Pomykalski and Domagalski (2015) for 2005–2013 (11.89%). On the other hand, the study by Podedworna-Tarnowska and Kiełpsz (2024) showed an average IR of 13.68% for the largest bids and 22.90% for the smallest bids between 2017 and 2021, while Sukacz (2005) reported 26% for the period between 1991 and 2002.

Comparing the results of our own research with foreign literature, it can be concluded that undervaluation is a common phenomenon, although its intensity depends on the market, the period and the phase of the business cycle. As Perz (2025) points out, this phenomenon was stronger in emerging markets than in developed markets. In China, for example, the average IR between 1989 and 1996 was 388.0%, while in mature markets, such as the US, it was 15.8% between 1960 and 1996. The most recent survey results for the US market (Ritter, 2025) for the period 1980–2023 show a record average IR of 158.0% for the period 2019–2023. The results for Poland (average IR of 9.73% in the own surveyed) rank much lower than in emerging markets or in selected periods in the US, but are in line with levels characteristic of mature markets or more developed emerging markets.

Analysis of the annual data in the self-study showed that a greater proportion of companies experienced an increase in their IPO price, although there was variation from year to year. The highest average returns (IR and AIR) were achieved in 2020. (43.88% and 40.92%), mainly driven by gaming companies and ALLEGRO. Aziewicz and Dobrowolski (2014) also highlighted the high volatility of IPO performance between 2005 and 2013. Their own study showed that average adjusted returns (AIR) were statistically significant for undervalued companies in 2010–2012, 2013–2015 and for all companies in the sample in 2019–2024. These results support the first part of the hypothesis of undervaluation in the short term.

With regard to long-term returns, our own research only partially confirmed the *underperformance* phenomenon observed in the literature (decline in the value of shares over a longer horizon). This phenomenon means that investors tend to lose out on investing in shares of debut companies compared to the market index or other companies. Ritter (2025) in his study for the US market (1980–2023) showed that the average 3-year adjusted returns (BHAR) were typically negative, e.g. −20.20% for the whole period and −296.40% for the years 2019–2023. Polish empirical studies also indicated lower returns on IPOs in the medium and longer term compared to the IPO date or market index. Sieradzki (2013) indicated an average negative abnormal return of −4.2% one year after the IPO. Zielinski (2013) found that the adjusted return of BHAR 36M on the WSE between 1994 and 2016 ranged from −14% to −28.6%. Rzewuska and Wrzesinski (2016) demonstrated that investments in companies with IPOs in 2006 yielded an average return 9% less than the index over a two-year period and 26% over a three-year period. Kwit (2006) estimated that after three years it was possible to gain 17% less compared to the shares of other companies listed on the WSE. Kochalski and Ratajczak (2025) showed a downward trend in the average return (BHR) on shares of companies with IPOs from 2009–2011 until the 370th day of trading, reaching an average of −19.35%. Aziewicz and Dobrowolski (2014) confirmed that the phenomenon of overvaluation after 12 months was not sustainable, with a more pronounced trend of negative returns emerging three years after the IPO.

The results of the own study for the period 2019–2024 are in line with these observations, showing negative average BHR and BHAR returns in all analyzed time intervals. However, the own study also showed periods in which the average returns of BHARs were positive, suggesting that *underperformance* is not a systematic phenomenon across all analyzed time intervals. Between 2010 and 2012, BHAR returns were generally positive, with the exception of the 24M, 36M and 48M intervals. Results from 2013 to 2015 were optimistic, with BHR and BHAR rates positive and statistically significant for intervals 1M, 6M, 12M, 24M, 36M. From 2016 to 2018, average BHR and BHAR returns were higher three years after the debut, and a statistically significant BHAR return was recorded for 60 months after the debut. This variability corresponds

to Aziewicz and Dobrowolski's (2014) observation that the overvaluation phenomenon after 12 months was not sustainable.

An analysis of the number of companies with positive and negative BHAR returns also shows variability over time. While 2010–2012 and 2013–2015 were dominated by companies with positive BHARs in shorter and medium horizons, 2019–2024 was dominated by companies generating negative abnormal returns in all time intervals.

In summary, the results of our own research confirm the existence of the phenomenon of underperformance of share prices in the short term on the WSE main market. On the other hand, with regard to the medium and long term, the results are variable and do not indicate systematic overvaluation (negative returns) in all analyzed time frames, although the underperformance phenomenon was evident in some period, especially in the years 2019–2024. This is consistent with the second part of the research hypothesis for the years 2019–2024, but not for the entire medium- and long-term period studied.

Conclusions

The aim of this study was to assess the development of short- and long-term returns on initial public offerings (IPOs) on the Warsaw Stock Exchange. The in-house study was aimed at verifying the hypothesis assuming the existence of anomalies on the WSE main market, consisting in the undervaluation of share prices in the short term and their overvaluation in the medium and long term. The main research method was the analysis of historical stock returns from IPOs between 2010 and 2024.

The study confirmed the phenomenon of undervaluation of share prices in IPOs on the Polish capital market during the analyzed period. The average immediate return (IR) for the period 2010–2024 was 9.73% and the adjusted immediate return (AIR) reached 9.60%. These results confirmed the first part of the research hypothesis of undervaluation in the short term.

With regard to medium- and long-term returns, our own research only partially confirmed the *underperformance* phenomenon observed in the literature, which means that investors tend to lose out on investing in shares of debut companies compared to the market index or other companies. Although negative average abnormal returns (BHARs) occurred for some periods and the *underperformance* phenomenon was particularly pronounced in the period 2019–2024, where negative average BHARs were recorded in all analyzed intervals, results in other periods (e.g. 2013–2015, 2016–2018 in some intervals) showed positive average BHARs. This means that the own study does not indicate systematic overvaluation (negative returns) in all analyzed time intervals. This is consistent with the second part of the research hypothesis for the years 2019–2024, but not for the entire medium- and long-term period studied.

This study is original due to its analysis of current data for the Polish main market of the WSE from 2010–2024, which fills the information gap after 2016. The study is comprehensive, covering both short and long periods, considering different investment horizons, which is rare in previous Polish studies. In addition, the analysis takes into account different time frames reflecting business cycles.

One of the noted limitations of the study's results is the lack of statistical significance for returns with longer intervals, due to a decrease in the number of companies included in the analysis. Of the 172 companies that debuted during the period, 82 were not included in the research sample for various reasons, such as mergers, acquisitions, bankruptcies or delisting. This means that the long-term analysis only looks at companies that have survived on the market until the end of 2024, which may affect the picture of long-term returns (potential burden of the survival effect).

The research sample was purposively selected based on specific criteria. Companies debuting on the alternative market NewConnect, those which transferred from NewConnect to the main market, as well as those with cross-listing (listed simultaneously on several trading floors) or dual listing were excluded from the analysis. Companies for which there was no data on the issue price or closing price on the day of listing were also excluded. These criteria limit the scope of the study to only classic IPOs on the WSE's main market carried out by companies meeting certain conditions of data availability and market presence, which may affect the possibility of generalizing the results to all types of IPOs or all companies that have ever debuted.

The information obtained in the study can be further used as a database and reference point for future analyses, for example comparing the effectiveness of IPOs on the WSE with other markets (especially emerging markets), examining the determinants of short- and long-term returns for the Polish market, or analyzing the impact of specific market and macroeconomic factors on the performance of IPOs in particular periods.

The results provide valuable insights for market participants. Information on undervaluation in the short term and volatility of returns in the long term is of direct relevance to investors (e.g., in the context of investment strategies), issuers (e.g., in the context of pricing policies in IPOs) and financial intermediaries.

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Hanna Kociemska https://orcid.org/0000-0003-3421-6574
Corresponding Author
PhD, Wroclaw University of Economics and Business, e-mail: hanna.kociemska@ue.wroc.pl

Sylwia Frydrych https://orcid.org/0000-0002-1215-4950
PhD, SGH Warsaw School of Economics, e-mail: sfrydr@sgh.waw.pl

GREEN BONDS AS CATALYSTS FOR CHANGE: DRIVING CO_2 REDUCTION AND SUSTAINABLE FINANCE ACROSS EUROPE

Abstract

The purpose of the article. The growing importance of sustainability and climate change mitigation has spurred a rise in green bond issuance across the European Union (EU). However, questions remain about the long-term effectiveness of these instruments in reducing CO_2 emissions, particularly given economic, governance, and environmental factors such as GDP and forest cover. Understanding the dynamics of various types of green bonds, including certified and self-labelled bonds, is essential for assessing their role in promoting sustainable development.

Methodology. Methodology/approach: the study aims to assess the relationship between green bond issuance and CO_2 emissions reduction in 25 EU countries from 2007 to 2022. It evaluates how different types of green bonds, including Climate Bonds Initiative (CBI)-aligned and social green bonds, contribute to decarbonization, considering factors such as governance quality, economic performance, and natural infrastructure. The research employs descriptive statistics, correlation analysis, and fixed- and random-effects panel data models.

Results of the research. Findings/implications: The results reveal that CBI-aligned green bonds have a statistically significant impact on reducing CO_2 emissions, with coefficients indicating an 8.5% reduction for a 1% increase in bond value. Self-labelled green bonds exhibit greater variability in effectiveness due to limited certification. Social green bonds have minimal impact on CO_2 emissions reductions, reflecting their broader focus on both environmental and social goals. Economic indicators, such as GDP per capita and forest cover, positively moderate the relationship between green bonds and emissions reduction, underscoring the importance of institutional capacity and natural carbon sinks in achieving sustainability goals.

Keywords: CO_2 emissions; sustainability; European Countries; panel data analysis
JEL Class: Q56, Q58, C33, O44

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Introduction

Green bonds fund decarbonization and support sustainable growth. They leverage capital markets to support environmental goals aligned with the EU's climate targets under the European Green Deal and the Paris Agreement. These frameworks aim to make the EU the first climate-neutral continent by 2050, emphasizing the need for financial mechanisms that blend economic advancement with environmental progress stewardship. Despite their increasing prominence, the effectiveness of green bonds in reducing CO_2 emissions is not yet fully understood, particularly when contextual factors such as economic prosperity, forest cover, and capital market maturity are accounted for (Bestvina et al., 2023). Although previous studies have identified the direct impacts of green bonds on environmental outcomes (Zhang et al., 2022), there remains limited exploration of the systemic factors that influence their efficacy across varying national and economic landscapes. Furthermore, the diverse typologies of green bonds—ranging from self-labelled and Climate Bonds Initiative (CBI)-aligned instruments to social green bonds—exhibit varying levels of impact, necessitating a deeper investigation into their individual contributions to decarbonisation goals (Flammer, 2020).

This study investigates how green bond issuance influences CO_2 emission reductions across EU countries, examining economic, natural, and market factors, and assessing their cost-effectiveness and broader socioeconomic and ecological impacts to inform sustainable climate mitigation strategies. The theoretical basis for green bonds lies within the discipline of environmental finance, which explores how financial markets and instruments can be utilized to achieve sustainability objectives. GB can be explained throught portfolio theory and decarbonizations economics, linking financial returns with environmental objectives. (Markowitz, 1952; Eccles et al., 2014).

Green bonds are crucial to decarbonisation economics, supporting the transition to low-carbon systems through targeted financial tools. The large capital needed for renewable energy and low-emission infrastructure often hinders their implementation. Green bonds address this issue by providing the liquidity necessary to fund these initiatives, thereby bridging the gap between financing needs and climate objectives (Al Mamun et al., 2022). Furthermore, they facilitate the internalisation of environmental externalities, encouraging both issuers and investors to prioritise projects with measurable environmental impacts, such as reductions in greenhouse gas emissions. Green bonds represent the practical application of portfolio theory and decarbonisation economics, functioning at the intersection of public policy and market-driven mechanisms. Governments and regulatory agencies foster favourable conditions for green bond issuance by providing incentives such as tax benefits, certification frameworks, and policy alignments, as exemplified by the EU Green Deal (European Commission, 2019). The following research questions have been formulated to guide and structure the analysis.

RQ1: Primary Question:

To what extent does issuing different types of green bonds (self-labelled, Climate Bonds Initiative (CBI)-aligned, and social green bonds) contribute to reducing CO_2 emissions across European Union countries? Secondary Questions:

RQ1.1. How do economic factors such as GDP per capita and governance quality moderate the relationship between green bond issuance and CO_2 emissions reduction?

RQ1.2. What are the differences in effectiveness among self-labelled, CBI-aligned, and social green bonds in achieving environmental sustainability goals?

This study contributes to the sustainable-finance literature in several important ways. First, unlike many previous studies that treat green bonds as a homogeneous category, it distinguishes among self-labelled green bonds, Climate Bonds Initiative (CBI)-aligned green bonds, and social green bonds, enabling a direct comparison of their environmental effectiveness. Second, the study employs a long-term panel dataset covering 25 European countries over the period 2007–2022, encompassing both the early development and subsequent expansion of the European green-bond market. Third, the analysis integrates institutional, economic, and environmental dimensions by considering governance quality, GDP per capita, and forest cover simultaneously. Finally, the study investigates not only whether green bonds are associated with lower CO_2 emissions but also which bond structures generate the strongest decarbonisation effects. This multidimensional approach provides new evidence on the mechanisms by which sustainable finance instruments contribute to climate transition objectives in Europe.

The paper begins with an introduction outlining the research objectives and the significance of green bonds in promoting sustainability. The literature review explores prior studies on green bonds and environmental finance. The methodology specifies data sources and econometric models. The results demonstrate the varying effectiveness of different bond types in CO_2 reduction. The discussion interprets the findings, and the conclusion summarises the key insights, while outlining limitations and sug-gestions for future research, which provide recommendations for further exploration.

Literature Review

Green bonds have become an essential part of sustainable finance. Early studies primarily concentrated on the financial performance of green bonds, often overlooking their environmental impacts (Silva et al., 2024). Recent literature has shifted focus towards evaluating their effectiveness in achieving decarbonisation and broader sustainable development objectives (Wang et al., 2022). Green bonds have emerged as critical instruments for facilitating sustainable development, enabling financial markets to align with global environmental goals (Chen et al.,

2024). These bonds provide a mechanism for mobilising capital towards projects that mitigate environmental degradation while offering financial returns. Scholars have categorised green bonds into distinct types, including self-labelled bonds, certified bonds (e.g., Climate Bonds Initiative-aligned bonds), and social green bonds, each demonstrating varying levels of transparency, performance, and environmental impact (Flammer, 2020; Wang et al., 2022).

Self-labeled green bonds are issued without formal third-party verification, raising concerns about their effectiveness due to the risk of greenwashing—a scenario where issuers exaggerate the environmental benefits of their projects (Anh Tu et al., 2020). While these bonds can contribute to sustainability when backed by credible issuers, studies suggest that their impact on carbon reduction remains limited compared to certified alternatives (Cheong & Choi, 2020).

In contrast, certified green bonds, which adhere to internationally recognised standards set by the Climate Bonds Initiative (CBI), demonstrate superior performance in achieving environmental goals. Empirical research highlights that these bonds are associated with significant reductions in CO_2 emissions, primarily due to structured oversight, monitoring, and reporting (Fatica & Panzica, 2020). Developed countries with advanced financial infrastructures, such as those within the EU, have capitalised on these bonds to support renewable energy, sustainable transport, and other green infrastructure projects (Alamgir & Cheng, 2023).

Social green bonds aim to tackle both environmental and social challenges, making them broader in scope than traditional green bonds. While they are effective in financing sustainable infrastructure, these bonds tend to have a more moderate impact on direct environmental outcomes, such as carbon reduction. Scholars argue that their dual objectives may limit their ability to achieve specific environmental goals compared to bonds with a narrower focus (Dan & Tiron-Tudor, 2021).

Green bonds have appeared as a vital instrument for sustainable investment and environmental resilience, gaining popularity among environmentally conscious investors and those seeking portfolio diversification (Cortellini & Panetta, 2021; Diaz-Rainey et al., 2023). The market has expanded rapidly since 2007, surpassing the £500 billion mark in 2018 (Abhilash et al., 2022a). Green bonds play a crucial role in financing renewable energy projects and promoting sustainability in European countries (Wang et al., 2023). Research has concentrated on market pricing, economic and environmental impacts, and legal issues surrounding green bonds (Cheong & Choi, 2020). Factors influencing the growth of green bonds include favourable regulatory environments and enhanced disclosure quality (Anh Tu et al., 2020). This instrument has demonstrated potential to support post-pandemic recovery efforts (Chen et al., 2020). Despite its expansion, challenges persist in securing funding for environmentally friendly projects (Anh Tu et al., 2020). The field continues to evolve, with ongoing research investigating various aspects of green bonds (Abhilash et al., 2022b). Green bonds have emerged as a promising

financial instrument for promoting sustainability and reducing carbon emissions across Europe and globally. Multiple studies have found that green bond issuance is associated with decreased CO_2 emissions at both national and state levels (Flammer, 2020; Fatica & Panzica, 2020; Pata et al., 2025). The effectiveness of green bonds is enhanced by third-party certification and external review processes (Flammer, 2021; Fatica & Panzica, 2020). Green bond proceeds are increasingly allocated to renewable energy, clean water, and low-carbon transportation projects (Taghizadeh-Hesary et al., 2023). Factors influencing green bond issuance in the EU include ESG ratings, fiscal balance, and population (Dan & Tiron-Tudor, 2021). While green bonds show promise, some studies suggest their impact on emissions reduction may be limited or variable (Bestvina et al., 2023; Wyszkowska & Filipiak, 2024). Overall, green bonds appear to play a catalytic role in driving sustainable finance and CO_2 reduction across Europe, though their effectiveness may depend on various economic and governance factors (Alamgir & Cheng, 2023).

Economic factors, including national GDP levels and regulatory frameworks, also significantly influence the effectiveness of green bonds. Stronger governance structures and more developed capital markets enhance green bonds' ability to achieve sustainability targets (Bestvina et al., 2023). Conversely, emerging markets may face barriers, such as limited investor confidence and insufficient institutional support, which hinders the issuance and impact of green bonds (Nguyen et al., 2024).

However, critics highlight several limitations to the optimistic narrative surrounding green bonds. Methodological flaws, including short data horizons and a lack of long-term performance assessments, challenge claims of significant environmental impact (Saha & Maji, 2025). Additionally, the effectiveness of green bonds is often confounded by external variables such as shifts in energy policy and market volatility, complicating efforts to isolate their impact on carbon reduction (Wang & Taghizadeh-Hesary, 2023).

In conclusion, while green bonds hold promise as tools for sustainable development, their success depends on factors such as bond type, certification standards, and the economic context. Future research should focus on improving data transparency, enhancing certification frameworks, and expanding empirical analysis to assess long-term environmental and economic outcomes.

Methods

The study investigates the link between green bond issuance and CO_2 emission reductions in EU countries and Switzerland from 2007 to 2022. It uses descriptive statistics, correlation analyses, and panel data models to analyze different green bond types, such as Self-Labeled Bonds, CBI Aligned Bonds, and Social Green Bonds. Data from sources like the World Bank and green bond records cover 25 countries, excluding Malta and Cyprus due to limited data. Variables

include GDP per capita, CO_2 emissions, forest coverage, and green bond values. Key statistics and correlation coefficients assess relationships between green bonds and emissions. Correlation results were generally insignificant and varied across years and bond types (see tables 1–6).

Table 1

Pearson correlation coefficient between CO_2 emissions and Self-Labeled Green Bonds value

Year	Correlation coefficient	P-value
2016	−0.457	0.543
2017	−0.041	0.948
2018	−0.534	0.466
2019	−0.130	0.759
2020	−0.320	0..401

Source: Own study.

Table 2

Spearman's correlation coefficient between CO_2 emissions and the Self-Labeled Green Bonds value

Year	Correlation coefficient	P-value
2016	−0.4	0.75
2017	0.4	0.517
2018	−0.4	0.75
2019	0.143	0.752
2020	−0.4	0.291

Source: Own study.

Table 3

Pearson correlation coefficient between CO_2 emissions and the CBI Aligned Green Bonds value

Year	Correlation coefficient	P-value
2012	0.244	0.843
2013	0.671	0.145
2014	0.461	0.18
2015	0.23	0.552

Year	Correlation coefficient	P-value
2016	0.621	0.031
2017	−0.017	0.953
2018	0.456	0.076
2019	0.003	0.991
2020	0.265	0.288

Source: Own study.

Table 4

Spearman's correlation coefficient between CO_2 emissions and the CBI Aligned Green Bonds value

Year	Correlation coefficient	P-value
2012	−0.5	1
2013	0.314	0.564
2014	0.127	0.733
2015	0.467	0.213
2016	0.545	0.071
2017	0.429	0.128
2018	0.379	0.148
2019	0.029	0.923
2020	0.148	0.558

Source: Own study.

Table 5

Pearson correlation coefficient between CO_2 emissions and the value of Social Green Bonds

Year	Correlation coefficient	P-value
2017	0.363	0.479
2018	−0.741	0.259
2019	−0.674	0.097
2020	−0.157	0.664

Source: Own study.

Table 6.

Spearman's correlation coefficient between CO_2 emissions and the value of Social Green Bonds

Year	Correlation coefficient	P-value
2017	0.091	0.864
2018	−0.4	0.75
2019	−0.607	0.167
2020	0.079	0.838

Source: Own study.

Panel data models, including fixed effects, random effects, and first difference models, were employed to investigate unobserved differences, variations within and between countries, and the impact of changes in green bond issuance over time. All analyses utilized R ver.4.4.2 software, with significance set at $p < 0.05$.

Panel data models provide insights into the behaviour of units across different entities and over time. Linear panel data models commonly used in econometrics can be represented as follows:

$$\gamma_{it} = \alpha_{it} + \beta_{if} x_{it} + u_{it}$$

Where:

$i = 1,\ldots, n$: Index for each country;

$t = 1,\ldots, T$: Time index;

u_{it}: Random error term with a mean of zero.

If the individual-specific component is entirely absent, the pooled OLS estimator is the most efficient estimator for β.

If there is no unobserved individual effect (i.e., no country-specific component) and the errors are spherical, pooled OLS is a consistent and efficient estimator of β. Alternatively, unobserved individual-specific components can be eliminated using first-differencing techniques:

$$\Delta\gamma_{it} = \alpha_{it} + \beta\Delta + \Delta u_{it}$$

where:

$\Delta\gamma_{it} = \gamma_{it} - \gamma_{it-1}$;

$\Delta x_{it} = x_{it} - x_{it-1}$;

$\Delta u_{it} = u_{it} - u_{it-1}$.

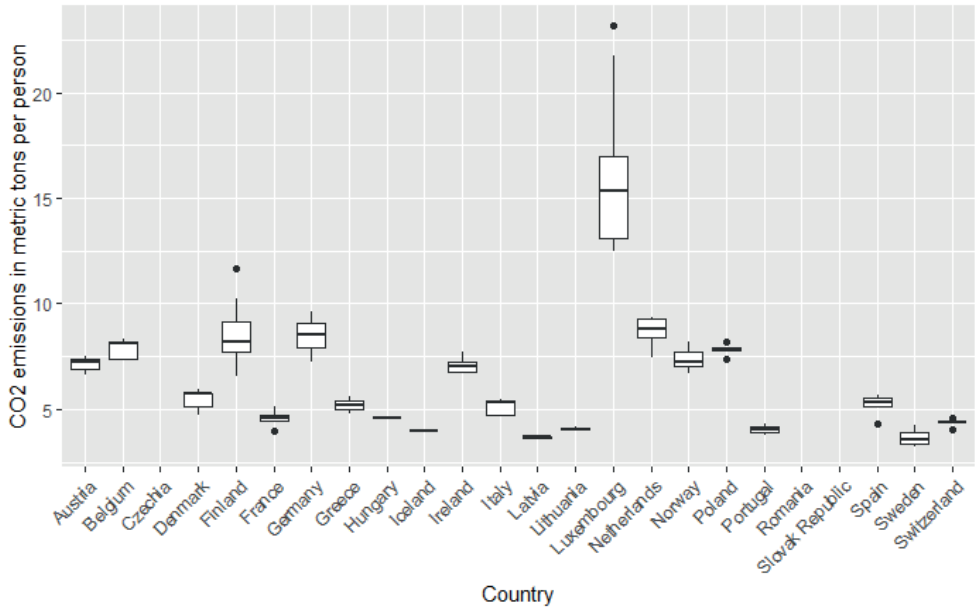
In the analysis, the dependent variable is an annual CO_2 emission level, which refers to the average level of CO_2 emission in a given country during a specific year. The main explanatory variable is the value of green bond issuance, measured in millions of USD, specifically for CBI Aligned or Social Green Bonds, with values lagged by one year relative to CO_2 levels. The control variables include GDP per capita, which is also lagged by one year; forest cover, defined as the proportion of forest area relative to the total area of the country and likewise lagged by one year; and the Worldwide Governance Index (WGI), an indicator of governance quality, which is likewise lagged by one year. This section presents various graphical characteristics of the data. The selection of control variables is grounded in the environmental finance and ecological economics literature. GDP per capita was included because economic development influences both the capacity to issue green bonds and the ability to invest in low-carbon technologies. Wealthier economies generally possess more developed financial markets, stronger environmental regulations, and greater resources for financing climate-transition projects. Forest cover was incorporated as a proxy for natural carbon sequestration capacity. Forest ecosystems function as carbon sinks and therefore may independently affect national CO_2 emission balances, regardless of financial-market developments. The Worldwide Governance Indicators (WGI) variable was included to capture institutional quality, regulatory effectiveness, and government capacity to implement environmental policies. Strong governance structures improve monitoring, transparency, and the allocation efficiency of green-finance instruments. Consequently, GDP per capita, forest cover, and governance quality are expected to moderate the relationship between green bond issuance and CO_2 emissions by influencing both the implementation and effectiveness of climate-related investments.

Figures 1–5 present some descriptive statistics. They reveal significant variations in CO_2 emissions, green bond issuance, and GDP across EU countries. Countries with higher median CO_2 emissions, such as Luxembourg and Germany, also exhibit substantial variability, indicating diverse environmental challenges and emission patterns. In contrast, nations like Sweden and Portugal demonstrate lower and more consistent emissions, reflecting effective mitigation efforts.

Green bond issuance (USD) varies significantly across countries, with economically advanced nations like Germany, France, and the Netherlands leading in volume. This suggests a correlation between financial market maturity and green bond market activity. Similarly, GDP levels vary widely, with wealthier economies contributing more to green financing initiatives, underscoring the role of economic capacity in fostering sustainable finance. These patterns underscore the interplay between economic development, environmental goals, and financial innovation in the EU context.

Figure 1

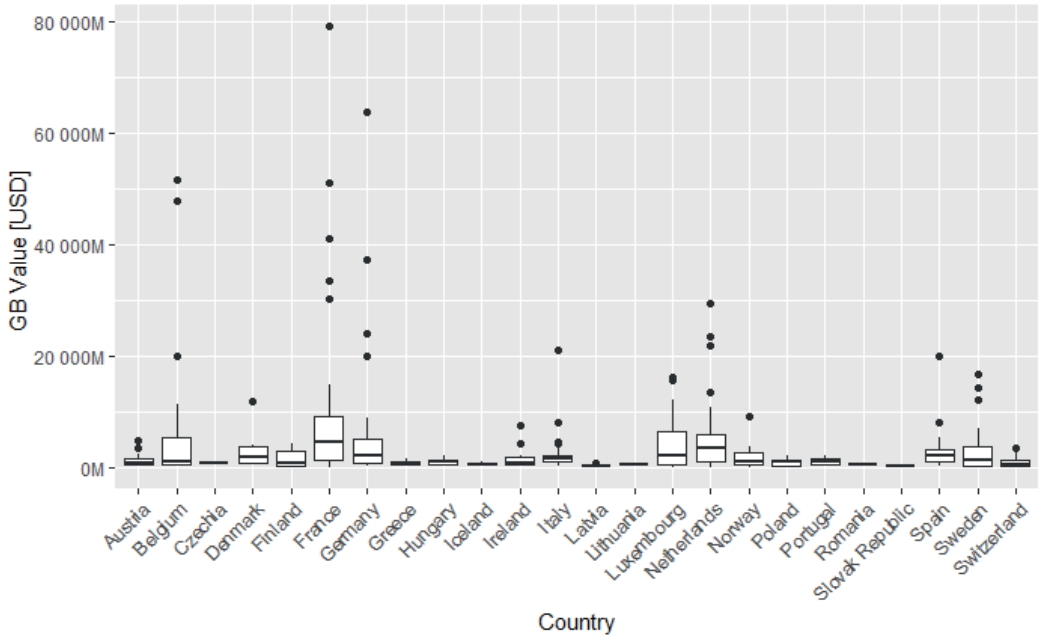
Bloxplot showing CO_2 emissions by country for Self-Labeled Green Bonds



Source: Own study.

Figure 2

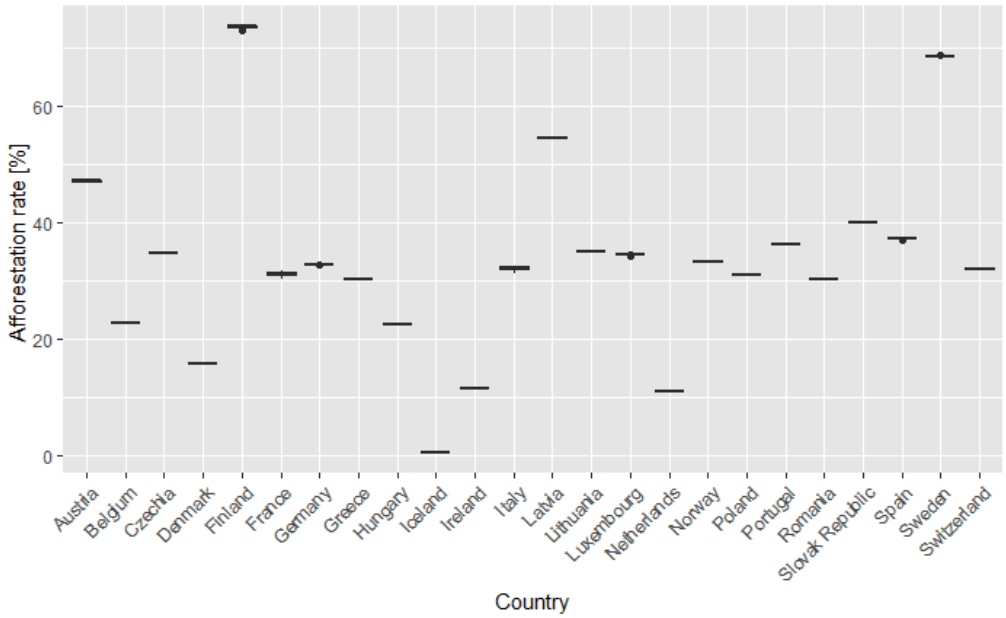
GB [USD] value in individual countries



Source: Own study.

Figure 3

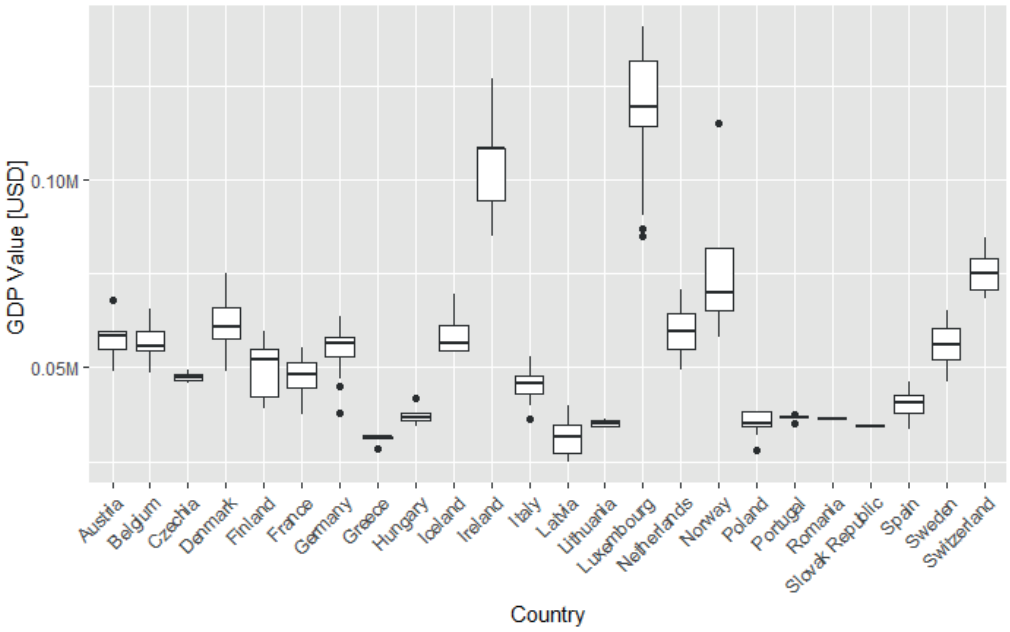
GB [USD] value in individual countries



Source: Own study.

Figure 4

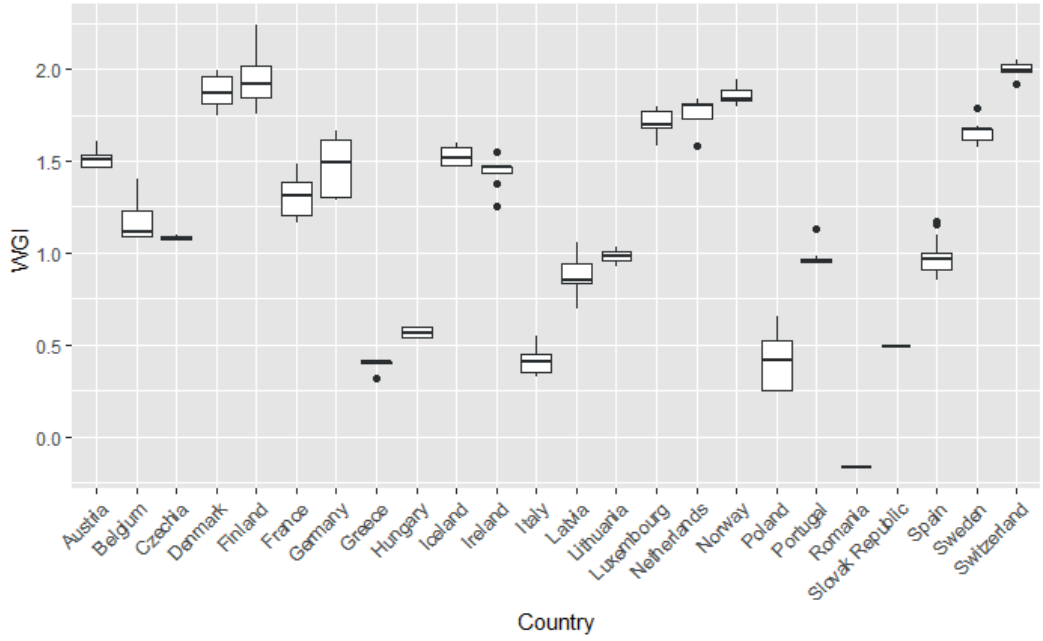
GB value [USD] within the countries



Source: Own study.

Figure 5

GB value [USD] within the countries



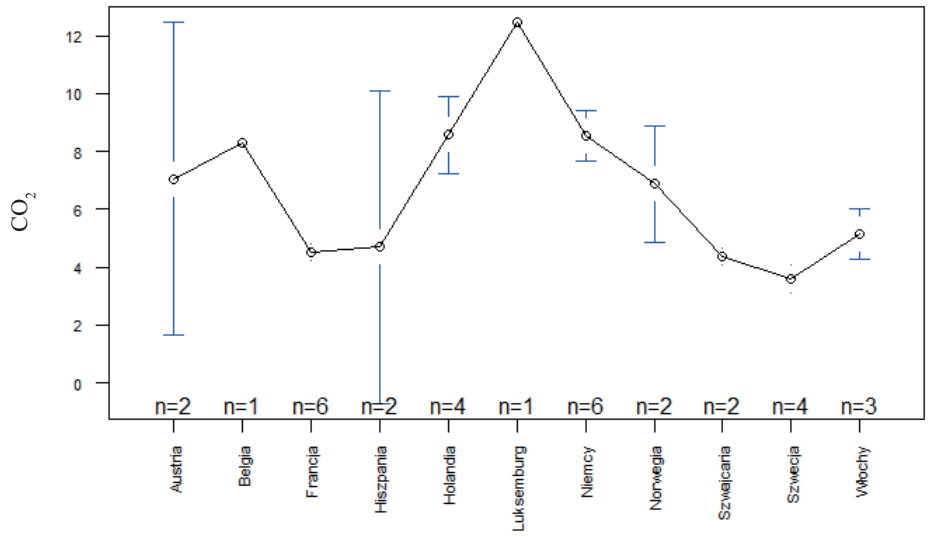
Source: Own study.

To model the relationship between Green Bonds and CO_2 emissions, we employed a panel data regression model. For the analysis, the data was log-transformed due to the significant differences in magnitude between Green Bond values and economic indicators. The comprehensive analysis presented in the table below encapsulates the aggregated results derived from panel data models focusing on three distinct categories of green financial instruments: Self-Labeled Green Bonds, CBI Aligned Green Bonds, and Social Green Bonds. Within this framework, coefficients, confidence intervals, and p-values are distinctly emphasised in bold where statistical significance is established ($p < 0.05$). Additionally, an asterisk (*) denotes the inclusion of lagged data by one year, specifically in relation to CO_2 levels.

Figure 6 illustrates the heterogeneity across countries for Self-Labelled Green Bonds. In this visualisation, dots represent the mean CO_2 values for each country, while the whiskers indicate the 95% confidence intervals for these means. It is evident that there is substantial variation across countries, suggesting significant cross-country differences in the relationship between Self-Labeled Green Bonds and CO_2 emissions (Figures 6–7).

Figure 6

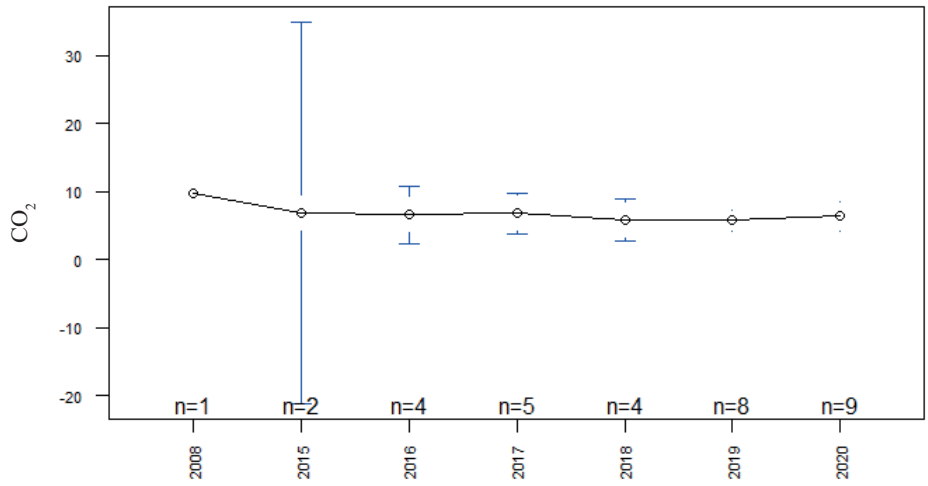
Heterogeneity between countries for CO_2 emissions with Self-Labeled Green Bonds



Source: Own study.

Figure 7

Heterogeneity between years for CO_2 emissions with Self-Labeled Green Bonds



Source: Own study.

To adopt a more systematic approach, we employed a random-effects panel data model, as the Hausman test p-value of 0.965 indicates that the random-effects model is more suitable than the fixed-effects model. In this model, the dependent variable is the level of CO_2 emissions. The dependent variable is the log of CO_2 emissions. Table 7 reports the estimates. Self-Labeled Green Bonds (lagged one year) are statistically significant ($p < 0.001$). The coefficient of −0.031 implies that a 1% increase in green-bond issuance is associated with a 0.031% decrease in CO_2 emissions, holding other variables constant.

Table 7

A panel data model showing the relationship between Self-Labeled Green Bonds and CO_2 emissions

Variable	Coefficient	2.5%	97.5%	P-value
Intercept	8.971	7.212	10.73	< 0.001
Value [USD]*	−0.031	−0.042	−0.019	< 0.001
GDP*	−0.459	−0.667	−0.251	< 0.001
Forestry*	−0.491	−0.663	−0.319	< 0.001
WGI*	0.177	0.061	0.292	< 0.001

The * symbol is intended to emphasise that the model used, in accordance with the concept from the publication, data values taken a year earlier than the explained variable (CO_2 level), if they were available.

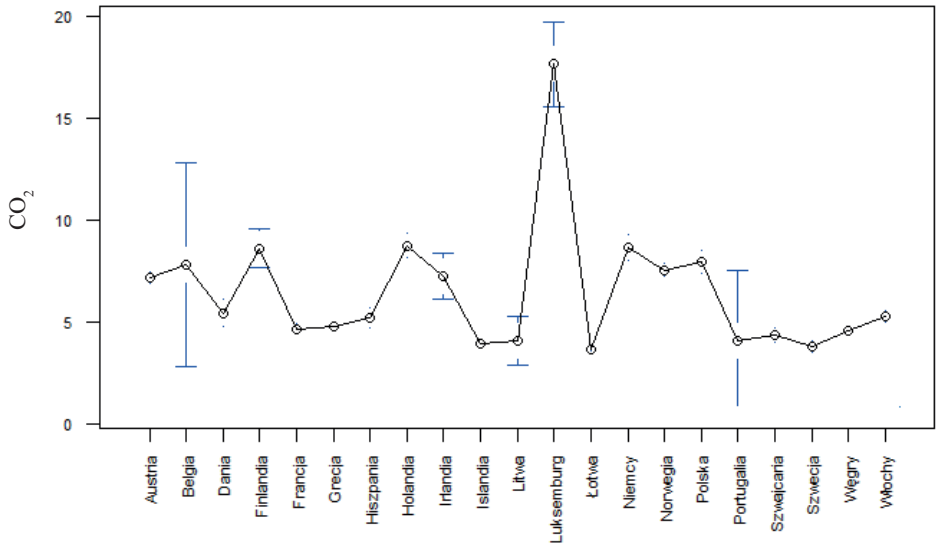
Source: Own study.

Figures 8–9 depict the variability among countries for CBI Aligned Green Bonds. In this visualisation, dots signify the average CO_2 values for each nation, while the whiskers represent the 95% confidence intervals for these averages. Similar findings can be observed as in the earlier example, emphasising significant differences among countries in the link between CBI Aligned Green Bonds and CO_2 emissions (Figures 8–9).

We employed a fixed effects panel data model using the same set of explanatory variables as in the previous model. The Hausman test (p-value = 0.001) indicates that the fixed effects model is more appropriate than the random effects model. The table below presents the estimation results. It can be observed that CBI Aligned Green Bonds are a statistically significant variable ($p < 0.001$). The coefficient of −0.085 indicates an average percentage decrease in CO_2 levels over time within each country when the value of Green Bonds increases by 1% (Table 8 in p. 72).

Figure 8

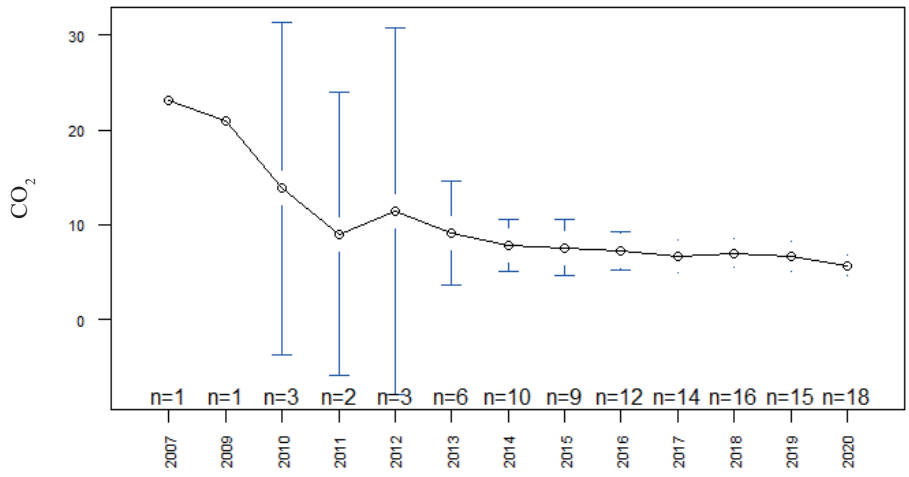
Cross-country heterogeneity for CO_2 emissions with CBI Aligned Green Bonds



Source: Own study.

Figure 9

Inter-annual heterogeneity for CO_2 emissions with CBI Aligned Green Bonds



Source: Own study.

Table 8

A panel data model showing the relationship between CBI Aligned Green Bonds and CO_2 emissions

Variable	Coefficient	2.5%	97.5%	P-value
Value [USD]*	−0.085	−0.126	−0.043	< 0.001
GDP*	1.137	0.911	1.363	< 0.001
Forestry*	−0.446	−0.608	−0.284	< 0.001
WGI*	0.107	−0.204	0.419	0.502

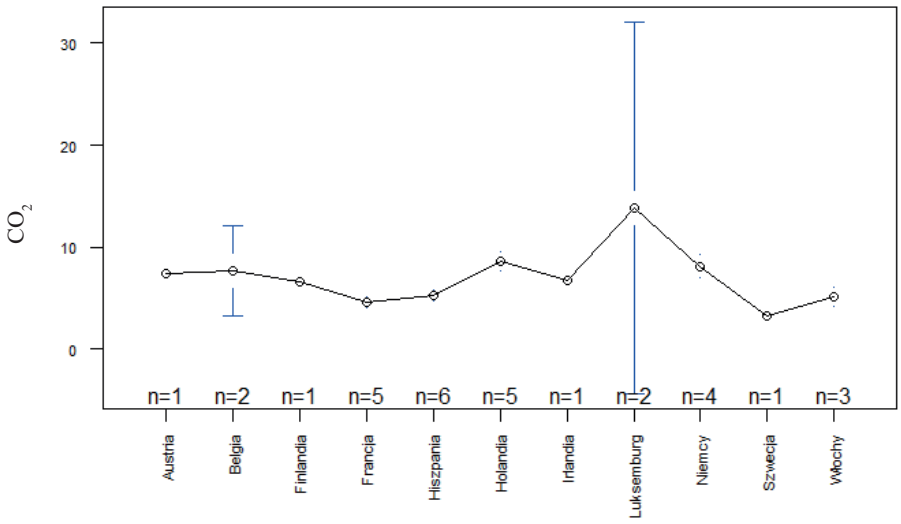
The * symbol is intended to emphasize that the model used – in accordance with the concept from the publication – data values taken a year earlier than the explained variable (CO_2 level), if they were available.

Source: Own study.

Heterogeneity across countries for Social Green Bonds is illustrated through a visualisation where dots represent the mean CO_2 values for each country, and the whiskers indicate the 95% confidence intervals for these means. Similar conclusions can be drawn as in previous cases, highlighting significant cross-country variability in the relationship between Social Green Bonds and CO_2 emissions (Figures 10–11).

Figure 10

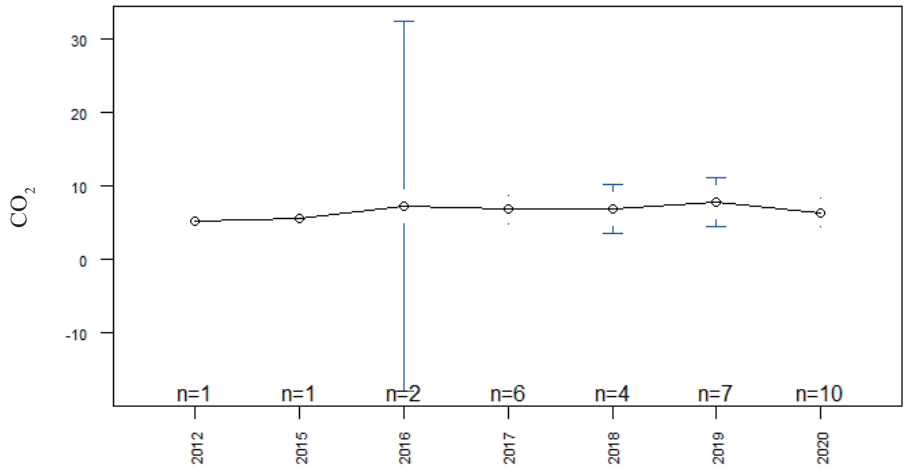
Cross-country heterogeneity for CO_2 emissions with Social Green Bonds



Source: Own study.

Figure 11

Heterogeneity between years for CO_2 emissions with Social Green Bonds



Source: Own study.

In this case, we employed a fixed effects panel data model using the same set of explanatory variables as in the previous analysis. The Hausman test (p-value = 0.001) indicates that the fixed effects model is more appropriate than the random effects model.

Table 9 presents the estimation results. It can be observed that the variable representing the value of Social Green Bonds is not statistically significant (p = 0.707). The coefficient of −0.024 indicates an average percentage decrease in CO_2 levels over time within each country for each 1% increase in Green Bonds, although this result is not statistically significant (Table 9).

Table 9

A panel data model showing the relationship between Social Green Bonds and CO_2 emissions

Variable	Coefficient	2.5%	97.5%	P-value
Value [USD]*	−0.024	−0.141	0.093	0.707
GDP*	−1.296	−3.131	0.539	0.238
Forestry*	13.627	−15.59	42.845	0.412
WGI*	0.701	0.129	1.273	0.074

The * symbol is intended to emphasise that the model used, in accordance with the concept from the publication, data values taken a year earlier than the explained variable (CO_2 level), if they were available.

Source: Own study.

Expanding the research with additional variables and, due to significant data gaps, it was decided to run simple models with one variable at a time to assess better the direct impact of the studied variables on the issue. Secondly, each time, the values of variables lagged by one year were used as explanatory variables to determine the delayed impact of these variables on the phenomenon. Empty spaces in the tables mean no coefficients because the random effects model did not converge.

Table 10

Summary table with the results of panel models

Variable	Model	Coefficient	2.5%	97.5%	P-value
Intercept	Self−Labeled GB	**8.971**	**7.212**	**10.73**	**< 0.001**
Value [USD]		**−0.031**	**−0.042**	**−0.019**	**< 0.001**
GDP		**−0.459**	**−0.667**	**−0.251**	**< 0.001**
Foerstry		**−0.491**	**−0.663**	**−0.319**	**< 0.001**
WGI		**0.177**	**0.061**	**0.292**	**< 0.001**
Intercept	CBI Aligned GB	**8.971**	**7.212**	**10.73**	**< 0.001**
Value [USD]		**−0.085**	**−0.126**	**−0.043**	**< 0.001**
GDP		**1.137**	**0.911**	**1.363**	**< 0.001**
Foerstry		**−0.446**	**−0.608**	**−0.284**	**< 0.001**
WGI		0.107	−0.204	0.419	0.502
Intercept	Social Green GB	**8.971**	**7.212**	**10.73**	**< 0.001**
Value [USD]		−0.024	−0.141	0.093	0.707
GDP		−1.296	−3.131	0.539	0.238
Forestry		13.627	−15.59	42.845	0.412
WGI		0.701	0.129	1.273	0.074

Source: Own study.

Self-Labeled Green Bonds significantly influence CO_2 emissions, with models exhibiting high explanatory power (up to 88% in the fixed-effects model). Key factors include previous-year emissions, GDP, energy efficiency, energy market activity, afforestation, and green bond financing, all of which demonstrate varying degrees of positive or negative impacts.

Table 11

Comparison of pooled, fixed and random effects panel data models for Self-Labeled Green Bonds

variable	coef_ pooled	p_ pooled	coef_FE	p_FE	coef_ random	p_ran-dom	R2_ pooled	R2_ random	R2_FE_ within	AIC*	BIC*	AIC_FE	BIC_ FE	AIC_ RE	BIC_ RE	BP	Hausman
prev_GB	−0.001	0.249	−0.000	**0.045**	—	—	0.224	—	0.412	68.103	68.936	10.906	11.739	—	—	7.241	—
prev_PKB	0.001	0.240	−0.000	**0.001**	−0.001	**0.001**	0.227	0.311	0.776	68.037	68.870	−5.487	-4.654	10.728	11.561	5.221	4.769
prev_ Zalesienie	−0.074	**0.011**	−1.557	0.178	−0.078	**0.039**	0.458	0.304	0.214	62.016	62.849	15.838	16.671	26.321	27.154	16.702	1.965
prev_WGI	1.176	0.266	6.504	0.110	1.669	0.217	0.219	0.304	0.288	68.209	69.043	14.148	14.981	25.636	26.469	9.205	2.082
prev_CO_2	0.925	**0.001**	1.569	**< 0.001**	0.939	**0.001**	0.981	0.235	0.884	4.904	5.737	−16.665	-15.832	2.838	3.671	1.139	10.338
prev_FEC	0.001	0.293	0.000	0.063	0.001	0.395	0.212	0.281	0.369	61.436	62.144	12.794	13.502	23.282	23.990	8.887	4.209
prev_EP	0.169	0.630	−1.013	< 0.001	−0.935	**0.000**	0.155	0.280	0.824	62.485	63.193	−6.366	−5.658	3.245	3.953	6.584	2.732
prev_EMI	−0.013	0.678	0.123	0.031	0.079	0.044	0.151	0.281	0.460	62.557	63.265	10.452	11.160	18.930	19.639	6.768	2.830

*pooled model

Source: Own study.

The fixed effects model was the best fit for CBI Aligned Green Bonds, showing the lowest AIC and BIC values, with Hausman tests favoring FE over RE. Key predictors included previous CO_2 emissions and the WGI, both of which significantly impacted current emission levels, while the model also effectively balanced complexity, predictive accuracy, and robustness to heteroscedasticity.

Table 12

Comparison of pooled, fixed and random effects panel data models for CBI Aligned Green Bonds

variable	coef_ pooled	p_ pooled	coef_ FE	p_FE	coef_ random	p_ran-dom	R2_ pooled	R2_ random	R2_FE_ within	AIC*	BIC*	AIC_ FE	BIC_ FE	AIC_ RE	BIC_ RE	BP	Hausman
prev_GB	−0.001	0.674	−0.001	**0.009**	—	—	0.003	—	0.102	440.007	442.389	216.439	218.821	—	—	289.654	—
prev_PKB	0.001	**0.001**	−0.001	**0.001**	−0.001	**0.001**	0.496	0.353	0.764	385.416	387.798	109.632	112.014	184.270	186.652	74.714	19.431
prev_ Zalesienie	−0.025	**0.267**	−2.078	**0.015**	−0.035	0.545	0.017	0.350	0.091	438.917	441.299	217.446	219.828	235.658	238.040	287.578	6.037
prev_WGI	2.595	**0.011**	4.592	**0.013**	3.329	**0.009**	0.081	0.346	0.096	433.513	435.895	216.984	219.366	230.423	232.805	296.020	1.028
prev_CO_2	0.953	**0.001**	0.977	**0.001**	0.953	**0.001**	0.984	0.217	0.779	109.095	111.477	104.459	106.841	109.095	111.477	3.806	0.139
prev_FEC	−0.001	**0.07**	0.001	0.988	−0.001	0.950	0.054	0.306	0.001	356.354	358.544	150.938	153.127	161.996	164.185	203.686	0.001
prev_EP	0.069	0.694	−1.497	**0.001**	−1.297	**0.001**	0.002	0.320	0.712	387.852	390.086	117.565	119.799	145.490	147.724	246.150	74.980
prev_EMI	−0.034	0.196	0.058	**0.001**	0.053	**0.001**	0.041	0.301	0.348	333.762	335.906	93.615	95.758	108.921	111.064	176.332	2.599

*pooled model

Source: Own study.

In the fixed effects model, the most significant factor was prev_CO_2, with a coefficient of 1.615 ($p = 0.001$) and an R^2_FE of 0.785, indicating a strong positive relationship between greenhouse gas emissions and the dependent variable within countries. Energy efficiency (prev_EP) showed a negative impact with a coefficient of –1.227 ($p < 0.001$), while a higher concentration of the energy sector (prev_EMI) was positively associated, with a coefficient of 0.157 ($p = 0.004$); GDP per capita had a slight negative effect, and WGI was not statistically significant. The FE model outperformed the pooled model in fit and accuracy, confirmed by lower AIC and BIC values and supported by Hausman and Breusch–Pagan tests that favoured fixed effects over the random model.

Table 13

Comparison of pooled, fixed and random effects panel data models for Social Green Bonds

variable	coef_ pooled	p_ pooled	coef_ FE	p_FE	coef_ random	p_random	R2_ pooled	R2_ random	R2_FE_ within	AIC*	BIC*	AIC_ FE	BIC_ FE	AIC_ RE	BIC_ RE	BP	Hausman
prev_GB	−0,001	0.094	−0,001	0.375	—	—	0.169	—	0.079	77.98	78.87	23.232	24.122	—	—	10.339	—
prev_PKB	0,001	**0,001**	−0,001	**0,001**	0,001	0.599	0.64	0.333	0.731	62.916	63.806	1.074	1.965	34.027	34.917	6.422	201.185
prev_ Zalesienie	−0.096	0.073	−3.674	0.162	−0.056	0.652	0.191	0.333	0.186	77.483	78.373	21.027	21.918	33.111	34.001	1.758	2.215
prev_WGI	4.082	**0.002**	5.156	0.057	4.439	**0.002**	0.476	0.327	0.317	69.654	70.545	17.86	18.751	27.633	28.524	2.135	0.141
prev_CO_2	0.819	**0,001**	1.615	**0,001**	0.802	**0,001**	0.962	0.283	0.785	22.373	23.263	−2.931	−2.04	13.516	14.407	0.199	9.699
prev_FEC	−0,001	0.175	0,001	0.937	−0,001	0.148	0.115	0.333	0.001	79.093	79.983	24.709	25.6	32.689	33.579	10.333	0.089
prev_EP	−0.143	0.734	−1.227	**0,001**	−1.136	**0,001**	0.012	0.334	0.854	81.091	81.981	−9.901	−9.01	4.227	5.117	6.638	1.152
prev_EMI	−0.084	**0.029**	0.157	**0.004**	0.062	0.168	0.267	0.332	0.575	75.708	76.598	9.306	10.196	29.318	30.209	3.894	44.92

*pooled model

Source: Own study.

To sum up, in the above statistical analysis we examined the impact of the possession and value of green bonds by the European Union countries on the level of CO_2 emissions, also considering significant confounding variables: GDP, forestation level and WGI, and we supplemented with new variables: FEC, EP, EMI. All these variables were presented in detail in tables. Correlations between both variables were at most average and statistically insignificant, and their large discrepancy can be explained by small data samples for a given year. The applied panel model for all bond types indicated that the variable value of green bonds and other variables were statistically significant in selected cases.

At first glance, the insignificant correlation coefficients reported in Tables 1–6 may appear inconsistent with the statistically significant coefficients obtained from the panel-data models. However, the two approaches address different analytical questions. The correlation analysis

examines simple bivariate associations within individual years and does not account for time lags, country-specific heterogeneity, or confounding variables. As a result, its explanatory power is limited, particularly when sample sizes are small and observations are unevenly distributed across countries and years. In contrast, the panel-data framework exploits both cross-sectional and longitudinal variation, substantially increasing the number of observations and allowing for the control of unobserved country-specific effects. Moreover, the models incorporate lagged explanatory variables and relevant controls such as GDP per capita, forest cover, and governance quality. Consequently, the panel estimations isolate the net effect of green bond issuance on CO_2 emissions more effectively than simple correlation measures. The significant coefficients observed in the panel models therefore suggest that the impact of green bonds becomes visible only after controlling for structural differences among countries and accounting for delayed policy and investment effects.

The panel model results, which show that:

- Climate Bonds Initiative (CBI) – compliant bonds show the strongest negative relationship with CO_2 emissions ($\beta = -0.085$; $p < 0.001$), confirming the effectiveness of environmental certification and supervision;
- Self-labeled green bonds also show a statistically significant emission reduction effect ($\beta = -0.031$; $p < 0.001$), although weaker than certified bonds, which may be due to the lack of certification standards and the potential risk of "greenwashing".

Social green bonds do not show a statistically significant relationship with CO_2 emissions ($p = 0.707$), which is consistent with their broader – not only environmental – scope of objectives. In addition, GDP per capita (negatively related to emissions), quality of governance (with differential impacts depending on the model), and forest cover (showing an emission-reducing effect) turned out to be significant moderators. Attention should be paid to the energy-efficiency variable (prev_EP), which, in each model, had a strong and statistically significant emission-reducing effect (e.g., $\beta = -1.227$ in the FE model for social green bonds).

The broad analysis of cross-country variability and the accurate interpretation of the heterogeneity of the results should be appreciated. It is clearly shown that countries with more developed financial markets (such as Germany or France) and higher institutional quality show better results in the use of green bonds as an instrument of energy transformation.

Conlusion

Descriptive statistics reveal considerable variability in green bond issuance across European Union member states, with economically advanced nations such as Germany and France exhibiting the highest levels of activity. Forest cover and GDP levels consistently moderate the relationship between green bond investments and reductions in CO_2 emissions. Countries with

higher forest cover experience greater CO_2 reductions from green bonds due to natural carbon absorption. Mature capital markets also enhance green bond financing efficiency, as shown by Germany, France, and the Netherlands, which have higher issuance volumes. The IMF (Cheng et al. 2024) found that sovereign green bonds can catalyse sustainable market development. Additionally, a systematic review by Al Hamrani and Al Hamrani (2025) highlighted that ESG performance and corporate governance significantly influence green bond market growth, further supporting the link between market maturity and issuance rates. Lastly, trends and observations indicate a positive trajectory in green bond issuance over time, which correlates with the establishment of improved regulatory frameworks within the EU. However, disparities persist, particularly in nations with less mature markets and governance structures. Integrating the literature review with statistical results highlights the connection between green bond issuance and CO_2 emission reductions in EU countries. The study finds a significant correlation, showing that certified green bonds, particularly those aligned with the Climate Bonds Initiative (CBI), achieve superior environmental performance. This aligns with prior research by Flammer (2021) and Fatica and Panzica (2020) on the importance of strong certification standards for measurable outcomes.

Green bonds connect climate policy with financial markets, encouraging sustainable investment and reducing carbon emissions, particularly CBI-aligned bonds with strict certification. Their effectiveness varies regionally, thriving in wealthy, well-regulated countries while facing challenges in emerging markets due to limited access and governance issues. Addressing certification inconsistencies and researching long-term project impacts are essential for strengthening green bonds as reliable sustainability tools. Green bonds are now integral to climate policies, as highlighted by the European Green Deal, which emphasises their role in achieving the EU's decarbonisation targets. This approach aligns financial incentives with environmental goals, enhancing green financial instruments' effectiveness. Statistical analyses confirm that CBI-aligned green bonds have the most significant impact on CO_2 reductions, as evidenced by coefficients that align with global sustainability benchmarks. This finding aligns with the research conducted by Taghizadeh-Hesary et al. (2023), which examined how the targeted allocation of certified green bond proceeds to renewable energy and low-carbon initiatives optimises their decarbonisation potential. The study further reinforces the idea that economic prosperity, indicated by robust GDP and fiscal stability, acts as a key predictor for the growth of green bond markets, supporting the findings of Dan and Tiron-Tudor (2021)

Forest cover significantly boosts green bonds' effectiveness, especially in countries rich in natural carbon sinks. Alamgir and Cheng (2023) show how financial instruments collaborate with natural resources for sustainability. Furthermore, developed financial markets improve the allocation of green bond proceeds, as seen in Germany and France, where advanced capital

markets enhance green financing for decarbonisation, aligning with Cheong and Choi (2020). Variability also exists among different types of green bonds. Self-labelled green bonds, although they contribute to CO_2 reductions, exhibit greater inconsistency in effectiveness due to varying certification processes and fluctuating investor trust. Anh Tu et al., (2022) highlighted the urgency for standardised labelling criteria to enhance both reliability and performance. Meanwhile, social green bonds, which aim to achieve both environmental and social objectives, yield moderate impacts on CO_2 reductions, as their broader focus may dilute their environmental effectiveness compared to strictly certified green bonds, as corroborated by Mavlutova et al. (2023).

Regional disparities pose additional challenges, especially in less developed markets within emerging economies. As noted by researchers such as Bestvina et al. (2023) and Wyszkowska and Filipiak (2024), these areas frequently deal with limited access to capital and governance issues, requiring the enhancement of institutional frameworks to fully harness the transformative potential of green bonds.

This study emphasizes the importance of strategic policies to enhance green bond benefits through improved certification standards, market access, and alignment with environmental goals, while noting limitations such as lack of long-term sustainability analysis and limited global comparison.

Green bonds are crucial for balancing economic growth and environmental sustainability, relying on mature markets, good governance, and certification. Frameworks like the Climate Bonds Initiative (CBI) increase their impact on reducing emissions. Outcomes differ by country; advanced economies leverage their financial systems and institutions, while emerging markets face barriers needing policy action. Combining green finance with natural assets like forests boosts environmental benefits.

Policymakers should promote innovation and credibility in green bonds, encouraging investors to focus on projects that yield both financial returns and environmental gains. Clear reporting and international standards build investor trust.

Market participants can use green bonds for diversification and ESG compliance, with issuers enhancing appeal through transparency. Further research is needed on biodiversity and long-term results.

The findings carry several implications for policymakers, regulators, and market participants. First, the stronger performance of CBI-aligned bonds suggests that certification and external verification mechanisms enhance the environmental effectiveness of green-finance instruments. Policymakers should therefore support the further harmonisation of green-bond standards within the European Union and encourage the adoption of transparent reporting frameworks. Second, the significance of governance quality indicates that institutional capacity remains a critical prerequisite for successful climate-finance initiatives. Countries seeking to expand

sustainable-finance markets should strengthen regulatory oversight, disclosure requirements, and monitoring systems. Third, the moderating role of forest cover highlights the importance of integrating financial instruments with broader environmental policies, including afforestation and ecosystem-protection programmes. Finally, investors may use certification status as an important signal when evaluating the credibility and potential environmental impact of green-bond investments. These findings reinforce the view that effective decarbonisation requires a combination of financial innovation, institutional quality, and environmental stewardship.

Several limitations should be noted. Data constraints led to the exclusion of some EU countries, limiting generalizability. The use of data up to 2022 does not reflect recent regulatory developments, such as the European Green Deal. Differences in bond types and certification approaches may affect comparability of results. Moreover, the focus on CO_2 emissions overlooks other dimensions of sustainability, such as resource efficiency. The dominance of advanced economies in the sample may also bias findings, and the assumption of linear relationships may oversimplify complex interactions.

Despite these limitations, the study contributes to the understanding of green bonds as tools supporting climate action and underscores their importance in the transition toward a sustainable economy.

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Sebastian Łukaszewski https://orcid.org/0000-0001-6802-9107
PhD, University of Applied Sciences in Konin, e-mail: sebastian.lukaszewski@konin.edu.pl

COMMERCIAL BANKS' READINESS TO PROVIDE AFTER-SALES CUSTOMER SERVICE

Abstract

The purpose of the article. The study aims to identify and assess the mechanisms shaping the quality of after-sales customer service in commercial banks, with particular emphasis on the accuracy and completeness of information, employee proactivity, and the practical usefulness of support provided to customers using banking services abroad.

Methodology. The empirical analysis was based on mystery shopping studies conducted between 2024 and 2026 as part of the Institution of the Year project. The purposive sample comprised commercial banks with at least ten physical branches in Poland: 13 banks in 2024–2025 and 14 banks in 2026. At the end of 2025, the institutions included in the study accounted for 65.1% of the Polish banking sector's total assets. The dataset comprised 800 standardized service interactions: 400 branch visits and 400 call-center interactions. Auditors posed as existing customers seeking assistance with euro transfers, card payments, cash withdrawals, currency conversion, Dynamic Currency Conversion (DCC), and other costs associated with cross-border transactions. The analysis examined the factual accuracy of the information provided, whether relevant information was communicated without prompting, and recurring patterns across years and service channels.

Results of the research. A high standard of after-sales service was not achieved consistently. Employees were more likely to provide correct information when directly asked than to communicate relevant information proactively. Transfer fees were discussed more frequently than delivery times, cut-off times, DCC, or costs not arising directly from the bank's tariff. The findings reveal a recurring gap between product knowledge and its practical application in customer interactions. After-sales information readiness is conceptualized as an organizational capability to transform dispersed product and procedural knowledge into accurate, complete, proactive, and practically useful customer support.

Keywords: commercial banking, customer service quality, after-sales customer service, mystery shopping
JEL Class: G21, D83, M31, G28

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Introduction

The quality of customer service in commercial banking is most often analyzed in terms of service quality, satisfaction, loyalty, customer experience and the functioning of individual contact channels. The latest research on digital banking also focuses primarily on the relationships between service quality, satisfaction and user experience (Moraes & Schaefer, 2026). Polish empirical studies have also examined the quality of the customer service process for customers wishing to open an account at a bank branch, highlighting the importance of the adviser's engagement and factors influencing the sense of security in specific circumstances (Matuszak-Flejszman & Łukaszewski, 2022). Relatively less attention is paid to the factual accuracy of the information provided to a customer who has already entered into a contract with the bank and requires assistance in using their product or service correctly.

In after-sales service, the value of the interaction does not stem solely from the availability of the channel, waiting times, the staff member's courtesy or the formal provision of a response. What matters most of all is whether, following contact with the bank, the customer possesses the knowledge enabling them to act in an informed, safe and economically rational manner. Assessing this component requires looking beyond self-reported customer satisfaction, as a response that is understandable and convincing may still be incomplete or incorrect.

The empirical basis of this article consists of repeated mystery shopping studies carried out between 2024 and 2026 as part of the 'Institution of the Year' project (Institution of the Year, 2024c, 2025c, 2026c). In the analyzed editions, the common scenario of a customer who already has a relationship with a bank and requires practical support in using payment and foreign exchange services was retained, while the specific scope of the questions was adapted to changes in the way cross-border transactions are carried out.

The aim of the research is to identify and evaluate the mechanisms shaping the quality of after-sales customer service at commercial banks, with particular emphasis on staff knowledge, the factual accuracy of the information provided, the thoroughness of the assessment of the customer's situation, service proactivity, and the practical usefulness of the solutions presented. The analysis aims to determine the extent to which bank staff provide factually correct information, whether they independently identify issues relevant to the customer, how the channel of contact affects the quality of support provided, and whether the identified gaps in knowledge and information are incidental or persist across successive rounds of the survey.

Based on the research objective and the theoretical considerations presented above, the following research hypothesis was formulated:

H1: In after-sales customer service, bank employees are more likely to provide factually correct information in response to direct customer questions than to communicate relevant information proactively without prompting.

The article's contribution is theoretical, methodological and empirical. Theoretically, it focuses the analysis of after-sales service quality on its informational function and the bank's ability to prepare the customer to use the service correctly. The methodological contribution stems from combining the mystery shopper perspective with an expert assessment of the factual accuracy of responses. The empirical contribution lies in the analysis of standardized interactions conducted by auditors acting as customers at bank branches and through call centers between 2024 and 2026.

Theoretical Foundations of After-Sales Customer Service Quality in Banking

The quality of customer service in commercial banking forms part of the broader issue of the quality of financial services. In the classical approach, service quality relates to the assessment of how a service is delivered, as perceived by the customer in relation to their expectations, experiences and prior notions of service standards. The SERVQUAL model defines quality as the difference between the customer's expectations and their perception of service delivery, and highlights the importance of reliability, responsiveness, assurance, empathy and the tangible aspects of service delivery (Parasuraman et al., 1988). A different approach is taken in the SERVPERF model, in which the focus has shifted from comparing expectations and perceptions to evaluating the actual delivery of the service (Cronin & Taylor, 1992). The performance-based perspective is particularly important for after-sales service, as it allows the analysis to focus on what actually happened during the customer's interaction with the bank.

Sector-specific scales of banking service quality extend the classical framework to include elements such as the effectiveness and reliability of service, accessibility, scope of services, price, dependability and the manner of communication with the customer (Bahia & Nantel, 2000). These elements remain important even after a contract has been concluded, but they do not fully capture the specific nature of after-sales service. The literature on after-sales services indicates that after-sales activities influence customer satisfaction, relationship retention and customer loyalty (Murali et al., 2016). Research directly relating these dependencies to the banking sector confirms the importance of the quality of after-sales interactions for customer satisfaction and the longevity of the relationship with a financial institution (Viet Ha & Trang, 2026). However, after-sales service in banking also fulfills a function that goes beyond shaping satisfaction. It can reduce the risk of product misuse, incurring unexpected costs, carrying out transactions incorrectly, or making decisions based on incomplete information.

Research on the integrated quality of banking channels indicates that the customer experience is shaped by interconnected touchpoints, and service quality should be viewed as the result of the functioning of the entire channel system (Sreejesh, 2024). Inconsistencies in the information provided at successive touchpoints can reduce service quality, regardless of how well

each channel functions when analyzed in isolation. Research on omnichannel banking shows that channel integration, the ability to move seamlessly between channels, and the customer's sense of confidence influence their experience and loyalty to the bank (Xuan et al., 2023). The importance of consistency in knowledge and communication standards across channels is also confirmed by research on the service provided to customers interested in opening a child's account, which demonstrated that the accuracy of information about the product and its features influences trust and the customer's final decision on which bank to choose (Matuszak-Flejszman & Łukaszewski, 2025).

The development of mobile banking further broadens the scope of quality as assessed by customers. Recent research indicates that the quality of mobile banking services is multidimensional and encompasses not only technical availability and user-friendliness of the interface, but also reliability, security, trust, responsiveness and the quality of information (Palamidovska-Sterjadovska et al., 2025). In Polish studies, customers perceive online banking as a convenient and increasingly natural way of interacting with their bank. At the same time, its growing prevalence heightens the importance of security, the transparency of service operating principles and the clarity of the information provided to users (Mazurek, 2023). The growing role of digitalization is also confirmed by research into the quality of service provided to customers interested in mortgages, which revealed significant differences in standards between banks and contact channels, as well as the need to improve the usability of digital tools and reduce waiting times for service (Waliszewski & Łukaszewski, 2025).

For the purposes of further analysis, a bank's after-sales customer service quality can be understood as the institution's ability to provide a customer who already holds a product or service with accurate, comprehensive, understandable and practically useful support, enabling the informed and secure use of that product or service. Understood in this way, quality encompasses three interrelated levels: interactional quality, communicative quality and factual accuracy.

Interactional quality relates to the way the customer is treated, the employee's engagement and the course of the conversation. Communicative quality refers to the clarity, organization and completeness of the message. Factual accuracy means that the information provided is consistent with the actual operating principles of the product, costs, deadlines, exchange rates, regulations and procedures. The first two levels can be assessed to a large extent by the customer. The third requires the application of an external criterion and the knowledge to distinguish correct information from a response that merely gives the impression of being credible.

Staff Knowledge, Information Asymmetry and the Risk of Misinformation in After-Sales Service

The importance of information in financial services stems from the persistent asymmetry of knowledge between the financial institution and the customer. The bank possesses detailed knowledge of the product's structure and the costs associated with it. The customer, even if they regularly use online and mobile banking, may not be familiar with the specific rules governing the use of individual products.

Information asymmetry does not merely refer to a difference in the amount of knowledge held by the parties to the relationship. Its practical significance becomes apparent when the customer does not know what information they should obtain before carrying out a transaction.

An employee's knowledge therefore plays a broader role in after-sales service than simply providing information about products. The employee should recognize the context of the customer's actions, determine what consequences may arise from choosing a particular solution, and highlight issues that the customer has not considered themselves. The quality of service is determined not only by the ability to provide answers, but also by the ability to assess whether the information provided is sufficient for the customer to use the service in an informed, correct and safe manner. This distinguishes reactive service from proactive service. A lack of information, partial information and incorrect information should not be treated as equivalent. A lack of response is usually noticeable to the customer and may prompt them to contact the bank again. Partial information may appear sufficient, even though it omits an element that is essential for decision-making. The greatest risk, however, is associated with incorrect information, as the customer may regard it as reliable and, on that basis, take action leading to unforeseen costs, delays in transactions, the application of an unfavorable exchange rate or a reduction in security.

In the literature on retail banking, increasing importance is being attached to service recovery mechanisms, which encompass the ways in which a bank responds to service failures, staff errors or disruptions to the service process. Research into service recovery systems in retail banks indicates that an institution's response to a customer's problem influences the assessment of the quality of the relationship, and that the process of restoring trust should be analyzed at both the employee level and the level of the organization as a whole (Rao et al., 2024). Recurring irregularities may signal gaps in service standards, training systems, knowledge-sharing practices, the up-to-date nature of internal materials, or quality control mechanisms. This approach is consistent with concepts of improving customer service in banking, which combine staff competence, a customer-centric focus, consistency of standards and the use of feedback

in the organizational learning process (Bolar et al., 2026). Research into the consumer credit market indicates that a positive assessment of the information received from a lender does not automatically mean that the customer's decision was rational and appropriate from the perspective of their financial situation (Czechowska et al., 2024).

The relationship between an employee's knowledge and the quality of service should not be interpreted solely in terms of individual competencies. Research conducted in the banking sector suggests that service quality may also be linked to levels of work-related stress, the alignment of management processes, and organizational commitment (Kim et al., 2024). Although these factors were not directly measured in our own research, they represent possible organizational determinants of the identified differences in the accuracy and completeness of responses.

The consequences of information asymmetry are most commonly analyzed in relation to the sales process and the risk of mis-selling. Mis-selling involves offering or presenting a product in a manner that is inappropriate to the customer's needs, by omitting material information or by exploiting the financial institution's information advantage. This risk may be exacerbated by an excessive focus on sales targets by the financial institution and its incentive schemes, at the expense of properly identifying the consumer's needs (Czechowska & Waliszewski, 2018). An analysis of such cases indicates that providing customers with incorrect information about the characteristics of a financial product can lead to significant losses for consumers and reveal weaknesses in institutional protection mechanisms (Kaczmarczyk, 2025). Although the concept of mis-selling primarily relates to the sales phase, its logic remains relevant even after a contract has been concluded. In such cases, the problem lies not in the product being ill-suited at the time of sale, but in inadequate customer support during the period of service use.

The development of financial consumer protection systems is leading to a gradual shift in emphasis from the formal fulfillment of the duty to provide information to the actual effectiveness of that protection. Comparative analyses of regulations in force in various countries indicate that legal standards have limited effectiveness if they do not contribute to reducing the number of complaints, misunderstandings of products or improper market practices (Son, 2025). A similar conclusion emerges from research into the effectiveness of consumer protection in the financial market. The mere introduction of a regulatory framework and disclosure obligations does not guarantee an automatic improvement in customer outcomes if the information remains difficult to apply or does not influence the actual behavior of financial institutions (Xia et al., 2024). Research into the Polish consumer credit market also shows that irregularities may occur both at the pre-contractual stage and during the performance of the contract as well as after its conclusion, which justifies extending consumer protection to the after-sales phase as well (Czechowska et al., 2023). The assessment of the quality of after-sales service should relate to the actual performance of the contract, rather than merely to formal compliance with procedures.

Accurate information is particularly important for customers in a vulnerable situation. Vulnerability need not stem solely from age, disability, financial circumstances or the customer's permanent characteristics. It may be situational in nature and arise in conditions of stress, haste, lack of knowledge, when using a service abroad, or when encountering an unfamiliar cost mechanism. The problems faced by financial services customers may be linked to their level of financial literacy, with comparative research findings highlighting in particular the importance of the quality of education for the scale of problems reported by consumers (Czechowska & Zatoń, 2018). Recent research also indicates that knowledge gaps may adversely affect financial decision-making and financial outcomes (Merter & Balcıoğlu, 2025). The OECD points out that identifying the needs of and providing appropriate support to financially vulnerable consumers is a key element of modern consumer protection (OECD, 2025).

A customer preparing for a trip abroad may become vulnerable not because they have permanently limited financial literacy, but because they must make a decision regarding mechanisms they use only occasionally. The relationships outlined above confirm the validity of the distinction made in this article between interactional quality, communicative quality and factual accuracy. The third of these dimensions is of particular importance, as customers do not always possess the knowledge required to independently verify the accuracy of a response. For this reason, assessing the informational component of customer service requires combining the customer's perspective with an external criterion of factual accuracy.

Methodology of the Empirical Research on After-Sales Customer Service Quality

The study took the form of a repeated cross-sectional survey. In successive rounds, standardized interactions between auditors and banks were observed, while the common focus on the after-sales use of payment and foreign exchange services was maintained and the specific scenarios were partially modified. The constant elements remained the situation of a customer who already had a relationship with the bank, the basic dimensions of quality assessment, and the procedure for conducting and documenting the audit.

The 'Institution of the Year' project is a multi-module program examining the quality of actual customer service delivery in banks. It is based on standardized interactions carried out in accordance with pre-defined scenarios, auditors' tasks and assessment criteria. Unlike self-reported surveys, popularity rankings and studies based primarily on retrospective assessments of satisfaction or an institution's image, the focus of observation is the course of a specific service interaction. In this context, mystery shopping is not a substitute measure of customer satisfaction, as the auditor's assessment and the subsequent assessment by an actual customer may relate to different aspects of the service (Blessing & Natter, 2019).

The project's results can be used for institutional benchmarking; however, this article did not analyze the performance of individual banks. The data was aggregated at the market, year, and contact channel levels to identify recurring patterns and quality shortcomings.

The mystery shopping method requires the results obtained to be treated as measurement data, the value of which depends on the reliability and validity of the study design (Finn & Kayandé, 1999). The number of audits and their distribution should be tailored to the level at which branches, chains or other organizational units are assessed (Finn, 2001). ESOMAR guidelines highlight the need to define in advance the scenario, the auditor's tasks, the assessment criteria and a standardized method for documenting observations (ESOMAR, 2005). Mystery shopping enables the observation of how a service is actually delivered, rather than relying solely on customers' statements (Wilson, 1998b). This method allows service performance to be measured through a controlled interaction carried out under conditions close to those in real-life situations (Wilson, 1998a).

In studies of the Greek banking sector, it was used to identify relationships between elements of the customer service process and possible avenues for its improvement (Tarantola et al., 2012). In Turkish banks, it was used to compare the quality of service provided by institutions with different ownership structures (Pinar et al., 2010). In a Polish banking study, it was used to assess compliance with service standards (Wicka & Podlińska, 2019). The mystery shopping method was also used to compare the quality of service provided to customers interested in mortgages by banks and mortgage brokers in Poland during the pandemic (Waliszewski & Łukaszewski, 2022). Its use in retail banking has also been the subject of earlier national analyses (Meder, 2005).

The comparability of results depends, among other things, on how the auditors' work is organized (Mazurkiewicz-Pizło & Pizło, 2018). In financial services, mystery shopping can be used to verify standards and identify weaknesses in the service process (Olejnik, 2011). In Polish literature, this method is viewed as a tool for assessing customer service standards (Gregor & Grzegorczyk, 2006).

In the research conducted, the mystery shopper method was extended to include expert verification of the factual accuracy of the information provided. The auditors adopted the perspective of a customer using the service, but did not limit their assessment to their own impressions, the staff member's politeness or the clarity of their statements. They also assessed whether the information provided corresponded to the actual rules governing the product in question.

This approach is consistent with recommendations on the use of mystery shopping in the financial sector, where the focus of observation may include, among other things, the quality of recommendations, the transparency of costs, the accuracy of disclosed information, and the institution's compliance with consumer protection rules (Mazer et al., 2015).

The banks were selected purposively. Commercial banks operating in the retail sector in Poland and having at least ten physical branches were eligible for the study. This criterion was met by 13 banks in 2024–2025 and 14 banks in 2026. In total, the institutions covered by the study accounted for 65.1% of the Polish banking sector's total assets at the end of 2025, based on the author's own calculations using the 2025 annual reports of the banks covered by the study and data published by the Office of the Polish Financial Supervision Authority (Urząd Komisji Nadzoru Finansowego, 2026).

In 2024–2025, the sample comprised: Alior Bank S.A., Bank Millennium S.A., Bank Ochrony Środowiska S.A., Bank Pekao S.A., Bank Pocztowy S.A., BNP Paribas Bank Polska S.A., Credit Agricole Bank Polska S.A., ING Bank Śląski S.A., mBank S.A., Nest Bank S.A., PKO Bank Polski S.A., Santander Bank Polska S.A. and VeloBank S.A. In 2026, the former Santander Bank Polska was included in the study under the name Erste Bank Polska S.A. (Erste Group, 2026), while UniCredit S.A. Oddział w Polsce was the new, fourteenth institution in the sample.

In each period under review, the study comprised ten branch visits and ten calls to each bank's call center. Overall, the dataset comprised 800 service interactions: 400 branch visits and 400 call-center interactions. The source data was drawn from six separate research modules of the 'Institution of the Year' project: three studies carried out at branches and three studies via remote channels, conducted in 2024, 2025 and 2026 respectively. From each module, only the results relating to after-sales use of banking services in connection with foreign exchange and international transactions were utilized. The analysis therefore did not cover the full range of criteria or all the results used in the original service quality surveys. The unit of analysis was a single service interaction, while the results were aggregated at the level of the market under study, the year and the contact channel. The rankings of individual banks were not used to assess their competitiveness, as the aim of the article is to identify recurring patterns and shortcomings in after-sales service, rather than to rank institutions (Institution of the Year, 2024a, 2024b, 2025a, 2025b, 2026a, 2026b).

In each edition, the auditor acted as a customer who already held an account and a payment card with the bank under review. The scenario involved obtaining the support needed to make proper use of the services already available to them. The selection of auditors should take into account their preparation, personal characteristics and the organizational conditions for conducting the study (Dutt et al., 2019).

The operationalization of service quality corresponded to the three dimensions defined in the theoretical section. Interactional quality concerned the course of the interaction and the staff member's engagement; communicative quality concerned the clarity and completeness of statements; while factual accuracy concerned the consistency of the information with the actual terms of the product, costs, deadlines, exchange rates and procedures.

It was particularly important to determine whether the employee provided the information on their own initiative or only after being directly asked by the customer. To this end, individual elements of the response were classified as provided spontaneously, provided upon request, or not provided even after a question was asked. For data that could be unequivocally verified, its factual accuracy was additionally assessed. This classification made it possible to distinguish between the availability of an employee's knowledge and its proactive use in the customer's interest. An employee might, for instance, know the correct answer, but only provide it once the auditor had asked a question regarding a specific cost, exchange rate, cut-off time, Dynamic Currency Conversion (DCC) or surcharge. From the perspective of reducing information asymmetry, such a situation is not equivalent to the employee independently identifying information relevant to the customer's decision.

The accuracy of the responses obtained was verified against the terms and conditions of service applicable at the bank in question during the survey period, in particular fee and commission schedules, terms and conditions, exchange rate tables, product information, payment system rules and procedures relating to the execution of specific transactions. This made it possible to distinguish correct information from responses that were incomplete, overly general, imprecise or incorrect. The analysis also focused on information whose absence or inaccuracy could have led to negative financial, operational, decision-making or customer security consequences. However, no separate critical error rate or new composite index was created. The aim was to determine the frequency and persistence of specific information-related issues, rather than to construct yet another ranking metric.

The analysis of the results was carried out at two complementary levels. The first involved comparisons made within the same edition and the same scenario. These made it possible to determine whether the manner in which a similar task was carried out differed between the branch and the call center. The second level involved a comparison of recurring elements between 2024 and 2026, in particular information concerning euro transfers, card payments, cash withdrawals, currency conversion, foreign currency accounts, DCC and surcharges. Due to modifications to the scenarios, the number of banks, the scope of the questions and the structure of the aggregated assessments, the comparisons between years do not refer to a single, unchanging composite indicator. They serve to identify recurring patterns and areas of information gaps.

In the analysis for the purposes of this article, the data is presented in an aggregated form, without identifying individual staff members and without using the results to assess specific individuals. This approach is in line with the principle that mystery shopping should primarily serve to assess and improve processes, standards and organizational quality, while ensuring that the scope of observation is proportionate and that the individuals involved in the study are protected (ESOMAR & GRBN, 2019).

Consistencies in Banks' Readiness to Provide After-Sales Customer Service

The analysis of the results focuses on recurring components of information delivery: achieving a high standard of customer contact, the spontaneous provision of euro transfer details, the relationship between the accuracy of responses and the need to ask for clarification, and the provision of information on DCC and other costs not directly arising from the bank's tariff. Due to partial changes in the scenarios, the scope of questions and the number of banks surveyed, comparisons between years are descriptive and functional in nature, rather than constituting an analysis of a single, unchanging indicator.

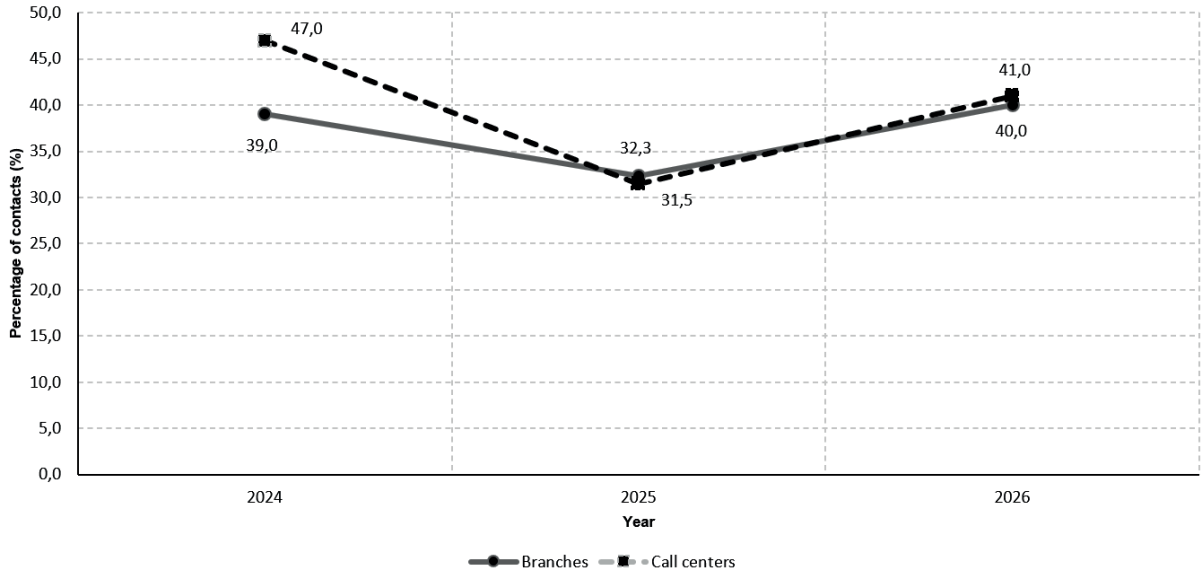
The first pattern is the absence of a consistent, universally achieved standard of high-quality service. The 80% threshold corresponds to the lower limit of the first quality tier in the methodology of the 'Institution of the Year' project, but in this article it has been used solely as an analytical threshold for a single contact (Institution of the Year, 2026d).

In 2024, this threshold was reached in 39% of branch visits and 47% of calls to the call center. In 2025, the corresponding figures were 32.3% and 31.5%, respectively. In 2026, they rose to 40% and 41%, respectively.

The percentages did not follow a consistent trend, and in each round the majority of contacts remained below the adopted threshold. The variation in the proportion of highly rated contacts between successive rounds is shown in Figure 1.

Figure 1

Percentage of contacts rated at least 80% by service channel in 2024–2026



Source: Own study based on data from the 'Institution of the Year' project (Institution of the Year, 2024c, 2025c, 2026c).

The fluctuations shown in Figure 1 do not allow us to conclude that a single improvement in the result in 2026 signified a permanent resolution of previous shortcomings. It is more reasonable to state that the sector possessed the capacity to provide very good service, but that this capacity had not been institutionalized to a degree that would guarantee a similar outcome in the majority of interactions. The high ratings for some visits and conversations confirm the feasibility of the desired standard; at the same time, the significant proportion of lower ratings indicates that the outcome still depended on the specific employee, the course of the conversation and the customer's level of engagement. From the perspective of organizational readiness, the problem is therefore not a lack of any competencies within the banks, but the uneven availability of these competencies in the actual service process.

The second pattern is the reactive nature of information provision. In subsequent rounds, individual transaction parameters were more often obtained following a direct inquiry than provided on the employee's own initiative. Proactive service involves identifying the customer's likely information needs before a lack of information leads to an error, additional costs or the need for further contact (Yan et al., 2026). In the case of a euro transfer, the basic set of information included the cost, the delivery date and the cut-off time.

A summary of the data in matrix form reveals a consistent pattern in the completeness of the information provided (Table 1). The cost of the transfer was most frequently provided spontaneously, the delivery date less frequently, and the cut-off time least frequently. In 2024, at branch offices, the cost of the transfer was provided without being asked in 33.8% of contacts, the delivery date in 20.0%, and the cut-off time in 19.2%. In the call center, these figures were 43.8%, 34.6% and 22.3% respectively. In 2025, during branch visits, information on the cost was provided without prompting in 26.9% of cases, information on the delivery time in 13.1%, and information on the cut-off time in 6.9%. For calls to the call center, the corresponding figures were 26.2%, 21.5% and 10.8%. In 2026, the figures for branch visits rose to 37.1% for cost, 21.4% for delivery time and 13.6% for the cut-off time, while the corresponding figures for calls to the call center reached 42.1%, 29.3% and 26.4%, respectively.

In all three rounds, the same hierarchy of spontaneously provided information was evident: the cost of the transfer was discussed most frequently, while the cut-off time was discussed least frequently. Even in 2026, however, the majority of customers did not receive the full set of information without having to ask additional questions.

The pattern of the values presented in Table 1 indicates that the likelihood of spontaneous reporting of information decreased as the level of detail and procedural complexity increased. In each survey round, the proportion of spontaneous responses was the highest for the transfer cost, lower for the delivery time and the lowest for the cut-off time. This pattern is consistent

with the assumption that parameters less directly associated with the cost of the transaction are less likely to feature in the standard course of a conversation. In practice, the customer often received an answer to a single question without a full discussion of the transaction's terms and conditions. Research on financial communication indicates that information that is simple and directly relevant to the customer's situation enhances the usefulness of decision support (Devlin & Mukerji, 2025).

Table 1

Information regarding euro transfers provided without the customer having to ask, by year and service channel

Information item	2024		2025		2026	
	Branches	Call centers	Branches	Call centers	Branches	Call centers
Transfer fee	33.8	43.8	26.9	26.2	37.1	42.1
Delivery time	20.0	34.6	13.1	21.5	21.4	29.3
Cut-off time	19.2	22.3	6.9	10.8	13.6	26.4

Scale: < 10% | 10–19.9% | 20–29.9% | 30–39.9% | ≥ 40%

Source: Own study based on data from the 'Institution of the Year' project (Institution of the Year, 2024c, 2025c, 2026c).

Differences between channels do not alter the fundamental interpretation. Rather, the data reveals two distinct manifestations of the same organizational problem: in branches, the shortcoming more often took the form of omitting detailed parameters, while in the call center, the response was sometimes more comprehensive upon further inquiry, but still lacked a consistently proactive approach.

The third pattern is the discrepancy between possessing the correct knowledge and applying it in practice. A high proportion of correct answers did not automatically mean that the customer received the relevant information without further prompting. For the purposes of the analysis, the difference between the percentage of correct answers and the percentage of information

provided without being asked was defined as the information proactivity gap. This gap is not a separate readiness index, but a descriptive measure showing what proportion of potentially available knowledge was not utilized during the standard course of a conversation.

A supplementary analysis of the 2025–2026 data indicates that, for transfer costs, the proactivity gap in 2025 amounted to 27.7 percentage points for branch visits and 48.4 percentage points for calls to the call center. In 2026, the corresponding gaps were 26.5 and 35.0 percentage points, respectively. For transfer delivery times, the gap ranged from 29.2 to 35.7 percentage points. The particularly large gap for calls to the call center in 2025 suggests that advisers were often able to provide correct information on the cost when asked, but rarely regarded it as an issue that should be discussed proactively. Due to the lack of comparable data on response accuracy in the 2024 data, this analysis covers the last two editions and is supplementary to the three-year comparisons of common elements of the scenario.

The results indicate that response accuracy did not always translate into the independent identification and communication of information relevant to the customer. The pattern identified can be described as conditionally effective service: accurate when a precise question is asked, but less comprehensive in situations where the customer did not know which issues to raise.

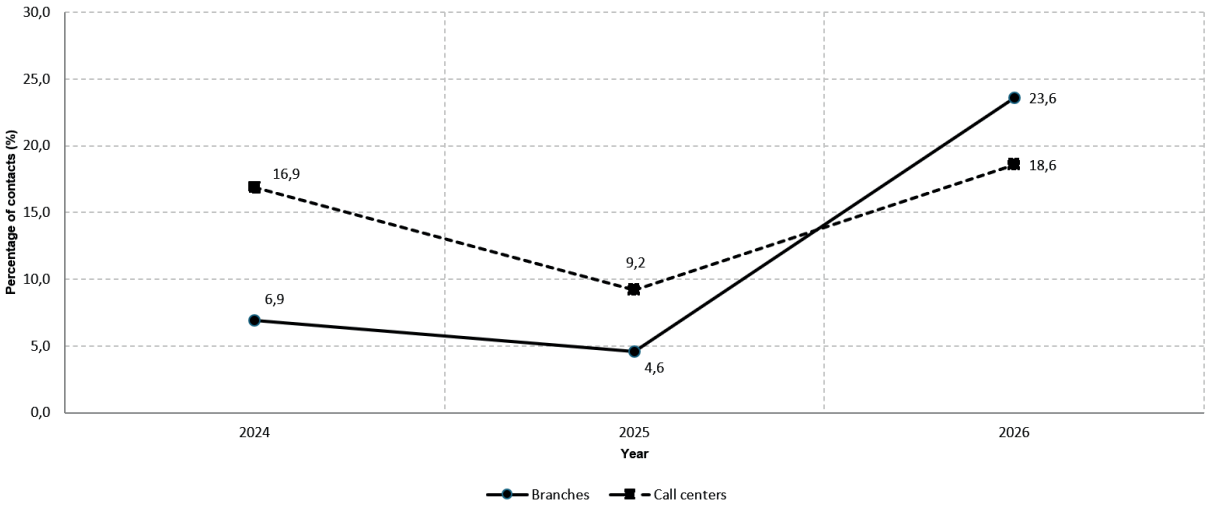
A good example is the comparison between the exchange rate listed in a table and that available at an online currency exchange. In 2025, at branches, a specific difference was pointed out without being asked in 4.6% of contacts, while in 63% of visits to banks with a currency exchange, no such comparison was provided even after a question had been asked (Institution of the Year, 2025b). In the call center, the specific difference was indicated without being asked in 10.9% of calls (Institution of the Year, 2025a).

The fourth pattern is that some responses focus on the fees formally charged by the bank, while overlooking the overall economic impact of the transaction. In the case of card payments and cash withdrawals abroad, the cost may arise not only from the bank's commission but also from the exchange rate, currency conversion fees, ATM operator charges and the application of DCC.

A common component across the three editions was the staff member's reference to DCC or the correct choice of transaction currency. The comparison was harmonized at the level of the information function, as the precise wording of the element under assessment varied somewhat across the successive editions. In 2024, DCC was mentioned in 6.9% of branch interactions and in 16.9% of call center calls. In 2025, the corresponding figures were 4.6% and 9.2%. In 2026, they rose to 23.6% at branches and to 18.6% in the call center. The results do not show a clear trend in one direction. Between 2024 and 2025, the figures fell in both channels, and rose in 2026. However, even the highest figure remained below 25% of the contacts surveyed. Changes in the percentage of contacts in which a member of staff referred to the DCC or the correct choice of transaction currency are shown in Figure 2.

Figure 2

Percentage of contacts in which a member of staff referred to DCC or the correct choice of transaction currency, by service channel, 2024–2026



Source: Own analysis based on data from the 'Institution of the Year' project (Institution of the Year, 2024c, 2025c, 2026c).

A further example of costs arising outside the bank's direct tariff being overlooked was the surcharge levied by the ATM operator. This element was explicitly highlighted in the last two editions of the survey. In 2025, the possibility of a surcharge being applied was highlighted in 23.8% of branch visits and in 38.5% of call center calls. In 2026, these figures rose to 39.3% and 44.3%. The results concerning the surcharge were not included in the three-year time series, as the 2024 dataset does not present this issue in a form directly comparable with the two subsequent editions.

The results presented in Figure 2 indicate that providing information on DCC and the correct choice of currency was not an established standard of service. The data on surcharges confirms that the problem encompassed a broader category of costs not directly arising from the bank's tariff. After-sales support should therefore include not only information on the bank's commission, but also details of other possible charges and the consequences of choosing a specific transaction option.

Redirecting a customer to the app can be useful if a member of staff explains which function to select, from which account the transaction should be initiated, and what the consequences of each option will be. Simply stating that transfers, currency exchange or limit changes are available in the app shifts the cognitive responsibility onto the customer. The literature on the quality of mobile banking and channel consistency emphasizes that the digital touchpoint should be

part of a seamless customer journey, rather than a separate location to which a staff member directs the customer without ensuring continuity of communication (Chandna & Ubba, 2026; Palamidovska-Sterjadovska et al., 2025).

Overall, the results indicate that the correct information was available in some interactions, but this did not always translate into comprehensive and proactive customer guidance. A pattern of conditionally effective service was frequently observed, in which the extent of assistance provided depended on the customer's ability to formulate detailed questions. This finding justifies an analysis of after-sales readiness as an organizational characteristic, encompassing not only staff competence but also access to knowledge, conversation standards and consistency across communication channels.

Discussion

The findings extend the traditional approach to the quality of banking service to include an informational dimension concerning the use of the product after the contract has been concluded. This is because information asymmetry does not disappear after the sale, but takes on an operational form: a customer may be familiar with the basic functions of an account or card, without understanding how costs are calculated, the sequence of currency conversions, deadlines, cut-off times or the consequences of choosing DCC.

The formal availability of terms and conditions, fee schedules or exchange rate tables does not mean that the customer has received sufficient information to make a rational decision. Digitalization may increase the accessibility of services, but at the same time heighten the risk of information overload and misinterpretation of complex financial mechanisms (OECD, 2026). The transfer of information from a paper-based to a digital environment does not eliminate the user's limited attention span or the difficulties in assessing the economic consequences of that choice (Salisbury et al., 2026).

Our own findings show that the banks studied were more often prepared to answer a direct question than to independently identify the full scope of information needed by the customer. Proactivity should therefore be regarded as an element of the informational quality of service, rather than as an optional courtesy.

In financial services, a distinction should be made between product knowledge and customer knowledge, i.e., the ability to recognize which elements of a product are relevant in a specific customer situation (Bergeron, 2025). The study's findings indicate that merely knowing the answer did not always lead to the provision of comprehensive support. Knowledge management processes can influence an organization's ability to share and utilize knowledge during customer service (Al-Muayad & Chen, 2025).

Although direct numerical comparisons are not warranted because international studies differ in their products, samples, service channels and outcome measures, the findings are consistent with broader evidence from other banking markets. Mystery shopping studies conducted in Turkey and Greece have demonstrated that service performance may vary between institutions and that standardized observations can identify specific weaknesses in service processes and priorities for improvement (Pinar et al., 2010; Tarantola et al., 2012). Evidence from Vietnam also confirms the relevance of after-sales service quality for customer satisfaction, although it is based primarily on customers' perceptions rather than on external verification of the factual accuracy of the information provided (Viet Ha & Trang, 2026).

A particularly relevant point of comparison is the mystery shopping exercise conducted by the European Banking Authority, which distinguished between information provided proactively, information disclosed only upon request and information not provided during the interaction (European Banking Authority, 2023). This distinction corresponds closely to the analytical approach adopted in the present study and supports the broader relevance of the information proactivity gap. The convergence of these findings suggests that the proposed information readiness framework may be applicable beyond the Polish banking sector, provided that the list of critical information items is adapted to national regulations, product structures and service-channel arrangements.

The importance of proactive support increases in situations of consumer vulnerability. A review of the literature indicates that vulnerability may be situational in nature and result from the interplay of customer characteristics, product features and market conditions (Verma et al., 2026). The perspective of the ethics of care emphasizes the importance of an institution's response to a customer's limited ability to independently assess a financial product (Mung et al., 2026). The market vulnerability model, on the other hand, points to the accumulation of individual and contextual factors (Crosby et al., 2026). Research on financial vulnerability confirms that it should not be limited to the permanent characteristics of specific consumer categories (Fernández-López et al., 2024).

A customer using banking services abroad may temporarily find themselves in such a situation due to a lack of experience, time pressure, a language barrier or unfamiliarity with the local payment system. Service standards should not assume that the absence of further questions implies a full understanding of the transaction mechanism.

The consequences of inadequate support are not limited to lower satisfaction. Research into consumer complaints about banking services indicates that a lack of appropriate information and ineffective problem-solving may co-occur with genuine financial difficulties faced by customers (Birkenmaier & Stratman, 2025). The significance of complaints as a means of

assessing the effectiveness of consumer protection through information has also been emphasized in Polish literature on the banking market (Czechowska, 2020). In the context under analysis, an error may result in unforeseen costs, payment delays, the application of an unfavorable exchange rate, loss of access to funds, or failure to utilize a more advantageous method of carrying out a transaction.

The recurrence of similar shortcomings across successive surveys and channels suggests that their causes may extend beyond individual staff members' lack of knowledge. The literature indicates that the quality of responses may be linked to work organization, stress and the conditions under which information resources are accessed (Kim & Yeo, 2024). This conclusion should be treated as an interpretation requiring further verification, as organizational factors were not directly measured in our own research.

Reducing this asymmetry requires organizational learning based on customer interactions. Analyzing large datasets of conversations can be used to identify recurring issues, update guidelines and develop training programs (Rocha-Salazar et al., 2026). At the same time, our own results do not indicate that the choice of channel alone resolves the problem of information quality. Channel consistency should encompass not only the technical continuity of service, but also the consistency of knowledge, recommendation criteria and the economic significance of the messages conveyed (Chandna & Ubba, 2026).

The growing use of automated support does not remove the bank's responsibility for the factual accuracy, completeness and practical usefulness of the information provided to customers. In financial services, advice based on artificial intelligence (AI) raises questions about accountability and the ethical quality of recommendations, while explainability remains important when automated systems support customer decisions (Brüggen et al., 2025; Ioannou et al., 2026). The quality of banking chatbots should therefore be assessed not only in terms of technical efficiency, but also in terms of the information they provide; cases requiring contextual interpretation should be referred to a competent employee (Hang et al., 2026).

Within the proposed framework, AI-assisted customer service should be treated as an additional mechanism for activating organizational knowledge rather than merely as a technical communication interface. Its performance should therefore be assessed against the same core criteria as human service: factual accuracy, completeness, timeliness, proactivity and practical usefulness. Additional AI-specific criteria should include the consistency of responses to equivalent questions, traceability to an authoritative and up-to-date knowledge source, recognition of contextual complexity, communication of uncertainty and timely escalation to a competent employee.

Future mystery shopping research could apply parallel scenarios to employees and AI-based assistants. This would make it possible to compare not only response time and customer perceptions, but also the frequency of factual errors, omissions, unsupported statements and failures

to identify information relevant to the customer's decision. AI may strengthen a bank's information readiness by making knowledge more readily available and consistent across channels, but it may also reproduce outdated information or generate credible-sounding yet incorrect responses if governance, verification and escalation mechanisms are insufficient (Nowakowski & Waliszewski, 2022; Brüggen et al., 2025).

Banks should define, for typical product usage scenarios, a minimum standard of critical information that must be provided regardless of the level of detail in the customer's inquiries. In the case under analysis, this set could include the feasibility of the transaction, its total cost, the method of currency conversion, the processing time, the cut-off time, available options, and risks such as DCC and surcharges. Information may be provided in layers: from a response to the immediate issue, through the elements necessary to avoid a foreseeable cost or error, to a more detailed explanation of how the service works.

It is also essential to define escalation procedures for situations where an employee or an automated system does not have a definitive answer. Explicitly indicating the need for verification is safer than providing a message that sounds credible but is incorrect. The assessment of service quality should therefore cover not only courtesy, response time and adherence to procedures, but also factual accuracy, completeness, proactivity and the ability to prevent negative financial consequences.

In theoretical terms, the results allow us to define a bank's information readiness as the organizational capacity to recognize a customer's information needs and to transform dispersed product and procedural knowledge into information that is accurate, complete, up-to-date, proactive and practically useful. It is not merely the sum of individual employees' competencies. It encompasses product and documentation design, knowledge management, staff training, the functioning of support systems, channel integration and organizational learning mechanisms. After-sales service reduces information asymmetry only when it enhances the customer's actual ability to take appropriate action.

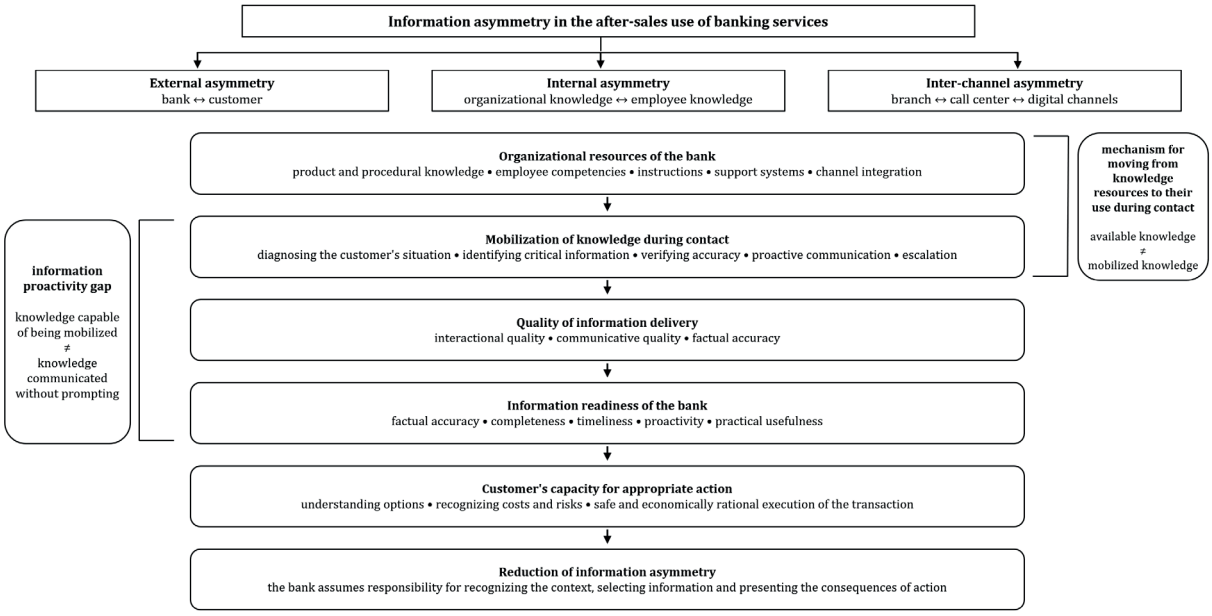
For future empirical applications, after-sales information readiness may be operationalized as a multidimensional organizational construct reflected in five observable dimensions: factual accuracy, completeness, timeliness, proactivity and practical usefulness. At the level of a standardized service interaction, factual accuracy may be measured as the proportion of verifiable information items communicated correctly; completeness as the proportion of predefined critical information items disclosed; proactivity as the proportion of such items communicated without prompting; timeliness as consistency with the rules, tariffs and procedures applicable on the date of the interaction; and practical usefulness as the provision of actionable guidance concerning the available options and their financial, operational or security consequences (Devlin & Mukerji, 2025; Yan et al., 2026).

The present study captures selected observable manifestations of these dimensions but does not estimate a composite information readiness index. Future research could report the dimensions separately or combine them into an index based on empirically justified weights. Validation should include expert assessment of content validity, inter-rater reliability of response coding, repeated audits across scenarios and channels, and criterion validity examined through relationships with complaints, repeated contacts, transaction errors and actual customer outcomes (Finn & Kayandé, 1999; Bahia & Nantel, 2000). Cross-country applications would additionally require testing whether the measurement structure remains comparable across regulatory and institutional settings.

On this basis, a model of a bank's information readiness in after-sales customer service has been proposed, as shown in Figure 3. The model combines three co-occurring forms of asymmetry with an organizational mechanism for transitioning from knowledge resources to their activation during customer contact, and subsequently to enhancing the customer's ability to take appropriate action.

Figure 3

Model of a bank's information readiness in after-sales customer service



Source: Own study.

The model presents information readiness as a mechanism for transitioning from organizational knowledge resources, through the activation of this knowledge during customer interaction, to enhancing the customer's ability to act appropriately. It takes into account three

co-occurring dimensions of the problem: asymmetry between the bank and the customer, an intra-organizational gap in access to knowledge, and cross-channel inconsistency. A proactivity gap arises when information available to an employee is only provided following detailed inquiry, rather than being independently recognized as relevant to the customer's decision.

Conclusions

The research conducted indicates that the fundamental shortcoming of after-sales customer service was not a complete lack of knowledge about services, but an insufficient ability to apply that knowledge consistently and proactively during customer interactions. Staff were more likely to provide correct answers following a direct inquiry than to independently identify the full scope of information required by the customer. Parameters going beyond the direct inquiry about cost – including the cut-off time, DCC and other costs not directly derived from the bank's tariff – were discussed particularly rarely. The findings therefore support H1, indicating that factual knowledge was more consistently activated in response to direct customer questions than communicated proactively during the standard course of the interaction.

The theoretical contribution of this article lies in conceptualizing information readiness as an organizational capacity to transform dispersed product and procedural knowledge into information that is accurate, complete, proactive and practically useful. The methodological contribution stems from combining standardized mystery shopping with an expert assessment of the factual accuracy of responses. From a practical perspective, the results justify introducing minimum standards for critical information, standardized knowledge sources or a single source of truth, and rules for escalating situations in which an employee or an automated system does not have a definitive answer.

A limitation of the study is the nature of the repeated cross-sections and the partial variability of scenarios, criteria and the range of channels between successive editions. A further limitation arises from the purposive selection of banks with at least ten physical branches, which restricts the generalizability of the findings to the entire banking sector, particularly to digital-only institutions. The results allow for the identification of recurring patterns, but do not justify treating every difference between years as a uniform trend or drawing causal conclusions. Furthermore, the study did not cover actual transactions carried out following contact or their financial consequences.

Further research should combine audits with an analysis of complaints, contact records and transaction errors, and should also compare the effectiveness of reactive versus proactive customer service. It is also worthwhile to examine how staff interact with automated systems and the impact of information completeness on customers' actual decisions. Further research should also develop and validate a multidimensional measurement scale of information readiness, initially reporting the individual dimensions separately and subsequently examining whether they

form a reliable and valid composite construct. After-sales service reduces information asymmetry only when the bank takes responsibility for recognizing the context, selecting information and explaining to the customer the consequences of the action being taken.

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Justyna Rybacka https://orcid.org/0009-0005-8559-3443
PhD, Uniwersytet WSB Merito w Gdańsku, justyna.rybacka@gdansk.merito.pl

COMPETITIVENESS IN THE BANKING SERVICES SECTOR TODAY FROM THE PERSPECTIVE OF GENERATION Z

Abstract

The purpose of the article. In order to respond rapidly to changing customer demands and technological advances, the modern banking services market must adapt quickly. Financial institutions offering similar products and services pose a threat to the banking sector. In order to adapt to market demands, banks must leverage their potential, select appropriate strategies and competitive tools as well as develop offerings that will be well received by customers, enabling them to achieve a strong competitive position. It is also crucial for banks to adapt to the requirements and expectations of Generation Z, who are characterised by impatience and an expectation of quick responses. They are a fully digital group. Social media signifi-cantly influences the decisions of its members. This study aimed to identify the factors influencing the competitiveness of banks in Poland from the perspective of Generation Z customers.

Methodology. The empirical research conducted for this study took the form of a quantitative survey. This was based on a questionnaire administered to a sample of 500 people. The study aimed to assess the factors influencing the competitiveness of banks in Poland from the perspective of Generation Z, and to identify the most important factors when choosing a bank. The focus was on banks operating in Poland.

Results of the research. The survey results indicated that Generation Z values new technologies above all else when interacting with a bank, while price is not a key factor for them. At the same time, the development of technology-based services continues to require support in the form of instructions on the bank's website or assistance from advisors and employees, in line with customer expectations. Therefore, questions and complaints about banking services raised by this group of young people should be addressed promptly, in line with their preferences. The survey results also show that traditional distribution channels do not appeal to this group of customers.

Keywords: banking services, bank, Generation Z, competition
JEL Class: G1, G5

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Introduction

The operations of banking institutions are becoming increasingly demanding and complex amid globalization, competitive pressures, rising customer expectations, and generational shifts. Banks must take into account developments across the entire financial industry, as well as those of their competitors within the sector. The financial industry is committed to implementing cost-saving digital platforms to reach a broad range of financial services consumers. Digital platforms can increase financial inclusion by providing access to financial services in a more affordable, convenient, and secure manner (Jack & Suri, 2014; Aziz & Naima, 2021; Khan et al., 2022).

Competition in the banking sector, in turn, is viewed as a process of rivalry among entities striving to achieve the same goals. In an effort to meet market demands, banks leverage their potential and select appropriate strategies and competitive tools. It is therefore essential to create an offering that is positively evaluated by customers and conducive to building a sustainable competitive advantage. In this context, competitiveness is understood as the ability to provide high-quality services whose value and appeal exceed those of competitors operating in the same sector and offering similar or identical products and services. Continuously strengthening competitiveness is one of the key challenges for banks.

The main objective of this article was to identify the elements that build banks' competitiveness from the perspective of Generation Z. The following specific objectives were formulated:

1. To identify the factors influencing the choice of a bank by Generation Z customers.
2. To determine the expectations of Generation Z customers regarding entities in the banking sector.
3. To identify the most important elements that distinguish a bank in the market, according to representatives of this generational group.
4. To determine whether, from the perspective of Generation Z representatives, financial institutions offering products similar to banking products constitute competition for banks.

In light of the established objectives and based on a review of the literature, the following research hypotheses were formulated:

H1. Price is not a key factor influencing Generation Z's choice of banking services;

H2. New technologies are the leading aspect of banks' competitiveness in Poland among Generation Z customers.

H3. Members of Generation Z are willing to use the services of financial institutions (other than banks) if they perceive them to be modern, innovative, and backed by positive reviews from other users.

For the purposes of this study, an empirical study (quantitative research) was conducted. The quantitative study analyzed the experiences and expectations of Generation Z individuals. The sample selection for the quantitative study was non-probability sampling. The sur-

vey questionnaire consisted of questions regarding customers' experiences and expectations regarding their interactions with commercial banks and other financial institutions. It included single-choice, multiple-choice, and open-ended questions. The respondents were characterized by age, gender, education level, and place of residence.

The study utilized a critical analysis of secondary sources, as well as the following methods: analysis, synthesis, description, deduction, induction, and reduction. The application of these methods complemented one another. Deduction enabled theoretical knowledge to be translated into assumptions concerning the population under study, while induction allowed conclusions to be formulated based on empirical findings. Synthesis and reduction, in turn, facilitated the integration and systematic organization of the collected information. The combined application of these approaches contributed to a comprehensive interpretation of Generation Z representatives' preferences regarding the use of banking services.

Definition and types of banking services

Banking services are a type of financial service. As W. Srokosz (2003, p. 197) points out, financial services including banking services are specific activities carried out by financial institutions (such as lending, investment, payment and insurance institutions) in the financial market. However, it is worth noting that this definition is broader than that of banking services.

Numerous authors analysing the concept of banking services highlight other characteristics and aspects of this issue. W.L. Jaworski (1998) states that banking services are contractual relationships between a bank and a customer. The bank offers its services, and the customer receives them. These services provide specific benefits to either the customer or the bank, and they are carried out using a bank account. In his definition, the author focuses on the parties involved in using a given service and how it operates. M. Capiga (2008, p. 137) defines this concept more concisely as contractual relationships between the bank, which offers the services, and the customer, who receives them. S. Flejterski, B. Świecka build on earlier definitions by highlighting the parties involved in service provision, as well as the time and place. She believes that banking services are provided by banks and other institutions to their customers, whether business entities or individuals, either through a traditional bank branch or via an electronic distribution channel. S. Flejterski, B. Świecka on the other hand, discusse the financial aspect of such services, noting that they are most often monetary in nature, provided for a fee and in the form of contracts (Flejterski & Świecka 2008, p. 330). Based on the above definitions, it can be concluded that these services are characterised by the following (Świderska et. al, 2016, p. 65):

- a complex structure;
- the establishment of specific relationships between the bank and the customer, typically of a financial nature;

- a uniform standard for conducting banking operations;
- the use of time as a criterion for determining their value;
- the influence of banking law.

When considering the issue of banking services, one must also examine their characteristics in comparison to other types of services. First and foremost, they are characterized by their intangible nature and the inability to store them. They are also not subject to standardization, as they are tailored to the customer's personal needs. What distinguishes this type of service is that it is tied to the person providing it, as these services are complex and require detailed knowledge of the financial services market knowledge that the average consumer lacks (Meder, 2006). Furthermore, A. Jonas points to the following characteristics of banking services: intangibility, inseparability, continuity of service, similarity, the inability to be stockpiled, the importance of trust for this type of service, and rapid technological progress. S. Flejterski, B. Świecka (2008, p. 334) also confirms that banking services belong to a particularly complex category of services. He distinguishes them specifically by their intangibility, heterogeneity, abstract nature, and high economic risk.

Services offered by banks can be classified according to the following criteria:

- the classical criterion division into credit, deposit, settlement, and ancillary services;
- the subject-based criterion division into services aimed at individual customers and services aimed at institutional customers.

This classification should also be supplemented by a criterion based on the distribution channel and customer contact, which considers the possibility of in-person contact with a bank employee or online and telephone channels. This is a key criterion that determines how relationships and communication with customers are built. Increasingly, the aspect of financial services distribution is also becoming a key factor in the decisions of younger generations. The latest advances in financial technology (FinTech) have made it possible to provide traditional financial services – such as loans, savings, and money transfers on mobile platforms and through other app-based programs (Arner et al. 2016).

Competitiveness in the banking services sector – definition

Banks are viewed as institutions of public trust. Competition in this sector is therefore not aggressive. Moderate competition is required to operate in conditions of economic stability. However, in order to remain competitive, banks must continuously take steps to enhance their attractiveness, as the competitive mechanism demands. As shown in Table 1, authors in the academic literature have identified factors influencing competitiveness in this sector over the years.

Table 1

Definitions of competitiveness in the banking services sector

Author	Definition
Stankiewicz M. J. (2005)	Although quality is the main source of competitive advantage, in the banking sector it does not guarantee sustained advantage. A bank's temporary dominance depends on the features and price of its products
Jonas A. (2002)	A sustainable competitive advantage can be achieved by providing high-quality services, maintaining a positive image and cultivating a strong reputation
Beck T., De Jonghe O., Schepens G. (2011)	It is not possible to analyse competitiveness in the banking sector without taking into account the interdependent behaviour of banks. Therefore, it is crucial to examine competition in the banking sector from the perspective of interbank relations
Rhoades S. A. (1993), Berger A. N., Demirgüç-Kunt A., Levine R., Haubrich J. G. (2004)	The competitiveness of a banking institution is influenced by market concentration and the value of loans granted by banks
Jia K., He Y., Mohsin M. (2023)	The expansion of banking activities has strengthened the competitiveness of various types of banks and their ability to attract customers
Lin M., Li B. (2025)	Innovation and technology are the driving forces behind competitiveness
Arefiev S., Serpukhov M., Blahun I., Varava L., Baula O. (2025)	Banks must respond quickly to external challenges and implement innovative solutions while ensuring the stability of the financial system

Source: own study.

The definitions cited also highlight the sector's evolution over the years. These definitions show that price is not the most important aspect of competition in banking. According to the authors cited above, the key factor influencing competitiveness in the banking sector is the number of these institutions and the size of their market shares. Information technology also has a significant impact on banks' competitiveness. A prerequisite for competitiveness is ensuring fast and efficient service and offering a wide range of products and services tailored to customer expectations. This, in turn, requires the introduction of product and organizational innovations. Therefore, competitiveness in this sector today means building a security-focused business model. Such measures are intended to support innovative development in the age of technological advancement, ensure competitiveness, and guarantee sustainability and stability under all conditions. The digitized nature of finance poses new challenges, such as cyberfraud and data breaches, which require consumers to be more vigilant and knowledgeable about potential misuse of financial resources, including banking services in the digital world (Lukonga, 2018).

It is also essential to build relationships with customers, particularly by creating value for them. The most important aspects of creating value for customers are: offering unique benefits, analyzing customers' long-term needs and expectations, the bank's continuous strategic development, and positive differentiation.

Today, increased competition in the banking sector has not only led to a rise in the number of new entrants but has also weakened the restrictive effects previously observed in a highly concentrated market. Cetorelli and Strahan (2006) argued that a less competitive banking system tends to allocate resources to large, established firms, raising barriers to entry for new firms and thereby limiting financing channels, which ultimately weakens economic growth. The above indicates that the competitiveness of the banking sector also contributes to economic development.

At this point, however, it is worth emphasizing that many financial services are moving into the virtual space, which fosters the development of alternative finance, involving the raising of funds and incurring liabilities through online platforms (Bilan et al., 2019, p. 70). This aspect poses a particular threat to the competitiveness of banks from the perspective of younger generations and their preference for innovative and technologically advanced solutions.

Factors Influencing a Bank's Value

As shown in Table 2, it is possible to identify a group of factors that currently influence an entity's competitiveness in the banking sector based on the definition of competitiveness.

Table 2

Factors Affecting Banks' Competitiveness in the Market

Contemporary factors contributing to a bank's competitive advantage	**Intangible assets**	Brand
		The bank's image
		Customer Loyalty
		Personalized Offer
	Human Resources	Employees
		Customers
	Material resources	Financial Assets
		Distribution Channels
		Technology

Source: own study.

The figure above illustrates how competitive advantage factors can be divided into three groups. The first group comprises tangible factors, including financial assets, a network of branches, ATMs, cash deposit machines and online or mobile service channels. It also includes modern software programmes that enable the creation of customer databases and the analysis of customer needs. Banks can leverage the potential of big data and artificial intelligence to gain a better understanding of customer needs, thereby increasing customer satisfaction by offering personalised services (Klein, 2019). These technologies allow banking institutions to focus on individual customer needs and respond effectively to their expectations (Cherkaoui, 2020), thereby gaining a competitive advantage in terms of intangible factors. Using new technologies enables banking institutions to provide 24/7 services while increasing operational efficiency and reducing operating costs (El Achari & Hattab, 2024; Lugun, 2024).

The second group consists of the bank's human resources, namely its employees and customers. Arefiev, Serpukhov, Blahun, Varava and Baula (2025) point out that human capital plays a key role in banks' competitive strategy. Based on the definition of competitiveness, we can identify a group of factors that currently influence competitiveness in the banking sector, as shown in Table 2.

Customers influence the creation of the bank's values, such as the quality of service and the products and services it offers.

The third group consists of intangible sources of competitive advantage, which include: brand, image, organizational culture, the quality of services provided, and the bank's personalized offerings. Today's consumers expect fast, easily accessible, and personalized banking services (El Achari & Hattab, 2024). This classification of factors contributing to a bank's competitive advantage appears to be the most appropriate grouping of factors in today's era of new technologies, as well as in an era where the human factor and intangible assets hold great significance for banking institutions in Poland.

A prerequisite for determining a bank's market position is identifying the sources of competitive advantage. These may take the form of distinctive or replicable capabilities. The former are difficult for competitors to copy. Therefore, achieving a sustainable competitive advantage focuses primarily on building it based on distinctive sources. These include: employee skills, the institution's reputation and image, the quality of customer relationships, and a unique and personalized offering. Developing an effective combination of distinctive values is possible only through consistently implemented strategies that is, a program centered on a conscious choice of what the bank intends to do and what it will not do. The concept of value-based management is based on the assumption that the value of any institution is created by two categories of assets: tangible and intangible. The first group of assets falls within the tradition of banking sector management. Therefore, these assets can be described as traditional factors of competitive advantage. In contrast, effective management of intangible assets creates a set of non-traditional factors of competitive advantage. These require a foundation in the capabilities that distinguish banks, such as market strategy, customer relationships, and the quality and personalization of services.

Factors Determining Generation Z Consumers' Choice of Banking Services in Light of an Empirical Study

Characteristics of Generation Z

Representatives of Generation Z participated in the study conducted for this report. They constitute a generational group of people born between 1997 and 2012 (Moon & Erdem, 2026). This is the first generation to have grown up with constant access to the internet and social media (Całek, 2021). Generation Z spends more time online than offline and prefers to use technology to communicate and maintain relationships. There is also a tendency among members of this generation to replace phone calls with video or text-based communication. The ability to

communicate without the Internet is significantly declining among members of this generation (Całek, 2021). J. Twenge, Z. Krizan, G. Hisler (2017) noted that Generation Z faces a problem related to constant internet use and being online.

This generation is taking advantage of ever-newer digital possibilities. Social media such as Facebook, YouTube, and Instagram play an important role in this group's lives (Mazurek-Łopacińska, 2018). TikTok is also gaining popularity among Generation Z, allowing young people to learn about finance and other areas of life in a more enjoyable way (Waśko, 2016).

It is also worth noting that members of Generation Z feel the need to express their own opinions, which explains their activity on social media, blogs, and forums. Before making a purchase, this group of consumers seeks out reviews on social media groups. They are also fairly impatient customers who value quick access to goods and do not want to wait long (Mazurek-Łopacińska, 2018, p. 64). What particularly characterizes this group of consumers is the fact that they are sensitive to the values upheld by the organizations whose services they use. The following factors become important:

- issues of fair treatment of employees;
- the interests of local suppliers;
- an ethical approach to production;
- environmental considerations.

This shows that Generation Z wants to have a real impact on the world around them. At the same time, Generation Z poses a challenge from a marketing perspective, as it exhibits the lowest level of brand loyalty compared to previous generations (Sharma & Dutta, 2025). Consequently, maintaining long-term customer engagement by creating memorable experiences such as virtual brand experiences – has become a strategic priority for companies (Bilgihan et al., 2024). The characteristics of Generation Z are presented in Table 3.

Table 3

Generation Z – Behaviors and Decisions

Description	Generation Z
Sales and marketing – impact	Social media, online networks, low loyalty
Purchase decision	Opinions on blogs and social media forums, rationalized and guided by one's values
Finance	A strong tendency to save

Source: own study.

Understanding the behaviours of different generations and consumer trends requires changes to the content and methods of communication with consumers. The literature emphasises that Generation Z will pose a particular challenge for businesses in the near future, as they are characterised by:

- significant purchasing power (Fromm, 2024);
- high levels of spending on innovations based on new technologies (Dynata, 2022);
- a high level of social engagement and openness to new technologies (Moon et al., 2025).

Understanding generational differences enables businesses to tailor their strategies to their target audience. Given the characteristics of Generation Z, banking institutions face the challenge of attracting this customer group, whose behaviours and preferences differ from those of previous generations (Generations X and Y).

Methodology of the study

The empirical research conducted for this study consisted of a quantitative survey. The survey was based on a questionnaire administered to a sample of 500 people.

The main objective of the study was to assess the factors contributing to the competitiveness of banks in Poland as perceived by members of Generation Z. The study sought to identify which factors are important when deciding which bank to choose. The focus was on banks operating in Poland.

To achieve the main objective, the following specific objectives were also defined:

- factors that distinguish a bank in the market among Generation Z representatives;
- from which sources do Generation Z customers obtain information about a bank and its offerings?
- factors influencing the choice of a bank by customers from the analyzed generation;
- customer expectations regarding entities in the banking sector;
- what is most important to customers when working with a financial institution?

The survey was conducted using the CAWI method. The questionnaire used for the survey consisted of questions regarding customers' experiences and expectations regarding their interactions with banks. Single-choice and multiple-choice questions were used, as well as open-ended questions.

Research results

Representatives of Generation Z indicated that innovative solutions, recommendations from other users on online forums and the bank's security were important factors when choosing and establishing a relationship with a bank (see Table 4).

Table 4

Factors influencing the development of banks' competitive advantage in Poland from the perspective of Generation Z (based on the results of the survey study)

Analyzed aspects	Factors	Dataset
Factors important in cooperation with a bank	Security	31.00%
	Innovative solutions	28.80%
	Positive opinions of other users	20.00%
	The bank's website	35.00%
Factors influencing the development of banks' image	Opinions of other users	33.60%
	The way customers are treated	43.80%
	Speed of problem resolution and complaint handling	41.80%
Characteristics of modern banks (what should they be like?)	Security	45.90%
	Innovative	41.10%
Elements distinguishing a bank in the market	Professional and fast service	19.60%

Source: own elaboration based on the conducted empirical study.

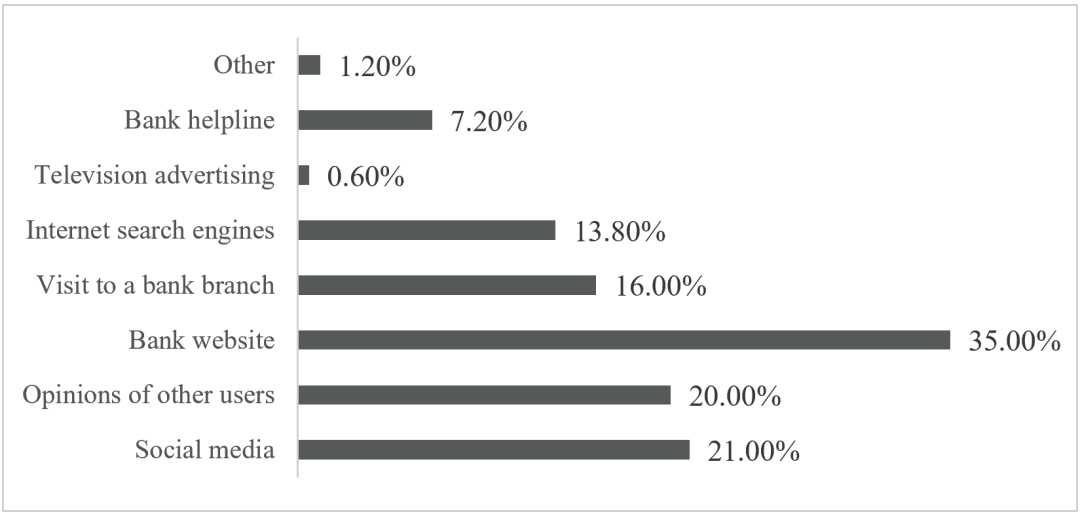
The aforementioned elements relate to intangible factors of competitive advantage, such as customer opinion, security, innovative services and the quality of customer service.

Respondents were asked to indicate where they obtained information about their bank's offerings (see Figure 1 for the results – p. 124). The bank's website was identified as the predominant source of information (35.00%). Customers also obtained information through social media (21.00%), the opinions and experiences of other customers (20.00%), and internet search engines (13.8%). By contrast, television advertising played only a marginal role in the process (0.6%).

In most cases, the bank's website appears to play the most important role in communication between the bank and its customers, and in providing information about the bank's offerings. Alongside this, respondents from Generation Z frequently cited social media and the opinions of other customers as sources of information about banking offers. A small group of respondents obtain information from the bank's helpline or advertising. Other sources of information mentioned by respondents included mobile applications, economic portals and correspondence from the bank (e.g., emails).

Figure 1

Sources used by respondents to obtain information about banks' offers

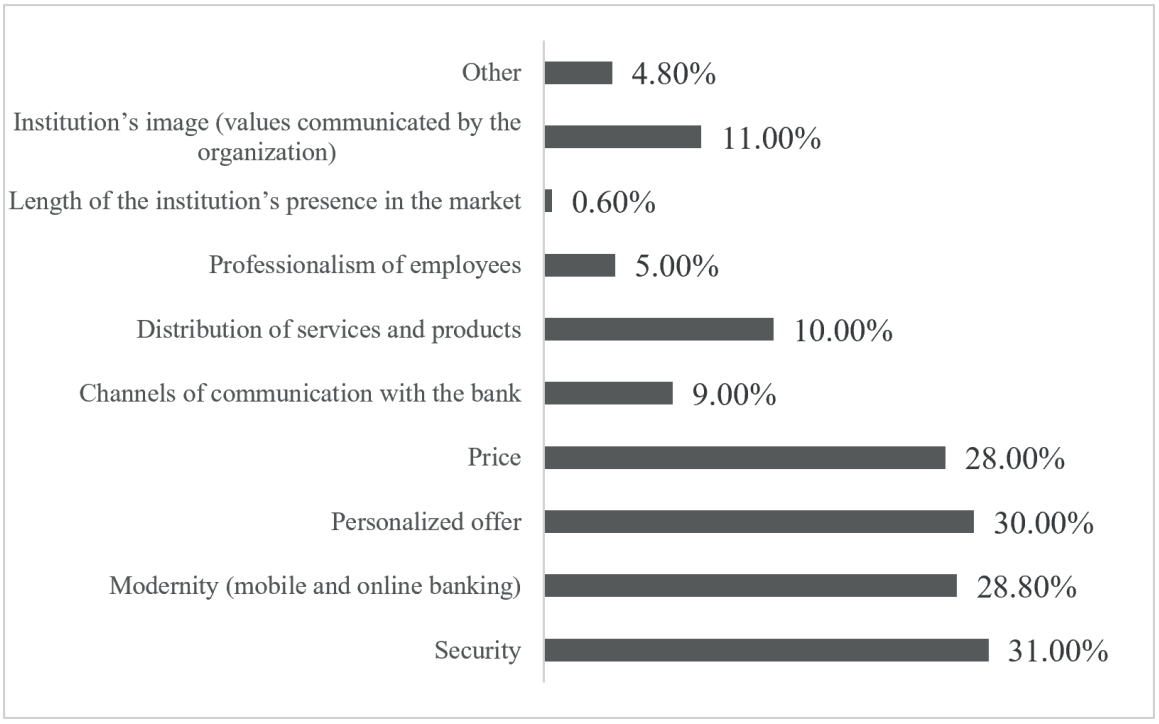


Source: own elaboration based on the conducted empirical study.

As shown in Figure 2, the aspects considered most important in cooperation with a bank were security (31.00%), offer personalisation (30.00%), the modernity of the bank and its services (28.80%). These aspects were followed by price (28.00%).

Figure 2

Factors important to respondents in cooperation with a bank



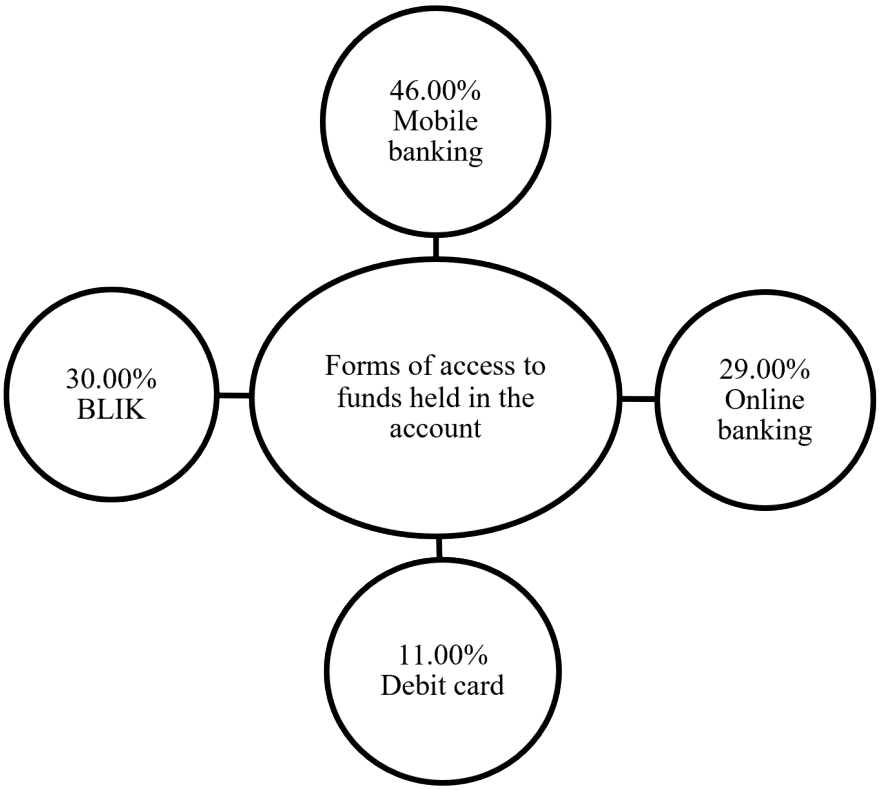
Source: own elaboration based on the conducted empirical study.

When selecting banking services, aspects such as the length of the institution's presence in the market (0.60%), the professionalism of employees (5.00%) and the channels of communication with the bank (9.00%) are important to only a small proportion of Generation Z respondents. More significant factors were security (31.00%) and personalised service (30.00%).

Mobile banking (46.00%) and online banking (29.00%) were the most common ways of accessing funds held in bank accounts among those surveyed. Respondents indicated these channels as the most frequently used for making payments and managing funds. Only a small proportion of respondents use debit cards linked to their accounts (11.00%), whereas a considerably larger proportion (30.00%) use the mobile payment service BLIK (Figure 3).

Figure 3

Key methods of using funds held in a bank account



Source: Own elaboration based on the conducted empirical study.

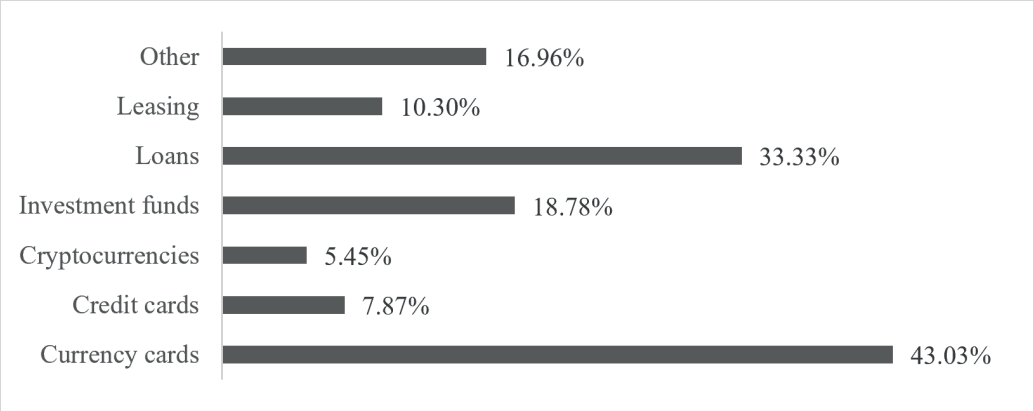
The least popular way to access funds held in a bank account is to withdraw cash at a bank branch (0.60%). Therefore, modernity was an important factor influencing respondents' choice of bank. Users of banking services value access to online and mobile banking, using these channels to manage their funds. Only a small number of respondents indicated using physical bank branches, highlighting the need to change the distribution model of banking services.

A growing number of Poles are using mobile banking to access services, enabling them to perform important operations such as making payments and opening accounts/deposits. This channel is growing in popularity, particularly among younger people, and is often the first aspect considered when evaluating a bank and its services.

Respondents were also asked about their use of services and products offered by financial institutions other than banks. 33.00% of Generation Z respondents indicated that they currently use or have used such services in the past. The main product used at non-bank financial institutions was currency cards (43.03%), as shown in Figure 4.

Figure 4

Types of products used by respondents in financial institutions other than banks



Source: own elaboration based on the conducted empirical study.

Within the 'Other' category, respondents suggested solutions such as structured products, currency transfers and brokerage accounts.

They were also asked about their motivations for using the services of non-bank financial institutions. 29.09% of respondents said that they chose a non-bank financial institution because its offer met their needs. For 21.21%, recommendations and positive customer reviews of a given institution and product were important. In turn, 17.57% of respondents indicated that price was a key factor. Respondents also stated that, in their opinion, non-bank financial institutions were characterised by fewer formalities, positive customer reviews and convenient, fast access to services via online platforms or mobile applications. Additionally, these services were often compatible with those of other institutions (e.g., enabling quick transfers or currency exchanges).

The above analysis indicates that respondents use the services offered by non-bank financial institutions. Correlation analysis revealed a moderate positive and statistically significant relationship between the level of savings and the number of products held that are offered by non-bank financial institutions ($r = 0.551$; $\rho = 0.593$; $p < 0.001$). This suggests that an increase

in savings is associated with a tendency to hold more products with non-bank financial institutions. This suggests that higher levels of savings encourage respondents to use the services of non-bank financial institutions.

The results also show a very strong positive relationship between the length of time spent using banking services and the number of products offered by non-bank financial institutions held. A very strong positive and statistically significant relationship was also found between the length of time respondents had been using banking services and the number of products offered by non-bank financial institutions that they held ($r = 0.911$; $\rho = 0.894$; $p < 0.001$). Therefore, the greater the respondents' experience of using financial services, the greater their propensity to use offerings from other institutions.

Discussion

Competitiveness in the banking sector is currently based not only on competition among banks themselves, but also on competition from financial institutions that offer products similar to those of banks but operate outside the banking sector. By leveraging new technologies and user experiences, innovative financial institutions have reshaped the dynamics of competition, placing technological agility, personalization, and innovation at the center of their value propositions (Gomber et al., 2017; Barroso & Laborda, 2022). Technology and reduced paperwork among these companies are becoming significant factors in competitiveness from Generation Z's perspective. Both FinTech companies and traditional banks are also increasingly relying on mobile apps (Lee & Yoon, 2026). This is also an important aspect for members of Generation Z, as the research has shown. Traditional banks are therefore striving to improve their services and cost structures to remain competitive, which benefits customers (Baker et al., 2023).

Fierce competition not only among banks themselves but also with non-bank channels encourages them to innovate and offer more attractive financial products (Ghosh & Golder, 2026). As research findings have shown, non-bank institutions can attract customers who are experienced in using financial products as well as those with higher levels of savings. As a result, this may reduce the profitability of traditional banks (Karaman et al., 2021).

The emergence of alternative FinTech-based platforms may therefore also pose a threat to traditional bank lending and have a negative impact on return on assets and net interest margin (Cuadros-Solas et al., 2023). Additionally, this threat may cause traditional banks to adopt riskier lending practices and lower their lending standards in order to attract the unbanked and low-income customers and remain competitive in the market (Corbet et al., 2024).

Given the findings of this study, it should also be noted that customers are increasingly using mobile banking apps and mobile payment systems, which in turn indicates a deeper technological transformation of financial services and markets (Akinbowale et al., 2023; Ahmed et al.,

2024; Mansaray et al., 2024; Del Sarto et al., 2025). These innovations can lead to the development of innovative products and services (Aloulou et al., 2023; Yang & Masron, 2023) and significantly improve customer relationships in the banking sector (Prokopenko et al., 2022).

In addition to modernity and technology, security is important to Generation Z, which has been highlighted as a key factor for this group when interacting with a bank. A sense of security achieved, among other things, through digital payments rather than manual payments for goods or services is essential because customer integrity directly supports trust in security features, such as authentication, which ensures safe and secure transactions. In practice, financial institutions must strengthen the security of their digital services, user-friendliness, and promotional strategies to build trust and engagement among Gen Z customers (Kurniati et al., 2025).

Conclusion

To summarize the above considerations, we should now address the research hypotheses formulated in the introduction.

Hypothesis 1 (H1) – price is not a key factor influencing Generation Z's choice of banking services. This hypothesis is supported by the fact that, for Generation Z, security, modernity, and a personalized offering are important when working with a bank (figure 2). Price ranks fourth, cited by 28.00% of respondents.

This also confirms Hypothesis 2 (H2), which states that new technologies are the leading factor in the competitiveness of banks in Poland among Generation Z customers. This hypothesis is supported, among other things, by respondents' answers indicating that mobile banking, BLIK, and online banking are the primary channels for accessing funds held in a bank account (Figure 3). Current customer expectations assume that access to banking services should be fast, reliable, and user-friendly, whether via online or mobile banking.

Hypothesis 3 (H3), in turn, posits that Generation Z respondents are inclined to use the services of financial institutions (other than banks) if they perceive them to be modern, innovative, and backed by positive reviews from other users. 29.09% indicated that the reason for using the services of a non-bank financial institution was that the offering met their needs. For 21.21%, the opinions of other customers who recommended a given institution and product were important. Respondents stated that, in their view, the non-bank financial institution's offer was characterized by: less paperwork, positive reviews from other customers, and the ability to use the product conveniently and quickly via a web platform or app. This therefore confirms Hypothesis 3.

The conducted research shows that banks face intense competition both within and outside the sector. Therefore, to remain competitive, they must focus on meeting the needs of both their current and potential customers. To attract members of the studied group – Generation Z, it is

essential to meet their expectations. In this context, it seems crucial to prioritize the development of mobile and online services ensuring fast, convenient, and, most importantly, secure access to their funds. For this group, security is the most important factor considered when choosing a bank and doing business with it. Therefore, banks' investment in new technologies as well as the related cybersecurity aspects is a key element in maintaining competitiveness in the market. Consequently, the first and most reasonable recommendation is to collaborate with reliable and innovative companies specializing in the development and implementation of new financial technologies, or to establish in-house departments dedicated to this area. Equally important for Generation Z is having access to modern products tailored to their needs within a financial institution. This means that banks' offerings must be unique and customized for each customer. The use of a comprehensive database (Big Data) on customers, their needs, and their consumer behavior certainly supports this approach. Banks have been following this trend for quite some time, but it is becoming increasingly important to utilize these solutions more intensively, since, on the one hand, these are the expectations of young customers, and on the other hand, FinTech institutions are already competing in this area. The study shows that competition exists not only within the sector itself but also outside of it, which poses an additional threat to banks as they vie for the attention of Generation Z with their offerings.

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Magdalena Ślebocka https://orcid.org/0000-0003-1957-3717
PhD, University of Lodz, Faculty of Economics and Sociology, e-mail: magdalena.slebocka@uni.lodz.pl

Marta Szaja https://orcid.org/0000-0002-4137-9104
PhD, University of Szczecin, Institute of Management, e-mail: marta.szaja@usz.edu.pl

Hasibe Aysan https://orcid.org/0000-0001-6485-9824
PhD, Ostim Technical University, Department of International Trade and Finance,
e-mail: hasibe.aysan@ostimteknik.edu.tr

Adrianna Ślebocka https://orcid.org/0009-0005-4411-491X
M.Sc. Arch. Independent researcher, e-mail: slebocka.adrianna1@gmail.com

THE IMPACT OF REVITALIZATION ACTIVITY ON THE RESIDENTIAL ATTRACTIVENESS OF SELECTED CITIES IN POLAND AND IN TURKEY

Abstract

The purpose of the article. This study identifies revitalization activities that enhance residential attractiveness across diverse socio-cultural and economic contexts. Employing case studies and multiple-criteria decision analysis (MCDA), the research evaluates three Polish (Lodz, Wroclaw, Poznan) and two Turkish cities (Hatay, Diyarbakır). The findings demonstrate that revitalization strategies must be meticulously tailored to local circumstances, and their effectiveness relies upon the successful integration of social, economic, and environmental objectives. Ultimately, this research offers urban planners and policymakers valuable insights and cross-regional best practices for formulating sustainable urban development policies.
Methodology. The article uses Methods for Cardinal Preference of Attribute Given, i.e., Simple Additive Weighting Method – SAW and Hierarchical Additive Weighting Method.
Results of the research. Revitalization is an effective tool for increasing the residential attractiveness of cities; however, its effectiveness depends on resident engagement, the coherence of urban planning, and consideration of local needs. Measures taken in this regard can be a significant factor in increasing residential attractiveness. The revitalization successes of the cities analyzed can serve as a foundation for further development and for addressing contemporary demographic and urban planning challenges. At the same time, the analysis confirms the need for further research on the relationships between revitalization processes and residential attractiveness, especially in the context of cities operating under different social and cultural conditions.
Keywords: revitalization, residential attractiveness, local government, development policy, urban development
JEL Class: R11, R23, R58

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Introduction

Although the impact of revitalization processes on urban development has been widely discussed in the literature, existing studies predominantly focus on case analyses within homogeneous institutional and economic systems. Consequently, there is a distinct research gap regarding cross-national comparative studies that confront structured, often EU-subsidized urban regeneration models (such as in Poland) with the urban policies of emerging markets facing different demographic and spatial pressures (such as in Turkey). Furthermore, there is a lack of rigorous, quantitative multi-criteria decision analysis (MCDA) tools applied to objectively measure changes in residential attractiveness across such diverse legal and cultural contexts. This paper bridges this gap by integrating MCDA into a cross-national comparative framework, thereby providing original insights into how different urban policies shape territorial attractiveness and demographic resilience beyond a single institutional setting. Cities, much like companies, compete with each other. This concept, dating back over a thousand years, was significantly advanced from a strategic management perspective Michael Porter in his 1995 article, *The Competitive Advantage of the Inner City*. Porter, renowned for his work on the competitive advantages of companies, sectors, and countries, applied his expertise to urban competitiveness. He analyzed cities as companies, focusing on their competitive strengths and weaknesses and outlining the roles of various stakeholders in enhancing urban competitiveness. However, Porter was not the first to view cities in this way. For instance, Kotler et al. (Kotler et al., 1993) argued that if cities are to compete with one another, they must adopt a mindset similar to that of companies.

It is indispensable that all the activities in cities are undertaken in a planned and methodical manner. This is what, to the largest extent, contributes to restoring cities to their former glory and to enhancing their residential attractiveness.

The scale of negative phenomena occurring in metropolitan areas (increasing degradation of the urban fabric, social issues such as unemployment, poverty or exclusion) along with the extensive area on which these phenomena take place have become one of the key issues touched upon on the global, European, national and local forums. Revitalization activities are aimed at recovering from the critical state of such urban areas in particular with regard to a potential increase in their residential attractiveness.

The research aim of the paper is to present the significance of the revitalization process from the point of view of residential attractiveness as well as to evaluate, in terms of multiple criteria, selected cities in Poland and in Turkey with regard to the said attractiveness.

In order to reach the pursued objective, the following research questions were posed:

1. Question 1: What are the priorities when revitalization undertakings are carried out in a city?

2. Question 2: What are the most import factors contributing to the residential attractiveness of the urban areas subjected to revitalization?
3. Question 3: What activities should be undertaken in order to restore to life degraded urban areas?

The layout and content of particular sections of the paper are dictated by the adopted research hypotheses:

1. H1: Revitalization activities carried out in cities contribute to an increase in their residential attractiveness.
2. H2: There is a positive correlation between the level of residential attractiveness and revitalization activities.
3. H3: The redevelopment of urban technical infrastructure serves the purpose of enhancing their residential attractiveness.

The selection of adequate cities for the purpose of the study was crucial for obtaining representative results and for drawing general conclusions. In the present study three cities from Poland (Lodz, Wroclaw, Poznan), and two cities from Turkey (Hatay, Diyarbakir) were selected as the examples which can be used to analyze the impact of revitalization on residential attractiveness. The selection criterion was based on the analysis of similarities and differences in the economic, social, historical and town planning contexts of the aforementioned cities.

The case study method was, inter alia, applied in the study as it is conducive to an in-depth understanding of the local revitalization considerations and their impact on residential attractiveness. The selection of the cities was carried out according to the following criteria:

1. the scale and intensity of revitalization undertakings. The cities differ from one another in terms of the scale of carried out activities, which makes it possible to evaluate their effectiveness under various conditions;
2. historical and social complexity. The selected cities are characterized by a rich history, social diversity and varied urban planning challenges;
3. the position in the national settlement network. Middle-size cities, which play a vital role in the national urban system, constitute a good representative of the average urban development in Poland (Wroclaw, Lodz and Poznan are ranked third, fourth and fifth respectively in terms of the number of inhabitants) and in Turkey;
4. the possibility of drawing intercultural comparisons. The cultural diversity between Poland and Turkey provides an opportunity to better understand universal and specific revitalization mechanisms.

For the analysis of quantitative data, a range of variables addressing various aspects of the issues raised was adopted. A detailed analysis of numerical data was conducted using figures from 2015, 2022 and 2024. In the course of the research process multiple-criteria decision

analysis methods (MCDA) were applied – the Simple Additive Weighting method (SAW) and the Multiplicative Weighting Method (also known as the Hierarchical Additive Weighting Method). MCDA methods enabled researchers to evaluate a few alternatives in terms of many decision-making criteria.

The article was divided into four parts. The second section provides a brief analysis of the literature on the subject, describing the significance of revitalization efforts for urban development. In the third part the research methods were outlined as well as the findings of the study. The fourth section presents the final conclusions and recommendations.

Literature Review – Revitalization as a Factor Enhancing the Residential Attractiveness of Cities

Revitalization of urban spaces year by year becomes a priority issue for modern cities which strive after sustainable development and improving the quality of life of their inhabitants. Skillfully planned revitalization processes may turn degraded areas into vibrant quarters thus increasing their residential and economic attractiveness. "Cities undergo constant change. They are never static, never finished, always adjusting to new circumstances. But over the last 30 years many European cities have experienced a pace of change far more rapid than at any other time in their recent history" (Couch et al., 2008).

Undoubtedly, long-lasting neglect spanning for decades led to the degradation of both urban infrastructure as well as the quality of public spaces, which has an adverse effect on the quality of life of residents and the overall city image in the domestic and international arena. In order to improve the quality of life of the social strata and to restore cities to their former glory, regeneration activities that are undertaken, are aimed at combating the degeneration of the urban fabric and negative phenomena.

Contrary to the widespread approach, revitalization does not focus solely on restoring infrastructure. It encompasses several other vital aspects which are taken into account when undertaking the efforts to recover degraded areas. The activities are not only of the urban character but also of the social, economic and environmental one. They constitute value added as regards the areas in which they are carried out.

The definition of revitalization, both in the Polish and foreign literature, underlines its multifaceted character which encompasses a physical, social and economic restoration of degraded urban areas (Balsas, 2007). It is an expedient process, the main guideline of which is enhancing the quality of life and restoring to degraded urban areas their former functions and attractiveness (Ashworth, 1991; Skalski, 1996; Zuziak, 1998; Turok, 2005; Markowski & Stawasz, 2007; Tallon, 2013; Roberts & Sykes, 2020; Attia et al., 2017; Hajdys & Ślebocka, 2021).

Revitalization is one of the rehabilitation methods of cities and other related settlements. Due to the geopolitical changes, which generated both economic and social changes to a city, central areas are the most vulnerable urban spaces. This vulnerability occurs directly through neglect and abandonment of the central areas, which in many cases are historical and part of the city's identity, or indirectly as a consequence of the territorial urbanization in any point of the region, by decentralizing living, commerce and office areas (Radoslav et al., 2013). On the other hand, urban development and redevelopment initiatives (Özdemirli, 2014) are common ways of revitalizing cities as well.

Regeneration activities bring about numerous benefits which can be distinguished into the following main categories:

- a political aspect consists in city branding and enhancing city prestige. Systemically carried out revitalization not only exerts a positive impact on the perception of a city by potential investors and residents but also contributes to increasing its significance in the domestic and international arena (Lees et al., 2008; Pancewicz et al., 2021);
- a technical aspect relates to improving city infrastructure. One of the pursuits of the initiators of revitalization processes is adapting a city to current technical standards. Recovery measures lead to a significant enhancement of the condition of public spaces, roads, i.e., urban infrastructure in a broad sense (Dec-Kiełb, 2024);
- a social aspect – based on strengthening and rebuilding social bonds. When designing revitalization projects, it is important to identify the needs of those who will use the space. This translates into the level of resident engagement in the revitalization process, consequently leading to more sustainable and lasting effects, a sense of community, and an improved quality of life (Smith, 1996; Mliczyńska-Hajda, 2013; Neto et al., 2014; Lisowska & Ochmański, 2016; Dec-Kiełb, 2024);
- environmental and cultural aspects – they integrate all kinds of undertakings conducive to ameliorating the quality of urban environment by sustainable management of natural resources, investments in ecological infrastructure and cultural heritage conservation as well as promoting local culture. In this way they positively affect the attractiveness of cities with regard to tourism (Madandola & Boussa, 2023);
- economic aspects – they are manifested by the stimulation of local economy by means of job creation, supporting local businesses, attracting investors (Roberts & Sykes, 2000) or by an increase in property values (Cameron, 2003).

To sum up, "urban areas have always performed a wide range of functions. Shelter, security, social interaction, and the sale and purchase of goods and services are among the traditional roles of a town or city. The relative importance of each of these functions has changed over time,

and such changes have created new demands for land, floor-space, infrastructure and the provision of a range of accompanying facilities" (Roberts & Sykes, 2000). Therefore, revitalization of urban areas plays a key role with regard to ameliorating the quality of life and stimulating local economy, which in turn contributes to a rise in residential attractiveness.

Residential attractiveness is a relatively new concept. It originates from the issues regarding territorial development and is based on mutual rivalry between cities. Residential attractiveness is gradually advancing and currently constitutes one of the fundamental components of the policy conducted by municipal authorities striving to reverse the process of depopulation (Miot, 2015; Kuzmanović et al., 2020).

Residential attractiveness refers to the qualities of a location that make potential residents want to move there or encourage current residents to stay (Fertner et al., 2015). This attractiveness can be enhanced by public policies aimed at revitalizing the area's residential appeal, thereby fostering a sense of attachment and attracting new residents (Miot, 2015). Some scholars suggest that the variation in features available in different urban areas accounts for their differing levels of attractiveness (Buch et al., 2014).

Different criteria affect the perception of a city as an attractive one. The major ones are as follows: amenities for social and family life, the level of economic development, job opportunities available in the place of residence or in its vicinity, conditions for sports and leisure, environmental factors etc. Growing expectations of residents in terms of residential standards are clearly noticeable. They concern not only proximity but also an unlimited access to social infrastructure facilities (schools, kindergartens, health centers), technical infrastructure (which ensures good commuting opportunities as regards the locations which are important for residents, the level of technical advancement of the water and sewage network adequate for a particular area, equipping flats in basic sanitary installations etc.) as well as paying attention to preserving nature-related attributes. In the literature on the subject numerous studies have been presented with regard to residential preferences. Empirical research has focused both on the physical characteristics of the places which shaped the said preferences (Pacione, 2003; Kim et al., 2005; Diepen & Musterd, 2009; Bader, 2011; Sinniah et al., 2016; Hasanzadeh et al., 2019) as well as on the social aspects touching upon the issues connected with ethnicity (Clark, 1991; Clark, 1992), age, the level of education, financial standing (Clark, 2009; Pisman et al., 2011; Andersson et al., 2019) and travel preferences (Handy et al., 2005; Van Acker et al., 2007; Susilo et al., 2012; Aditjandra et al., 2012; Luckey et al., 2018). The findings of earlier research indicated, inter alia, that attractiveness of a particular area in the perception of its inhabitants as well as their residential preferences are determined by exogenous factors – connected with the characteristics of the evaluated area and endogenous factors – pertaining to the traits of character of the evaluating person (Bartnicka, 1989). Researchers also put forward

a set of positive qualities which make up the residential attractiveness of a particular area, i.e., nature-related ones, utilitarian ones, social ones, town planning and architectural ones and aesthetic ones which can be assessed by various indicators (Bartoszek et al.,1997; Jałowiecki & Szczepański, 2006).

Therefore, the perception of the residential attractiveness of a city is affected by objective aspects (the standard of buildings, associated infrastructure, landscape-related attributes, potential jobs, the proximity of social infrastructure facilities) as well as by subjective ones (the level of residential aspirations, emotional attachment to a particular area, aesthetic preferences etc.) (Szafrańska, 2016).

The relentless competition between cities compels their authorities to manage the city in a way that will ensure appropriate conditions for stable, sustainable development in the long term and contribute to positive demographic processes. Therefore, human potential is one of the key elements that cities compete for. It concerns the "potential for work, human resources – that is, a set of possibilities, abilities, skills and motivations inherent in people, and thus in the territorial unit" (Gołębiowska, 2005; Zabierowski, 2011). Each city strives to attract new residents, primarily young people and those with high qualifications. This is ultimately intended to lead to the creation of a stable and strong local social and intellectual capital, as well as to contribute to slowing down the ageing process and population decline (Pytlak, 2010; Malecki, 2000) in the area.

Undoubtedly, revitalization of the degraded urban fabric servers to attain the aforementioned strategic objective of the city. It is due to the fact that it significantly affects residential attractiveness and the enhancement of the quality of life of the inhabitants. It is also conducive to arousing interest on the part of new residents.

The most common ways in which revitalization exerts a positive impact on the residential attractiveness of cities encompass:

- the amelioration of the condition of infrastructure (the technical one, the social one) – within the framework of the revitalization process the existing infrastructure may be modernized and enhanced; the improvement of the technical condition of roads, pavements (walkways), systems of public transport as well as facilitated access to electric power and the water and sewage network; the construction, extension or modernization of schools, kindergartens, libraries, municipal reading rooms. All the aforementioned elements contribute to making a city a more functional and comfortable place to live in (Osman, 2016);
- public space and greenery – revitalization can focus on developing new green areas, parks, squares and cycle paths; the extension of this kind of areas is not only conducive to leisure but also creates a pleasant and quaint environment, which attracts residents and encourages them to spend time outdoors in an active manner (Jaszczak et al., 2021);

- a lively cultural and entertainment offer – new culture centers, theatres, art galleries, cinemas and entertainment spots which emerge in the course of revitalization arouse the interest of residents and tourists by creating a vibrant cultural scene (Peterson 1979; Gainza 2017);
- improved aesthetics and architecture – revitalization may encompass renovations and architectural restoration of the existing buildings and the introduction of new, attractive architecture. This translates into the city aesthetics and creates exquisite visual impressions (Forte & Girard 2009);
- security and the quality of life – regeneration activities can exert an impact on improving security in the areas which were formerly neglected or are more prone to crime. It positively affects the quality of life of residents and their sense of security (Mason, 2003);
- a variety of services and amenities – revitalization often triggers the development of new shops, restaurants, cafés and other services, which improves the availability of everyday amenities for residents (Vural-Arslan et al., 2011);
- community engagement – the engagement of the local community in the revitalization process may enhance a sense of community and pride in the city, which attracts residents and contributes to creating a positive spirit of collectivity (Lawson & Kearns, 2010);
- a rise in the real property prices – due to improving infrastructure, aesthetics and the quality of life, the price of real property in the areas subjected to revitalization may increase, which attracts investors and the people interested in purchasing or renting real property (Wadu et al., 2018).

Despite a wealth of academic research on urban regeneration (Roberts et al., 2020; Couch et al., 2008), the relationship between the effects of revitalization and the residential attractiveness of urban areas remains insufficiently understood. Existing research focuses primarily on the spatial, economic or social effects of revitalization processes, without examining the impact of regeneration measures on residential satisfaction (Kim & Sim, 2026a; 2026b), quality of life and residents' locational choices (Mouratidis, 2021; Mouratidis & Yiannakou, 2022; Chin et al., 2025). There is a clear shortage of research on post-socialist cities in Central and Eastern Europe, where regeneration processes take place within different historical and institutional contexts (Stanilov, 2007; Tsenkova, 2014). Consequently, there is a need to develop comprehensive research models that allow for the assessment of the impact of revitalization on residential attractiveness from the residents' perspective, as well as the long-term effects of these processes. Understanding how revitalization efforts contribute to increased residential attractiveness can provide valuable insights for urbanists, city planners, decision-makers involved in the regeneration of degraded urban fabric, lawyers, sociologists, and financiers. This, in turn, can translate into the development of more effective revitalization strategies.

Strategies that are better suited to the needs of the local community, contributing to attracting new residents, increased demand for properties, an increase in the number of infrastructure investments, and an enhancement of the city's prestige.

Materials and Methods

To address the theoretical and empirical objectives of this study, a cross-national comparative approach focusing on selected municipalities in Poland and Turkey was adopted. Comparative urban research frequently faces the challenge of contextual commensurability. However, contrasting a Central European EU member state with an emerging market economy at the crossroads of Europe and the Middle East offers a substantial cognitive value for urban regeneration and spatial attractiveness literature.

Poland exemplifies the Central European post-socialist urban transformation model, heavily anchored in the institutional, legal, and financial frameworks of the European Union. Urban regeneration in Polish cities (Lodz, Wroclaw, Poznan) operates under cohesive legislative mandates (such as the Polish Act on Revitalization of 2015) and relies heavily on structured EU structural and cohesion funds. Turkey, conversely, represents a rapidly urbanizing emerging economy characterized by a highly centralized governance model (e.g., TOKİ interventions) and distinct demographic pressures. Turkish urban regeneration is primarily driven by state-led infrastructure initiatives, market-driven redevelopment, disaster-mitigation imperatives, and geopolitical shifts.

Cognitive Value: Comparing these two distinct institutional regimes enables the identification of universal drivers of residential attractiveness (e.g., green space provision, basic technical infrastructure) versus context-dependent mechanisms (e.g., reliance on external EU subsidies versus rapid state-led crisis management).

The selected countries display contrasting urbanization trajectories and macro-level vulnerabilities:

- Demographic Resilience vs. Shrinkage: Polish cities operate within a broader national context of demographic ageing and suburbanization/depopulation (notably in post-industrial hubs like Lodz). In contrast, Turkish cities experience rapid population movement, internal migration, and distinct demographic expansion;
- Nature of Urban Degradation: While degradation in the selected Polish cities stems from historical post-industrial decline and socio-spatial transition after 1989, urban transformation in the selected Turkish cities is profoundly shaped by acute external shocks – namely, civil security conflicts and reconstruction in Diyarbakır, and catastrophic seismic events (the 2023 earthquakes) in Hatay.

Figure 1

Maps of the country showing the locations of the cities analyzed in the study



* The scale of the countries relative to one another is not maintained.

Source: created by the authors.

Therefore, when evaluating the level of residential attractiveness of the selected cities in Poland and in Turkey ten variables depicting the situation in particular cities in 2015, in 2022, and in 2024 in the social, economic, infrastructural, environmental and administrative sphere were taken into consideration.

This article uses Methods for Cardinal Preference of Attribute Given, i.e., Simple Additive Weighting Method and Hierarchical Additive Weighting Method. Simple Additive Weighting method (SAW) is probably the best known and very widely used method of MADM. The method is well summarized by MacCrimmon (1968). A basic discussion of the underlying considerations is given by Churchman and Ackoff (1954), and by Klee (1972).

Due to profound differences in macroeconomic contexts and data architecture (TÜİK vs. GUS), the Polish and Turkish cities were normalized within their respective national subgroups (against local maximums). While the SAW scores facilitate an assessment of urban development dynamics over time, the absolute values cannot be directly compared across the two countries.

To each of the attributes in SAW, the DM assigns importance weights which become the coefficients of the variables. To reflect the DM's marginal worth assessments within attributes, the DM also makes a numerical scaling of intra-attribute values. The DM can then obtain a total score for each alternative simply by multiplying the scale rating for each attribute value by the importance weight assigned to the attribute and then summing these products over all attributes.

After the total scores are computed for each alternative, the alternative with the highest score (the highest weighted average) is the one prescribed to the DM. The additive form is depicted by the following formula:

$$U(\mathrm{a}) = \sum_{j=1}^{\mathrm{n}} c_{\mathrm{j}}(\mathrm{a}) w_{\mathrm{j}} \tag{01}$$

where:

$w_j \geq 0$ is the weight of the c_j criterion;

c_j(a) is the value obtained by operation a for the c_j criterion function.

The c_j function is nondecreasing for the benefit criterion and nonincreasing for the cost criterion.

Simple additive weighting method requires a comparable scale for all elements in the decision matrix. The comparable scale is obtained by applying eq. to the following criteria:

- of the benefit type (e.g., exclusively for boosters), that is the more the better (the higher the value the better); in such a case we use the following formula for the calculations (1):

$$r_{ij} = \frac{x_{ij}}{x_j^*} \tag{02}$$

where:

x_{ij} – the present value

x_j^* – the maximum value which we take into consideration or the best value out of the considered alternatives:

- of the cost type (e.g. exclusively for inhibitors), that is the less the better (the lower the value the better); in such a case we use the following formula for the calculations (2):

$$r_{ij} = 1 - \frac{x_{ij}}{x_j^*} \tag{03}$$

where:

x_{ij} – the present value

x_j^* – the maximum value which we take into consideration or the best value out of the considered alternatives.

The abovementioned formula is applied solely in the situation when we consider the cost criterion. In the situation when we consider both types of criteria – of the benefit type and of the cost type we use formula No. 1 (for the benefit criterion) as well as the last formula No. 3 (for the cost criterion):

$$r_{ij} = \frac{x_j^{min}}{x_j^*} \tag{04}$$

where:

x_j^{min} – the minimum value which we take into consideration or the worst value out of the alternatives considered;

x_{ij} – the present value.

Simple additive weighting method uses all *n* attribute values of an alternative and uses the regular arithmetical operations of multiplication and addition; therefore, the attribute values must be both numerical and comparable. Further, it is also necessary to find a reasonable basis on which to form the weights reflecting the importance of each of the attributes (Hwang & Yoon, 2011).

Besides the additive form, also the multiplicative form of the function was applied which can be depicted by the following formula:

$$U(a) = \frac{\prod_{j=1}^{n}[1 + kc_j(a)w_j] - 1}{k} \tag{05}$$

where:
$w_j \geq 0$ is the weight of the c_j criterion;
$c_j(a)$ is the value obtained by operation *a* for the c_j criterion function;
the c_j function is nondecreasing for the benefit criterion and nonincreasing for the cost criterion;
$k > -1$, $k \neq 0$ is the scaling constant.

The evaluation of the residential attractiveness of the cities which were the subject of the study was carried out by going through every consecutive stage of the method described (Grabiński, 1988; Panek & Zwierzchowski, 2013; Nermend, 2017):

Step 1 – Defining the problem, generating alternatives and determining criteria

The decision-making problem should start with a clear defining of the problem, delineating the alternatives, specifying the subjects, goals and all the points of the conflict along with limitations, the rate of uncertainty and key issues. After that the problem can be put into the framework indicating the evaluation criteria.

Step 2 – Assigning weights to criteria

Subsequent steps cover the assigning of weights to criteria. Those weights that indicate the relative importance of criteria in the multiple-criteria problem which is under consideration can be determined by means of techniques such as Analytical Hierarchy Process and the Sismos approach (Hwang & Yoon, 1981; Kobryń, 2014).

Step 3 – Development of the scoring matrix

The phase in which the model is developed constitutes the process in the course of which "the essence" of the problem is isolated from a complex picture so that the problem could be appro-

priately evaluated (Hwang & Yoon, 1981). In the end of this stage the MCDA problem can be depicted in the form of a matrix in the following way:

- where x_{ij} is the score assigned to the i alternative in relation to the j criterion, w – is the j criterion weight, n – is the number of criteria, and m – is the number of alternatives.

Step 4 – Selection of an adequate method

The multiple-criteria method must be selected and applied to consider the problem in order to rank the alternatives. Data and the rate of uncertainty constitute key factors for the decision maker when selecting one out of several multiple-criteria methods (Abdullah & Adawiyah, 2014).

Step 5 – Data normalization

Normalization is the process of preliminary data processing in order to facilitate the comparison of the said data and further analysis. The collected input data (indicators) are expressed in different units of measurement (km, item, m², PLN) and they have different areas of variability and thus it is not possible to directly carry out arithmetic operations on the said data or to compare them. The process of normalization of the variables will provide an opportunity to eliminate the aforementioned formal limitations and the difficulties related to interpretation (Kukuła, 2000).

Step 6 – The ranking of alternative solutions

Eventually, the ranking of alternatives is arranged appropriately, and the best alternative is prescribed as the solution (Nermend, 2009; Nowak, 1990).

To assess the residential attractiveness of the selected cities in Poland and Turkey in 2015, 2022 and 2024 the data was normalized and processed using the Simple Additive Weighting (SAW) method and the Multiplicative Weighting method. The obtained normalized values for each city and year are presented in the following tables.

Table 1

Ranking of Polish cities in 2015 based on the SAW method

POLAND 2015	Lodz	Poznan	Wroclaw
Additive Weighting Method	0.825	0.778	0.935
Multiplicative Weighting Method	1.145×10^{-11}	0.234×10^{-11}	4.784×10^{-11}

Source: own elaboration based on data published by Statistics Poland, https://bdl.stat.gov.pl/bdl/start.

Table 2

Ranking of Polish cities in 2022 based on the SAW method

POLAND 2022	Lodz	Poznan	Wroclaw
Additive Weighting Method	0.807	0.797	0.969
Multiplicative Weighting Method	0.866×10^{-11}	0.314×10^{-11}	6.934×10^{-11}

Source: own elaboration based on data published by Statistics Poland, https://bdl.stat.gov.pl/bdl/start.

Table 3

Ranking of Polish cities in 2024 based on the SAW method

POLAND 2024	Lodz	Poznan	Wroclaw
Additive Weighting Method	0.791	0.806	0.939
Multiplicative Weighting Method	0.511×10^{-11}	0.417×10^{-11}	5.232×10^{-11}

Source: own elaboration based on data published by Statistics Poland, https://bdl.stat.gov.pl/bdl/start.

General Trends in Poland:

- Lodz shows a constant decrease in attractiveness – the SAW method results indicate a decline in the attractiveness index for the city between 2015, 2022 and 2024. This suggests that despite revitalization efforts, external factors such as economic downturns, demographic changes, or infrastructural challenges might have contributed to lower perceived attractiveness.
- Poznan is showing a steady growth in its residential appeal. Despite having the least favorable starting point of the three cities analyzed, it has completely turned its situation around over the course of nine years, achieving a marked improvement compared with the other urban centers.
- Wroclaw's continuous improvement – the highest SAW value in the analyzed years suggests that Wroclaw has maintained and even enhanced its residential attractiveness. This improvement could be attributed to successful urban planning, infrastructure development, and an expanding job market. A noticeable decline in what was already a high figure between 2022 and 2024 may be linked to an improvement in Poznan's standing and in the parameters analyzed.
- Values decline in the Multiplicative Method – the negative values observed for Lodz in the Multiplicative Weighting method may indicate increasing disparities in attractiveness indicators relative to other cities, possibly due to socio-economic polarization.

Table 4

Ranking of Turkish cities in 2015 based on the SAW method

TURKEY 2015	Hatay	Diyarbakır
Additive Weighting Method	0.697	0.508
Multiplicative Weighting Method	9.719×10^{-11}	0.813×10^{-11}

Source: own elaboration based on data published by Statistics Turkey, https://www.tuik.gov.tr/Home/Index.

Table 5

Ranking of Turkish cities in 2022 based on the SAW method

TURKEY 2022	Hatay	Diyarbakır
Additive Weighting Method	0.616	0.628
Multiplicative Weighting Method	3.532×10^{-11}	4.347×10^{-11}

Source: own elaboration based on data published by Statistics Turkey, https://www.tuik.gov.tr/Home/Index.

Table 6

Ranking of Turkish cities in 2024 based on the SAW method

TURKEY 2024	Hatay	Diyarbakır
Additive Weighting Method	no data available	0.578
Multiplicative Weighting Method	no data available	2.241×10^{-11}

Source: own elaboration based on data published by Statistics Turkey, https://www.tuik.gov.tr/Home/Index.

General Trends in Turkey:

- In the provinces of Hatay and Diyarbakır, both improvements and deteriorations were observed. In Hatay Province, a marked decline was observed during the analyzed period, although the interpretation of the 2024 results remains limited due to the lack of fully reliable data following one of the strongest earthquakes to strike Turkey this century. In the case of Diyarbakır, however, a more varied trend is observed in the SAW method; nevertheless, compared to 2015, the 2024 result still indicates a significant growth. This suggests that urban revitalization efforts, infrastructure development, and policy interventions have positively influenced residential attractiveness.

Comparative Observations:

- The results suggest that Polish cities have experienced a more pronounced improvement in residential attractiveness compared to Turkish cities, as reflected in the SAW scores.
- Wroclaw stands out as the most consistently attractive city in Poland, while Diyarbakır has emerged as the leading city in Turkey in terms of residential attractiveness growth.
- The decline observed in Lodz may indicate urban challenges such as depopulation, economic stagnation, or inefficiencies in revitalization programs.
- The Multiplicative Weighting method, though showing very small numerical values, reinforces the observation that Poland's urban transformation has had a more balanced impact compared to Turkey's more varied outcomes.

The evaluation of residential attractiveness using both additive and multiplicative weighting methods provides a comprehensive understanding of urban dynamics in Poland and Turkey. The findings highlight the importance of strategic urban planning, investment in infrastructure, and effective policy measures to ensure sustainable urban growth and attractiveness. The future research could further explore the socio-economic drivers behind these changes and examine additional indicators to refine the assessment framework.

Between 2015, 2022 and 2024, Wroclaw and Poznan demonstrated a steady and stable increase in residential attractiveness. Conversely, despite ongoing revitalization efforts, Lodz loses ground in the model, primarily due to persistently weak demographic indicators and a declining net migration rate. Among the Turkish cases, Diyarbakir exhibited significantly more dynamic development than Hatay (prior to the earthquake), capitalizing fully on improvements in its infrastructural indicators. The multiplicative weighting method is highly sensitive to extreme values, as a single poor-performing criterion drastically reduces the overall score. Consequently, Poznan recorded a very low MW score in 2015 due to its limited social housing stock compared to Lodz and Wroclaw, although it markedly improved its position by 2024.

The selected cities differ in terms of historical, social and town planning contexts, which made it possible to carry out a comprehensive analysis of the impact of revitalization on the residential attractiveness. The comparison between Poland and Turkey provided an opportunity to explore universal and local revitalization mechanisms such as:

a. the role of cultural heritage in constructing urban identity;
b. the effectiveness of revitalization programs in terms of improving the quality of life of residents;
c. the relation between revitalization and an influx of new residents.

Lodz is a city with a rich industrial history which since the 1990s has been undergoing an intense economic and urban transformation. These are the reasons why Lodz was selected for the purpose of the study:

a. significant revitalization activities such as the overhaul of the Priest's Mill or the New Centre of Lodz project;

b. a rich industrial history and the challenges ensuing from it related to adapting historic buildings (the collapse of textile industry brought about a considerable number of degraded areas and vacant buildings in the very city center);

c. demographic problems of the city such as depopulation and ageing society which affect residential attractiveness (the number of residents in 2022 accounted for 93.93% of the population from the year 2015 (Główny Urząd Statystyczny, n.d.).

Wroclaw is an academic and economic hub which is developing dynamically and which for a long time has invested in the revitalization of historic areas. This city was selected for the following reasons:

a. a sustainable revitalization development e.g., the Nadodrze regeneration program which constitutes an example of a sustainable approach to social and economic revitalization;

b. a multicultural history which has affected the character of the city and the diversity of its residents;

c. a dynamic economic development which attracts new residents and investors.

Poznan as a city characterized by a considerable economic and social potential constitutes an interesting case in the context of revitalization. The arguments for selecting this city were as follows:

a. complex regeneration undertakings such as the overhaul of Srodka and the Old City (Staszewska 2017, pp. 53–66);

b. a robust labor market which attracts young people and thus affects the residential attractiveness;

c. the cultural character of the city which strengthens social ties and the sense of belonging of the residents.

Hatay is a city characterized by a strategic location and a rich history, which makes it an interesting case for studying revitalization in the context of geopolitical and social challenges. The city was selected on account of the following factors:

a. the historical significance of the city which is at the juncture of various cultures and religions;

b. revitalization activities which encompass renovating historic buildings and improving the city infrastructure;

c. the impact exerted by migration and conflicts, which makes Hatay a unique example in terms of urban planning and social revitalization.

Hatay was chosen since the city was devastated because of the big earthquakes experienced on the 6th of February 2023. On February 6, 2023 two earthquakes of magnitude 7.7 and 7.6 occurred in southeastern Turkey, centered in Kahramanmaraş city. These earthquakes caused great destruction in 10 cities, including Hatay, causing thousands of deaths and injuries. According to the experts, an earthquake of this magnitude is experienced in Turkey once a century.

Diyarbakir is one of the oldest cities in Turkey. It represents a region which is characterized by considerable socio-political challenges. The selection of this city ensued from its following aspects:

a. the cultural and historical richness, in particular the ancient city walls included on the UNESCO World Heritage list;

b. the scale of its town planning problems encompassing intense urbanization and conflict-related destruction;

c. the revitalization potential which combines the restoration of cultural heritage with enhancing the quality of life of the residents.

The historical center of the city was destroyed as a result of terrorist actions that started at the end of 2015 and continued in the first months of 2016. In the Sur district of Diyarbakir in 2015–2016, The Kurdistan Workers' Party (PKK) terrorists rendered thousands of houses unusable, as well as mosques, churches and historical sites.

The research period covered three single years: 2015, 2022 and 2024. In 2015 the Act on Revitalization came into force in Poland, which not only defined the notions but also specified the legal framework of the process, whereas the year 2022 was of particular importance due to the fact that the COVID-19 pandemic restrictions ended then, which resulted in intensified revitalization undertakings. The year 2024 is marked as the end of research period.

The collected research material was presented in the tabular form 1–4. In order to validate the research hypotheses, put forward in the introductory part of the article, the following rates were applied, divided into boosters and inhibitors:

1. Net primary school enrolment rate (%) (a booster), which assess the level of primary education among children of official school age. A high net enrolment index indicates a good quality of education and the easy availability of schools, which attracts families with children

at the same time providing an incentive to settle in a particular area. As for the cities included in the study in Poland and Turkey, this indicator remains at a similar level, as all the cities analyzed place great importance on a high level of primary education;

2. Balance of internal migration for permanent residence (persons) (a booster) indicates the level of attractiveness of a city as a place of residence. A positive migration balance may translate into a higher number of people who wish to settle in a given city rather than find another place to live, which can be indicative of the level of its attractiveness. Among the cities in Poland which were the subject of research Wroclaw is ranked in the first position (in the year 2022 Lodz lost its third position in the ranking of cities in Poland in terms of population to Wroclaw (Główny Urząd Statystyczny, n.d.). In Turkey Hatay is more often indicated as the preferred place of residence than Diyarbakir despite its being situated in the seismic zone. In 2022 the situation of the Diyarbakir city improved. It was related to the fact that the Turkish government allocated approximately USD 3.4 billion to the restoration of the territories destroyed in the fighting which broke out in 2015 between government forces and Kurdish militants after the collapse of peace negotiations between the Kurdistan Workers' Party (PKK) and the Turkish state (*Rząd Turcji*…, n.d.);

3. Entities entered in the REGON register per 10,000 residents of working age (a booster). The number of such entities makes it possible to estimate the level of economic activity. Among the Polish cities the lowest rate was reported in 2015 in Lodz. It is the effect of a slow depopulation of the city and an outflow of young people. As regards the cities in Turkey, Hatay is characterized by a higher level of businesses, where conducting business activity is advantageous due to more considerable government subsidies for entrepreneurs and ensuing potential benefits and tax relief (when comparing the year 2022 with 2015);

4. Housing stock of municipalities – social housing (a booster). The number of social housing flats as well as their availability is vital especially for the poor and for the people with low income. As a result of the undertaken regeneration activities such as renovations and modernization of the exiting condition of the buildings it is possible to gradually increase the pool assigned for distribution among those in need. In analyzed periods in Poland the city of Lodz achieved the best results in this regard, however, both Wroclaw and Poznan maintain at a steady level their housing potential. In Turkey thanks to subsidizing the regeneration of the degraded urban fabric Diyarbakir steadily restores its housing resources, whereas the situation in Hatay has not changed;

5. Average number of persons per dwelling (an inhibitor). This rate gauges residential density which directly translates into the quality of life of the residents. The more square meters per one resident, the higher the comfort and the better the living conditions. And improving the quality of life is one of the priorities of revitalization. It also exerts a direct impact on the residential

attractiveness of a given city. The worst situation among the analyzed cities in Poland was noted in Poznan, whereas in Turkey in Diyarbakir. The rates were the same in 2022 and 2024;

6. Residential buildings connected to water supply infrastructure – in % of total residential buildings (a booster). An unimpeded access to the infrastructure directly translates into the quality of life and at the same time it contributes to improving the housing standards. All the cities which were the subject of analysis are making steady attempts at increasing the number of buildings connected to water supply infrastructure;

7. Residential buildings connected to sewage infrastructure – in % of total residential buildings (a booster). Nowadays the access to sewage infrastructure is taken for granted. The lack of it directly contributes to the deterioration in the quality of life of residents. Local self-government authorities put an emphasis on ensuring an unimpeded, private access to sewage infrastructure in the degraded areas. It is hard to imagine not prioritizing such efforts, which affects the residential attractiveness rating of a given city. When comparing the conditions in this regard in the analyzed cities in Poland, the worst situation was noted in the city of Lodz, which gradually increases the number of residential buildings connected to sewage infrastructure, however, the said number still leaves much to be desired (*Łódź będzie w 100 proc. skanalizowana*…, 2019);

8. Total area of parks, parkettes and neighborhood green areas (ha) (a booster). Green areas constitute an essential factor which affects the residential attractiveness of cities. Providing residents with an access to spaces for recreation and leisure is also a vital element of revitalization activities (Hajdys & Ślebocka, 2020, p. 58). The more such spaces in urban areas the better the quality of life, which can translate into an increase in the number of residents and thus into the amount of income at the disposal of the local self-government and as a result a rise in the pool of financial resources which can be allocated to revitalization undertakings. It can also positively affect the perception of a particular area as attractive from the point of view of potential residents. It is also important to ensure that the revitalization efforts do not cause depletion or devastation of green areas. It would be optimal if such resources were increased (Najwyższa Izba Kontroli…, 2022, p. 15).

The selection of the cities (Lodz, Wroclaw, Poznan, Hatay, Diyarbakir) was based on their diverse revitalization contexts, which provided an opportunity to take a holistic approach to the analyzed problem. The analysis of the aforementioned cities made it possible to better understand the impact of revitalization activities on residential attractiveness under different geographic and cultural conditions. The findings of the study may be useful for municipal authorities, town planners and researchers dealing with the urban policy and planning.

The city of Lodz is distinguished by its ambitious revitalization projects such as post-industrial spaces transformations, e.g., into the EC1 Science and Technology Centre or the Manufaktura arts center, shopping mall, and leisure complex. The aforementioned undertakings

positively affected the attractiveness of the city from the perspective of investors. However, there still exists a problem of low standards prevalent in many residential areas as well as the outflow of people caused by the lack of complex support programs for the residents with the lowest income. Therefore, there persists the key challenge related to integrating the revitalized spaces with other quarters of the city as well as to job creation in the immediate neighborhood of the residential areas. In this connection, it is advisable for the city to establish a cohesive network of ties between residential, recreational and business areas by developing public transport and the infrastructure for pedestrians and cyclists (the integration of revitalized spaces). The introduction of programs aimed at enhancing energy efficiency in residential buildings and at providing subsidies for the tenants residing in the revitalized areas (a financial support for tenants) may bring positive outcomes. Another recommended activity aimed at enhancing the residential attractiveness of the city (promoting Lodz as the city of culture) is the development of cultural events and local initiatives as a factor which attracts new residents and retains the existing ones.

As regards Wroclaw, it effectively implements revitalization projects focusing on the restoration of the riverside territories such as the Odra River Boulevards. The investment activity carried out in this area improved the quality of public spaces and led to an increase in the number of high standard apartments in the vicinity of the city center. The challenges that the municipal authorities face concern predominantly the revitalization of the neglected quarters such as Nadodrze, where the restoration of the urban fabric does not always effectively prevent the process of gentrification. Wroclaw constitutes an example of a city where revitalization contributes to ameliorating the diversity of the cultural and recreational offer and this in turn is conducive to attracting new residents. It advisable for Wroclaw to introduce the mechanisms which could support the low-income residents such as rent subsidies or the construction of government housing in the revitalized areas (offering solutions to the problem of gentrification). The construction of new cycle paths and improving public transport in the revitalized areas in order to enhance their accessibility (developing the mobility infrastructure) is another proposal for Wroclaw. As regards neglected quarters, the kind of undertaking which could positively affect the quality of life and residential attractiveness is the intensification of green plantings in particular areas (green revitalization).

In Poznan the revitalization activities carried out so far focused predominantly on the historic areas of the city such as the City Centre and the Old Market Square. The investments targeted at the renovation of historic tenement houses and modernization of public spaces contributed to an increase in the tourist attractiveness of the city. An insufficient engagement of the residents in the decision-making process still poses a problem, which impedes the long lasting effects of revitalization in terms of improving the quality of life. A migration of population to the suburbs

can be observed in the city, which points to the need of better adjusting the revitalized areas to the requirements of modern families. It is recommended for Poznan to introduce social consultations at every stage of the process of revitalization. The participation of residents will thus make it possible to more effectively adjust the activities to the needs and expectations of the local community (participatory society). Another proposal is the development of flats adjusted to the needs of families with children, including the proximity of green areas and educational infrastructure (the enhancement of the housing offer). Expanding the scope of revitalization undertakings to the less attractive quarters of the city, including peripheral districts constitutes another activity which could counteract the outflow of people to the suburbs (balancing revitalization activities).

Hatay is a city which in the aftermath of an earthquake faced the difficult challenge of restoring the degraded urban fabric. The natural disaster not only left thousands of buildings in ruins but also contributed to displacing thousands of residents. The city, which was earlier associated with precious historic monuments, which was regarded as an interesting point on the tourist map of Turkey because of its history, was forced to take the difficult challenge aimed at an economic recovery and restoration of the lost potential.

The revitalization of Hatay centers on the most significant elements which, inter alia, encompass: preserving the regional heritage, enhancing the local identity, providing resilience to natural disasters e.g., floods and increasing the residential attractiveness of the city. Due to the scale of damage, the initiative which was undertaken at that time entailed designing 5000 houses with a total area of 50 ha. Taking into consideration the cultural heritage a new environment was created which was sustainable and functionable (World Design Organization, 2024) and covered, inter alia, new public green zones, efficient public transport or community centers. First and foremost, social inclusiveness was of prime importance. It constitutes an indispensable element of fair and sustainable urban development. In the context of revitalization, its role consists in ensuring that the benefits ensuing from the undertaken activities are accessible to all the social groups. It contributes to constructing cohesive, resilient and attractive cities. The adoption of such a restoration strategy by Hatay is supposed to enable the city to achieve positive, long term results in the social and town planning aspect. It is recommended for this city to carry out revitalization activities considering its specific natural conditions (seismic zones and flood inundation areas).

Diyarbakir is the largest city in the Kurdish south-east region of Turkey, which undertakes revitalization activities related to the destruction resulting from warfare permanently waged in this area. In the year 2015 the city became the scene of combat between the Turkish army and the Kurdish PKK guerrillas. Almost the entire historic center of the city was destroyed and therefore the undertaken recovery activities are of a different nature. The said activities have

entailed a heavy project-based reconstruction of the city since then. Work has been initiated to rebuild the district, which was cleared of terrorists by the operations of the security forces. Nowadays, it is aimed to host five million tourists with the completion of the construction in the district, where more than seven thousand houses and the area where 21 thousand people lived were destroyed during the terrorist actions.

Diyarbakir with its unique architecture and the city walls included on the UNESCO World Heritage list is an example of a city where revitalization combines the conservation of cultural heritage with improving the quality of life. The findings of the analysis indicate that:

- an effective use of the cultural heritage as a resource attracts investors and tourists, which positively affects residential attractiveness;
- however, the political context and social tensions constitute a considerable constraint to the cohesion of revitalization activities.

It is recommended for the city of Diyarbakir to intensify the efforts aimed at reconstructing the degraded area (Daily Sabah, 2024) but to also to undertake the activities of a soft character focused on improving the level of education. A high rate of illiteracy can still be noted in the city, especially among the residents of a Kurdish origin. In this case it is worth taking into consideration the political and social context, the main objective of which are activities aimed predominantly at restoring the local community after the years of conflicts.

The comparison of five selected cities from Europe (Lodz, Wroclaw and Poznan) and the Middle East (Hatay and Diyarbakir) points to several universal revitalization mechanisms such as:

- the key role of investing in infrastructure and public space in improving the quality of life of residents;
- the significance of conserving the cultural heritage for the purpose of constructing the urban identity and increasing residential attractiveness;
- the challenges related to social integration, avoiding gentrification and balancing the interests of various social groups.

Conclusions and Recommendations

In response to the presented research questions, findings indicate that the main priorities for revitalization are improving technical and housing infrastructure, public spaces, accessibility, and social integration. The most important factors shaping residential attractiveness are migration trends, housing conditions, economic activity, and access to infrastructure and green spaces. The most favorable trends were observed in Wroclaw and Poznan, while Lodz struggled with a declining population; the situation in Diyarbakır has improved, whereas Hatay requires reconstruction focused on resilience following the 2023 earthquake. Consequently, revitalization efforts should combine infrastructure investments with social and demographic measures tailored to local conditions.

To sum up, revitalization is an effective tool for improving the residential attractiveness of cities; however, its effectiveness depends on the involvement of residents, the coherence of urban planning, and the consideration of local needs. Measures taken in this regard can be a significant factor in increasing residential attractiveness. In the case of Wroclaw, the high residential attractiveness indicators are consistent with the findings of Mouratidis (2021), who indicates that the quality of public spaces, the availability of infrastructure and the development of green spaces are among the most important determinants of resident satisfaction. At the same time, Lodz's lower scores confirm the observations of Roberts & Sykes (2020), according to whom even advanced regeneration projects do not guarantee an improvement in residential attractiveness if they are not accompanied by measures to curb depopulation and social exclusion.

Interesting results were also obtained for Turkish cities. The latest research on housing regeneration emphasizes the importance of integrating infrastructure, social and environmental measures to achieve sustainable development outcomes (Chin et al., 2025). In each of the cities analyzed, regeneration initiatives have contributed to improving living conditions and stimulating interest among investors and residents. At the same time, the analysis revealed the local specificity of revitalization projects, resulting from differing historical, cultural and political contexts in Poland and Turkey. Turkish cities require strategies that take migration and conflict into account, whilst Polish cities focus on managing post-industrial and urban transformation. Undoubtedly, therefore, revitalization strategies must be tailored to the specific challenges and resources of each city, thereby maximizing social and economic outcomes. Investment in infrastructure, public space and the protection of cultural heritage are key factors influencing the effectiveness of revitalization projects. The success of regeneration depends on the ability to combine social, economic and environmental objectives into long-term, coherent actions. The analysis showed that the effectiveness of regeneration does not depend solely on the scale of infrastructure investment. In both Poland and Turkey, social factors are of key importance, including housing availability, educational attainment, the quality of public spaces and the preservation of local identity.

These findings are consistent with the concept of residential attractiveness, understood as a city's ability to attract and retain residents through a high quality of life and favorable housing conditions (Mouratidis & Yiannakou, 2022). The revitalization successes of the cities analyzed may form the foundation for further development and for addressing contemporary demographic and urban challenges. At the same time, the analysis confirms the need for further research into the relationships between revitalization processes and residential attractiveness, particularly in the context of cities operating under different social and cultural conditions. This partially fills the identified research gap concerning the comparative assessment of the impact of regeneration on residential attractiveness in cities of Central and Eastern Europe and the

Middle East. The cities under study can effectively utilize their existing revitalization successes as a foundation for further development and for addressing demographic and urban challenges. The findings of this study will contribute to a better understanding of the mechanisms of urban revitalization and may serve as a basis for the development of more effective urban policy.

In summary, the recommendations formulated herein represent an original analytical contribution derived directly from the multi-criteria evaluation of urban revitalization trajectories in Poland and Turkey. By systematically aligning empirical MCDA outputs – spanning infrastructural modernization, demographic balance, and environmental quality – with the broader theoretical discourse on territorial competitiveness and residential attractiveness, this study bridges the gap between quantitative policy evaluation and context-sensitive spatial strategy. Consequently, the proposed intervention pathways serve not merely as contextualized solutions for the studied municipalities, but as transferable, policy-relevant frameworks capable of guiding sustainable urban regeneration across contrasting socio-institutional and post-disaster operational environments.

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Arkadiusz Iwanicki https://orcid.org/0000-0003-1320-1699
M.A., University of Lodz, Department of Economic and Medical Informatics, e-mail: arkadiusz.iwanicki@uni.lodz.pl

TRANSACTION STRUCTURE AND ACTIVITY CONCENTRATION IN THE STELLAR BLOCKCHAIN REGISTER

Abstract

The purpose of the article. The aim of this article is to examine the Stellar payment network in terms of transaction dynamics over time, asset structure, and the concentration of participant activity using transactional data obtained from the public blockchain ledger.

Methodology. The empirical investigation was conducted using a sample of 1,000 consecutive ledgers retrieved from the Stellar public ledger. The data were processed in the Python environment with the use of the pandas, matplotlib, and networkx libraries. Quantitative analytical methods were applied, including measurements of the number of operations, asset structure, transaction value distribution, and concentration analysis based on Lorenz curves, the Gini coefficient, and network centrality metrics within the transaction graph.

Results of the research. The obtained evidence indicates a high level of activity concentration within the Stellar network – a small number of addresses account for the dominant share of transaction volume. The network structure exhibits a core–periphery pattern, in which a narrow group of highly central nodes plays a crucial role. The observed pattern reflects a structure typical of open blockchains – numerous marginal accounts and a small core that is strategically important for system liquidity. The findings may serve as a basis for further research on the decentralization and stability of payment systems built on blockchain technology.

Keywords: blockchain, network analysis, payment networks, decentralization, DeFi
JEL Class: O33, L86, C88

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Introduction

The growth of global economic interconnections has led to an intensification of cross-border financial flows. Of particular importance are international money transfers, which have traditionally been processed through the SWIFT system. Although SWIFT has remained a central component of international banking for decades, access to the network and the surrounding payment infrastructure can be restricted as part of financial sanctions (Cipriani et al., 2023).

An alternative to this traditional model is blockchain-based solutions such as Stellar. Unlike SWIFT, which serves only a messaging function, Stellar integrates both the communication and settlement layers, enabling near-instant transaction finality and direct value transfer between participants (Lokhava et al., 2019). The Stellar network, developed by the Stellar Development Foundation since 2015, uses its native currency XLM and allows the issuance of tokens linked to fiat currencies and other assets. Its key innovation is the Stellar Consensus Protocol (SCP), a federated Byzantine agreement mechanism that enables consensus to be achieved under an open membership model (García-Pérez & Schett, 2020).

The operation of the Stellar network is based on a public distributed ledger, which can be compared to a digital accounting book. Each ledger records the network state resulting from a set of validated transactions, each of which may contain one or more operations. Accepted transactions and their constituent operations are incorporated into successive ledgers, which close approximately every five seconds (Lokhava et al., 2019). This process is facilitated by the SCP consensus mechanism, which differs from the energy-intensive Proof-of-Work methods used, for instance, in Bitcoin. In SCP, network participants – known as validating nodes – independently choose sets of other nodes they trust (so-called quorum slices). These form broader groups (quorums) that collectively agree on the ledger state resulting from submitted transactions. Only when a sufficient number of trusted nodes reaches agreement is a new ledger closed. As a result, Stellar enables fast and secure payment settlements while maintaining open participation and eliminating the need for mining mechanisms (Gaul et al., 2019).

Stellar has applications across various domains, including retail payments, remittances, asset tokenization, and token-based banking (Shamsi et al., 2022). Importantly, this project – like other blockchain-based solutions such as Ripple – does not seek to eliminate traditional financial institutions but rather to integrate them with a new payment infrastructure. Consequently, Stellar represents an intriguing case study combining technological innovation with practical applications in the financial sector.

The aim of this article is to examine the Stellar payment network in terms of transaction dynamics over time, asset structure, and the concentration of participant activity using transactional data obtained from the public blockchain ledger. The research design includes measurements of transaction volume dynamics and the number of operations, assessment of asset

structure, and analysis of participant concentration using Lorenz curves and the Gini coefficient. Particular attention is devoted to network topology and the identification of key nodes. The resulting evidence is compared with the findings of previous studies to assess Stellar's potential as a global payment infrastructure.

Research Method

The empirical study was based on an analysis of transactional data from the public Stellar ledger, which constitutes the technological foundation of the network's operation. Each ledger records account balances and validated transactions together with their constituent operations. Owing to the open access provided through the Horizon interface, it is possible to retrieve complete ledger sequences and analyze them using any analytical tools. The source data were collected using a custom Node.js script. This script employed the official stellar-sdk library to communicate with the Horizon server, axios for handling HTTP requests, and the fs module for streaming data into CSV files. The solution allows both downloading a specific range of ledgers and retrieving the latest n ledgers. The script implements an iterative mechanism for traversing all operations within each ledger, with pagination and filtering options. Using this approach, a complete operation-level dataset was gathered for a sample of 1,000 consecutive ledgers dated before 13 September 2025. The script recorded detailed information about each operation, including its type (e.g., payment, create_account, account_merge, trade), sender and recipient identifiers, asset type (native XLM or user-issued tokens), amount, and timestamp. For enhanced data control, an additional field, details, was included to store diagnostic information. The compiled CSV file served as the basis for subsequent analyses.

The second stage of the research was conducted in the Python environment. The following libraries were used:

- pandas and numpy – for loading files, cleaning data, and creating event data frames,
- matplotlib – for creating visualizations and histograms,
- networkx – for constructing and analyzing the transaction graph, including the computation of centrality measures.

The empirical investigation proceeded in multiple stages. The first step involved isolating actual value transfers, i.e., payment operations. Subsequently, the assets transferred through payment operations were examined to assess the diversity of asset flows in the ledger. The next stage consisted of analyzing ledger activity over time. For each ledger, the total number of operations and the aggregate amount transferred through payment operations were calculated. These time series enabled the evaluation of network activity variability and the identification of periods of increased load.

The following stage focused on asset structure analysis. A ranking of the most frequently used tokens was created, based on both the number of payment operations and the aggregate amount transferred. The distribution of individual payment amounts was also examined through histograms, allowing for the identification of both small-value payments and rare, large-scale transfers. A particularly important part of the empirical investigation was the assessment of activity concentration among network participants. For each address, the total volume of received and sent payments was calculated. Based on these data, rankings of the top-N participants (N = 1, 10, and 1% of the population) were created, along with Lorenz curves. In addition, Gini coefficients were computed to provide a quantitative measure of inequality in activity distribution.

The final stage involved network analysis. Based on the transactional data, a directed graph of the Stellar network was constructed, where nodes represented blockchain addresses and edges represented payment flows between them, with transferred amounts used as edge weights. Using the networkx package, weighted flow measures were computed, including in-strength, out-strength, and total strength. These measures represent the sums of incoming, outgoing, and combined payment amounts, respectively, rather than the numbers of connections. This analysis enabled the detection of hub structures and the assessment of whether network activity is evenly distributed or dominated by a small group of entities.

All empirical outputs – from time series and histograms to rankings, Lorenz curves, and network indicators – were saved as CSV and PNG files. These outputs formed the basis for interpretation in the context of the existing literature and for drawing conclusions regarding the nature and potential of the Stellar network as a global payment infrastructure. The time-series assessment allows for assessing the network's stability and capacity to handle increasing load. The assessment of asset structure captures the diversity and practical scope of the platform's applications. The concentration measures, supported by Gini coefficients, reveals the extent to which network activity is dispersed or dominated by a few participants. Finally, graph-theoretic and centrality measures identify the key nodes that may serve as institutional payment hubs. The combined application of these methods provides a comprehensive view of Stellar's operation – both from technical and economic perspectives – and enables an assessment of its suitability as a potential infrastructure for cross-border payments.

Literature Review

Blockchain technology has attracted wide attention as a potential alternative to traditional payment systems, offering greater transparency, lower costs, and shorter settlement times (Lokhava et al., 2019). Stellar, as one of the leading platforms of this type, introduced a unique consensus mechanism – the Stellar Consensus Protocol (SCP) – whose correctness has been formally proven (García-Pérez & Schett, 2020). The literature emphasizes that, unlike classical PBFT models or

Proof-of-Work mechanisms, SCP enables open membership and high energy efficiency, which is of particular importance in financial applications. At the same time, researchers note that blockchain technology is not free from risks, and that certain consensus mechanisms may be vulnerable to specific attacks and do not always guarantee a higher level of security compared to traditional centralized systems (Baranowski & Korczak, 2022). Furthermore, Dasgupta et al. (2019) highlight that the development of blockchain still faces significant security challenges, including cryptographic vulnerabilities as well as network- and application-layer attacks. The authors identify eight major categories of threats, including Sybil and Eclipse attacks, timing manipulation, vulnerabilities in smart contracts, and risks related to quantum computing, emphasizing that these technologies require further advancement before they can serve as fully secure financial infrastructures.

From an economic perspective, Stellar is viewed as a platform supporting tokenization and decentralized payment solutions. Research points to its growing role in the banking sector, where it is used for token issuance and asset distribution through collective mechanisms (Shamsi et al., 2022). Howell et al. (2023) draw attention to the degree of node decentralization in the Stellar network compared with other platforms, noting the limited hosting-provider diversity and the dominance of large cloud service providers. This analysis shows that, despite the open nature of the SCP protocol, the practical decentralization of the network is significantly constrained by the concentration of technical infrastructure. The present study complements this approach by analyzing transactional flows between wallets, offering a different perspective on decentralization – not in terms of node distribution and ownership, but by evaluating the distribution of activity and value transfers among network participants. The comparison of both perspectives indicates that, at both the infrastructural and financial-flow levels, the Stellar network exhibits a high degree of concentration, raising questions about the actual level of decentralization of the platform.

The issue of decentralization and activity concentration in blockchain networks has been the subject of numerous quantitative studies. The literature increasingly applies inequality measures – including the Gini coefficient – to assess the degree of value-flow centralization. The possibility that the top 1% of addresses may control between 70% and over 90% of a measured network resource illustrates why comparisons must clearly distinguish among token holdings, consensus power, and transaction volume. Jia et al. (2022) demonstrated that governance-token balance distributions differ substantially across emerging public blockchains, while Juodis et al. (2024) documented pronounced differences in wealth concentration between the examined Layer 1 and Layer 2 networks. It is worth noting that the discussion on the balance between decentralization and efficiency is crucial not only from the perspective of distributed systems theory but also in the practical context of applying blockchain technology to international payments. Like other next-generation platforms, Stellar faces the challenge of reconciling high scalability and settlement speed with maintaining an adequate degree of power distribution within the network.

Research Results

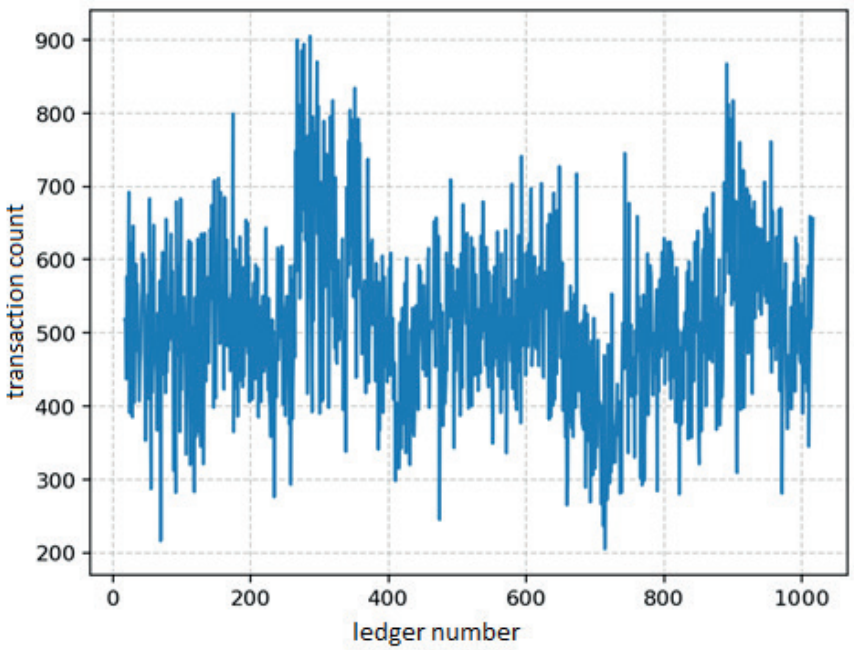
The aim of the empirical analysis was to capture the characteristics of the Stellar network based on data from a sample of 1,000 consecutive ledgers. Quantitative examination of the collected dataset produced findings in three areas: the dynamics of operations, the structure of assets, and the concentration of participants along with the overall network structure.

Transaction Dynamics

In the analyzed sample, a high variability in the number of operations per ledger is observed, with typical values ranging between 400 and 700 operations (Figure 1). The recorded peaks indicate periods of increased activity, which may be associated with token issuance or exchange events. Even greater variability is evident in aggregate amounts transferred through payment operations, which display a wide range and the presence of outlier payment operations (Figure 2). The observed pattern confirms that the Stellar network is capable of handling both small-scale payments and large-value payment operations.

Figure 1

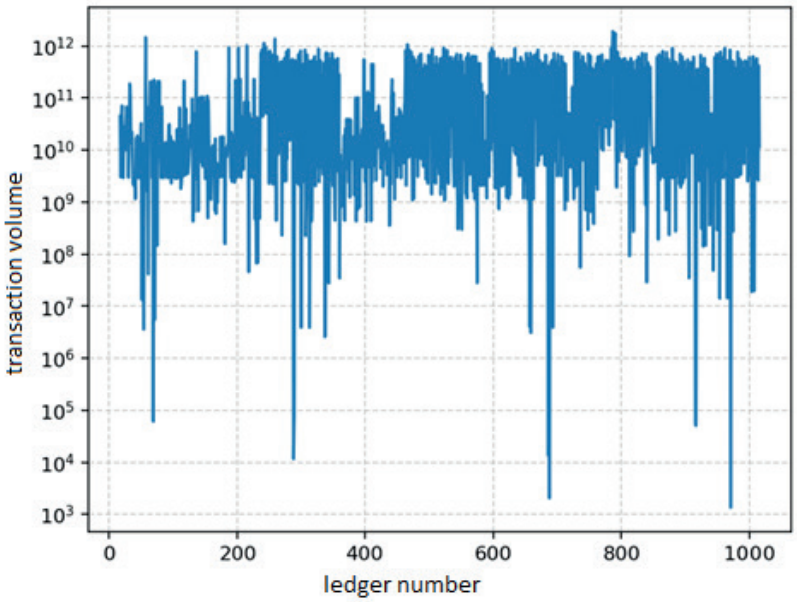
Number of Operations per Ledger



Source: author's own visualization based on Stellar blockchain ledger data, prepared with the matplotlib library in Python.

Figure 2

Payment Volume per Ledger – All Assets



Source: author's own visualization based on Stellar blockchain ledger data, prepared with the matplotlib library in Python.

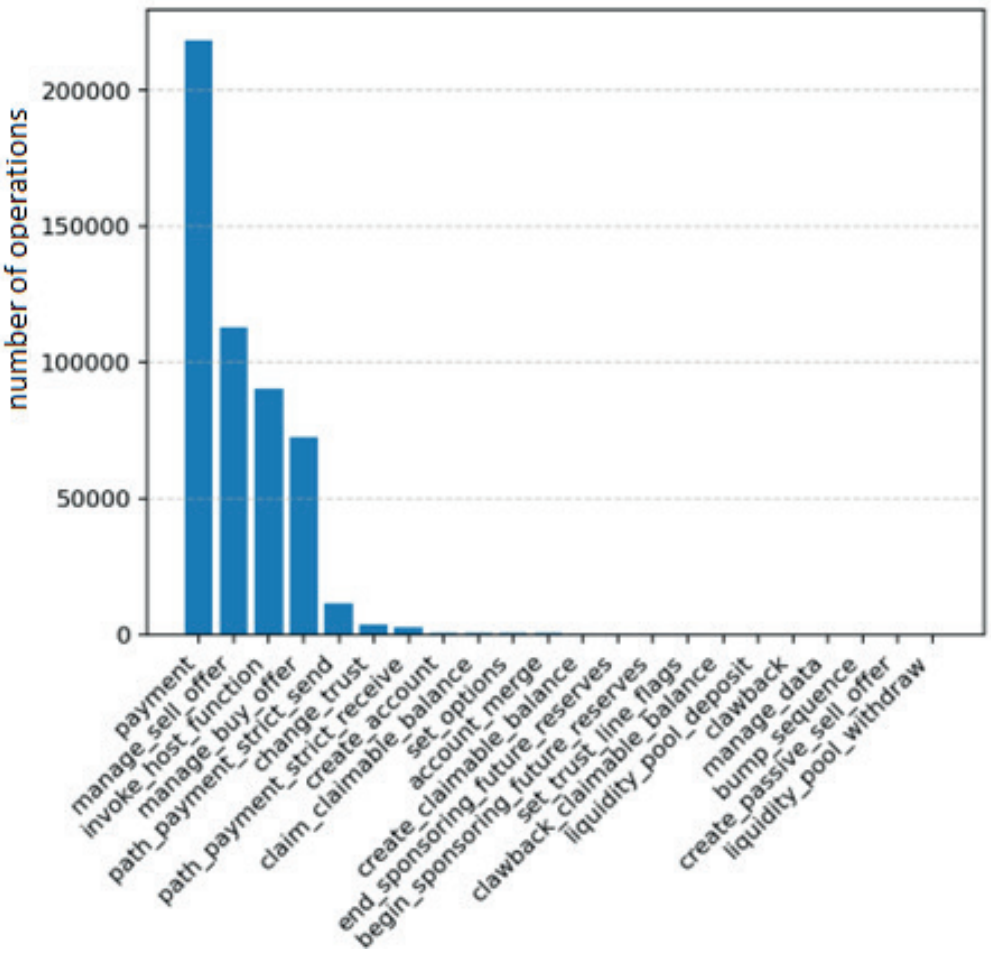
Examination of outlier values showed that the top 1% of the largest payment operations accounted for a substantial portion of the total volume. The largest individual payment operations exceeded 9.1×10^{11} units in assets such as XRP, XLM, and USDC. Among the high-value transfers, several payment operations were also recorded in less common tokens, including GERMANIUM (8.99×10^{11}) and CHROMIUM (8.84×10^{11}). These findings confirm the highly skewed nature of the distribution – the network processes both numerous small payment operations and a small number of large-scale transfers.

Asset Structure

The distribution of operation types confirmed the dominant role of value transfers (payments), which accounted for the vast majority of operations in the examined sample (Figure 3). In terms of the number of payment operations, the highest shares were recorded for XLM, SSLX, and USDC, while among the tokens, XRP and those linked to fiat currencies (EUR, USD, CAD) and financial instruments (e.g., AAPL, TSLA) also played a significant role (Figure 4).

Figure 3

Share of Operation Types – by Count

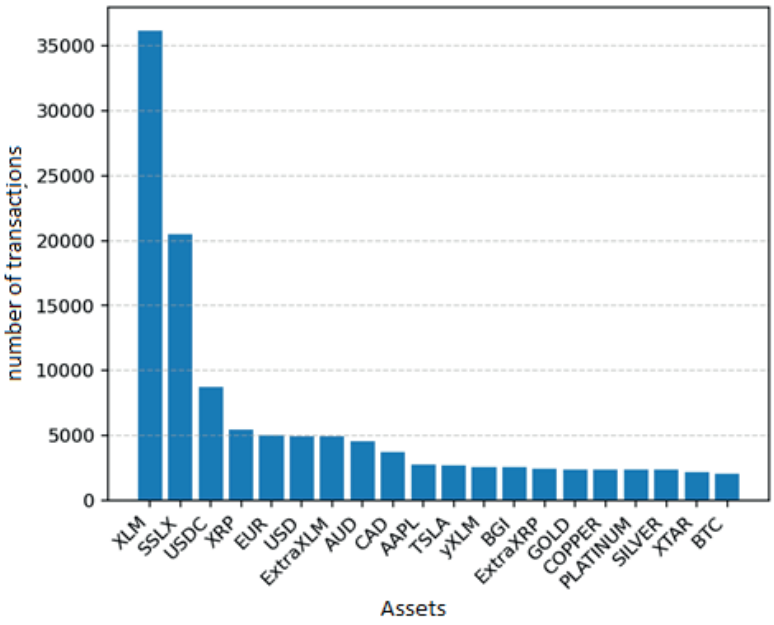


Source: author's own visualization based on Stellar blockchain ledger data, prepared with the matplotlib library in Python.

In turn, the volume-based analysis shows that the most significant assets include tokens linked to traditional currencies and commodities, rather than solely the native XLM token. The largest payment flows were recorded in tokens such as EUR and USD (traditional currencies), as well as CAD and AUD, all of which substantially exceeded XLM's share in quantitative terms (Figure 5).

Figure 4

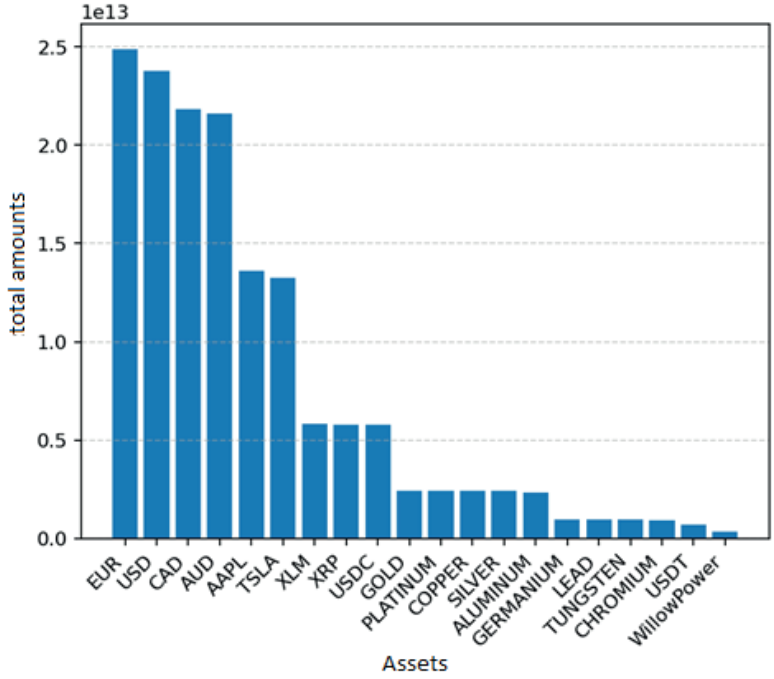
Top Assets by Number of Payment Transactions (Top 20)



Source: author's own visualization based on Stellar blockchain ledger data, prepared with the matplotlib library in Python.

Figure 5

Top Assets by Payment Volume (Top 20)



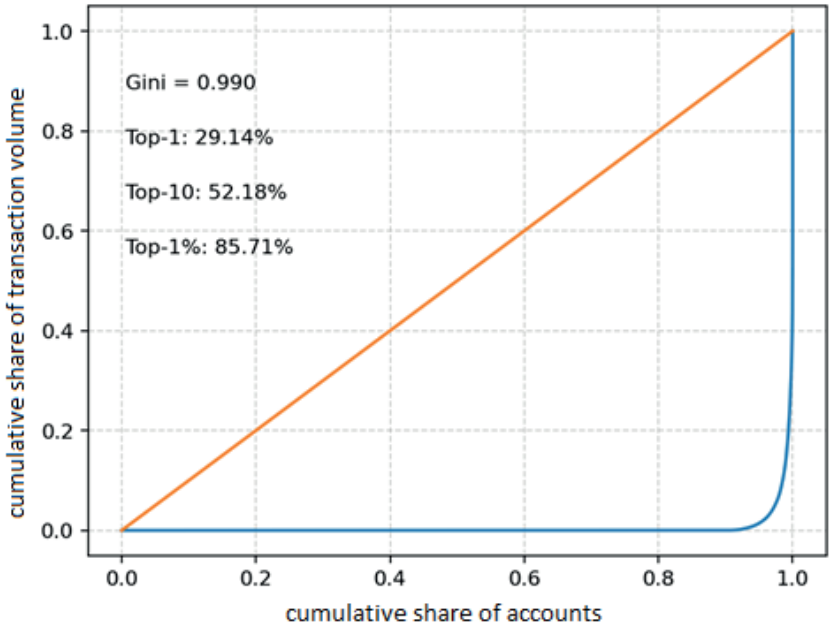
Source: author's own visualization based on Stellar blockchain ledger data, prepared with the matplotlib library in Python.

Participant Concentration and Network Analysis

The next stage involved assessing the concentration of participant activity. The application of the Lorenz curve and the Gini coefficient clearly demonstrated that transaction activity within the Stellar network is highly concentrated. The Gini coefficient reached a value of 0.99, indicating an extremely unequal distribution of activity. The largest single account in the analyzed sample accounted for 29.14% of the total transaction volume, while the ten largest participants were responsible for more than half of the volume, and the top 1% of accounts accounted for nearly 86% of the total transaction volume (Figure 6).

Figure 6

Lorenz Curve – Total Volume per Account

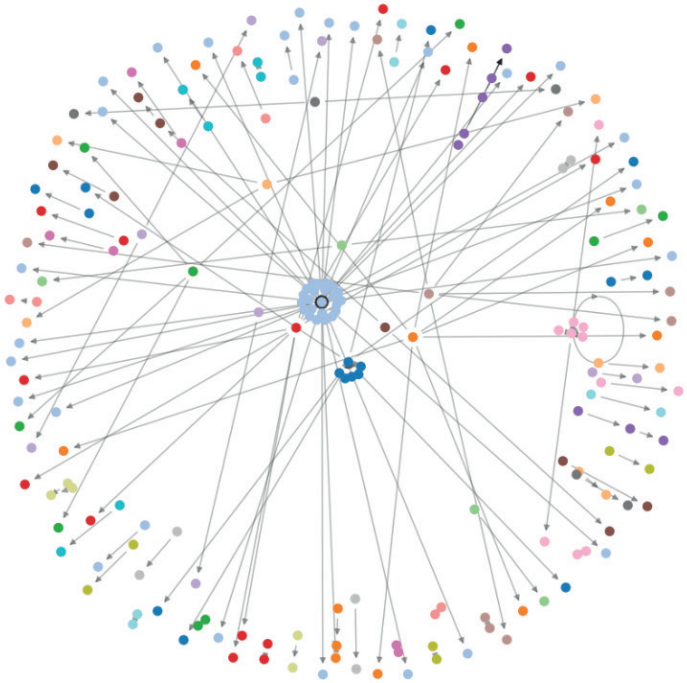


Source: author's own visualization based on Stellar blockchain ledger data, prepared with the matplotlib library in Python.

The constructed transaction graph (Figure 7) reveals a core–periphery structure typical of blockchain networks, dominated by a few central nodes with high centrality and a large number of connections. This indicates that, despite the network's open nature, the liquidity and overall functioning of Stellar largely depend on the activity of a narrow group of entities.

Figure 7

Communities in the Stellar Network (Graph Analysis)



Source: author's own visualization based on Stellar blockchain ledger data, prepared with the matplotlib library in Python.

The community detection algorithm confirmed the presence of several distinct groups of nodes. Most of the activity was concentrated within the largest community, dominated by key nodes. The topology of the transaction graph indicates a highly concentrated structure. The largest nodes exhibited very high total-strength values (the combined amounts of inbound and outbound payment flows) (Table 1). Due to the lack of publicly available metadata (e.g., home_domain), it was not possible to unambiguously identify the owners of these accounts. In particular, the two top-ranked addresses displayed nearly zero in-strength and very high out-strength values, suggesting that they may have functioned as distribution hubs, forwarding funds to other network participants. Such activity patterns may indicate accounts belonging to exchanges, financial institutions, or specialized service providers operating within the Stellar network.

Table 1

The Most Significant Nodes in the Stellar Network by Incoming and Outgoing Payment Amounts

Account address (shortened)	Incoming amount (in-strength)	Outgoing amount (out-strength)	Total amount (total strength)
GAVU7F5JQ…OTPBP…	~0	9.18×10^{13}	9.18×10^{13}
GC4KZI5J…LBJNDT…	~0	2.69×10^{13}	2.69×10^{13}
GBLPLCH4Z…MJXJJ…	4.69×10^{12}	4.72×10^{12}	9.41×10^{12}
GBGVP5AJS…FIIL…	4.36×10^{12}	4.46×10^{12}	8.82×10^{12}
GBWWDAUBX…NLJS…	3.53×10^{12}	4.46×10^{12}	7.99×10^{12}

Source: author's own elaboration based on data from the Stellar blockchain ledger.

These values are incomparably higher than the median of the distribution, which amounted to only 0.01, demonstrating that flows within the network are heavily dominated by a small number of entities. Additionally, the in-strength and out-strength values of the five most significant nodes were compared. The comparison indicates that the dominant accounts conducted almost exclusively outgoing payment flows. For instance, the address GAVU7F5JQ…OTPBP… had an out-strength of 9.18×10^{13} with a nearly zero in-strength. A similar pattern was observed for the address GC4KZI5J…LBJNDT… (out-strength 2.69×10^{13}, in-strength 0). More balanced activity was observed for other nodes, such as GBLPLCH4Z…MJXJJ…, for which inbound and outbound values were approximately equal ($\approx 4.7 \times 10^{12}$). This evidence suggests the existence of both "sending hubs" and nodes that participate more symmetrically in the transfer of funds in both directions.

Discussion of Results

The obtained evidence indicates a high level of activity concentration, with a small number of nodes functioning as transactional hubs. The Gini coefficient for transaction volume in the analyzed sample reached 0.99, while the top 1% of accounts accounted for nearly 86% of the total volume. Such a high degree of inequality is comparable to values reported in studies of other blockchain networks. Although their analysis concerns wealth distribution rather than transaction volume, Juodis et al. (2024) reported Gini coefficients of 0.6538 for Bitcoin and 0.8298 and 0.8457 for Ethereum before and after its transition from Proof-of-Work to Proof-of-Stake, respectively. Values above 0.95 were observed for the examined Layer 2 networks. Jia et al. (2022) likewise identified substantial inequality in governance-token distributions across

selected emerging public blockchains, although their analysis concerns token holdings rather than transaction volume.

Comparable observations also concern the role of central nodes. In the Stellar study, the three largest accounts exhibited total-strength values on the order of 10^{13}–10^{14}, whereas the median of the distribution was only 0.01. This discrepancy confirms the existence of a centralized structure in which a few nodes dominate the remaining participants. A similar phenomenon was described by Sultanik et al. (2022), who found that in Bitcoin and Ethereum, a small number of mining pools and infrastructure providers control the majority of network power, rendering decentralization largely superficial. In comparison with previous studies, the methodological approach is also noteworthy. Tasca (2015) analyzed Bitcoin transfer data in an aggregated form, whereas Juodis et al. (2024) used the Herfindahl–Hirschman Index and complementary inequality measures to assess wealth concentration, finding markedly greater concentration in the examined Layer 2 networks than in Bitcoin and Ethereum. In the present Stellar analysis, direct data from 1,000 consecutive ledgers were used, allowing for an assessment of both payment-volume dynamics and asset structure. This approach aligns with contemporary on-chain analyses such as those by Schmid and Shestakov (2024), who demonstrated, using data from the Gitcoin and Internet Computer projects, that despite formal mechanisms of democratization, actual decision-making power tends to be concentrated within a small group of entities.

It is worth emphasizing that concentration in blockchain networks is not limited solely to transactional flows. Petryk and Li (2025) showed that similar phenomena occur within developer and community structures, where a small group of programmers is responsible for key decisions regarding protocol development. The Stellar findings thus contribute to the broader discussion on the limitations of decentralization – even in systems designed to be open, market, technological, and organizational mechanisms often lead to concentration of both activity and power.

From a financial-market perspective, the findings indicate that Stellar combines functions relevant to cross-border settlement with substantial concentration in the accounts that channel value. The observed use of fiat-linked tokens and high-value transfers supports its potential role in payment and tokenization services, consistent with the applications discussed by Lokhava et al. (2019) and Shamsi et al. (2022). However, the present sample does not establish comparative transaction costs, service quality, or long-term capacity; it therefore supports an assessment of structural potential rather than a claim of superiority over established payment infrastructures.

For banks and payment service providers, the concentration measures have a direct operational interpretation. If the unidentified hub-like accounts perform exchange, custody, or settlement functions, their dominance may improve routing efficiency while also creating dependence on a small set of intermediaries. Disruption, withdrawal, or illiquidity at such nodes could therefore affect the continuity and distribution of payment flows. This inference is consis-

tent with the broader concern that formal openness can coexist with concentrated infrastructure, as reported for Stellar by Howell et al. (2023), but the anonymous ledger data do not permit attribution of the observed accounts to particular institutions.

The findings also matter for financial supervision. Address-level transparency does not by itself provide institutional transparency: the ledger shows the size and direction of flows, whereas the identity, legal status, contractual obligations, and risk-management arrangements of the dominant operators remain unknown. For the financial sector, this distinction limits counterparty assessment and complicates the evaluation of concentration and operational risk. Accordingly, any institutional use of Stellar as payment infrastructure would require governance and monitoring arrangements that connect on-chain activity with identifiable service providers; the current dataset can identify where concentration occurs, but not whether those arrangements are in place.

Research Limitations

At the same time, the empirical design is subject to several important limitations. First, due to the anonymous nature of the Stellar network, it is not possible to unambiguously assign accounts to specific financial institutions or business entities. Identification would be feasible only if an account operator publicly disclosed metadata (e.g., through the home_domain parameter in the stellar.toml file). In the analyzed sample, none of the five largest nodes contained such information; therefore, the interpretation was limited to a functional characterization (e.g., as sending hubs or intermediary nodes) without specifying ownership. Second, the sample covered only 1,000 consecutive ledgers, which allows for an analysis of short-term network properties but does not fully reflect long-term trends or structural changes. For this reason, future research should include longer observation periods and combine ledger data with information from exchanges and payment operators. Such an approach would enable a more comprehensive characterization of the roles of individual participants and a clearer understanding of their significance within the global payment infrastructure based on Stellar technology.

Conclusions

The empirical investigation captured the fundamental characteristics of the Stellar network's operation in the short term. Transaction-dynamics measures revealed clear fluctuations in the number of operations and aggregate payment amounts across consecutive ledgers, indicating varying intensity of network usage over short time intervals. The examination of asset structure showed that, in addition to the native XLM token, tokens linked to fiat currencies and other financial instruments also play a significant role, reflecting the wide and diversified range of the network's applications. Another important finding was the identification of outlier values.

Rare but extremely large payment operations, which confirmed the strongly skewed nature of the flow distribution. A particularly noteworthy result is the high level of participant activity concentration, as measured by the share of the largest accounts in total volume, the Gini coefficient values, and the shape of the Lorenz curves. Finally, the graph-based analysis confirmed the presence of hub-like nodes that dominate the network in terms of aggregate incoming and outgoing payment amounts. These nodes, acting as senders or intermediaries, play a crucial role in fund transfers, indicating that Stellar's actual decentralization is limited in practice.

From a financial-sector perspective, Stellar can function as a programmable payment, exchange, and settlement layer rather than merely as a market for XLM. The network combines open membership with issuer-specific assets, a built-in decentralized exchange, path payments, and atomic transfers involving assets issued by different entities. Anchors connect this shared ledger with domestic payment rails by providing fiat on- and off-ramps, while a path payment can convert the sender's token into the recipient's token within one operation. For banks and payment service providers, this model offers a possible alternative to multi-hop correspondent chains and may support faster routing, greater competition, and more continuous cross-border service. It can therefore affect financial market infrastructure by relocating part of the exchange and settlement process from bilateral institutional chains to a common network. However, the present dataset does not compare end-to-end costs, service quality, or long-term capacity with established systems; the conclusion is consequently limited to technological and structural potential (Lokhava et al., 2019; Zhuo et al., 2023).

The application of Stellar in the financial sector can involve a division of responsibilities among several regulated actors. Banks, regulated financial institutions, money service businesses, and FinTech companies act as anchors or token issuers; other institutions may provide custody, wallets, liquidity, validation, or bridge and compliance services. Stellar's trustline model permits an issuer to authorize which accounts may hold its asset. In the anchor model, the issuer also has to organize reserve custody, redemption, auditing, and compliance with applicable AML/KYC requirements. Bridge and compliance servers can connect ledger operations with existing account systems and enable institutions to exchange information about senders and beneficiaries before approving a transfer. These functions show that cooperation with banks is not incidental to institutional adoption: it is central to converting on-chain tokens into enforceable claims on off-chain value (Lokhava et al., 2019; Zhuo et al., 2023).

Asset tokenization extends this institutional model beyond fiat-linked payment tokens. Documented uses of the Stellar ledger include assets linked to currencies, real estate, commercial bonds, carbon credits, and other application-specific rights. Research on an open-source voting application further demonstrates that Stellar tokens can encode non-monetary claims and can be used as auditable, transferable records, although the same study identifies limitations

in smart-contract functionality and network throughput. At the application layer, a separate payment-portal prototype shows how wallets, a Stellar software development kit, and Horizon services can be combined to initiate and confirm token transfers. For financial institutions, these examples suggest opportunities to develop currency-backed payment tokens, securities or other asset representations, but each instrument still requires an identifiable issuer, clearly defined holder rights, secure custody, reliable redemption or transfer arrangements, and an appropriate legal classification (Lokhava et al., 2019; Barański et al., 2020; Khilji, 2023).

A major practical opportunity offered by Stellar is to combine cross-border payments with financial inclusion. Case studies of African Stellar-based projects indicate that local-currency stablecoins, integration with familiar channels, cash-in and cash-out access, and partnerships with local payment and identity providers can make services more accessible to unbanked and underbanked users. They also show why banks and existing payment institutions need not be wholly displaced: their domestic rails, compliance capacity, customer access, and liquidity can complement the common ledger. The benefits are context-dependent, however. Adoption depends on financial and digital literacy, reliable identity arrangements, user-friendly interfaces, local-currency liquidity, and cooperation among governments, financial institutions, technology firms, educational institutions, and civil-society organizations. The examined projects remain at an early stage, so their potential for inclusion should not be interpreted as evidence of universal or large-scale effectiveness (Zhuo et al., 2023).

These opportunities are accompanied by risks that are material to banks, supervisors, and financial market regulators. The concentration observed in the present study means that routing efficiency may coexist with dependence on a limited number of hubs. Earlier Stellar research also shows that validator misconfiguration and dependence on systemically important operators can impair network liveness and may require manual coordination during disruption. Fiat-linked tokens introduce additional reserve, redemption, custody, liquidity, cyber-security, operational, and market-integrity risks. At sufficient scale, weak backing or a loss of confidence could create redemption pressure, while dominant stablecoins could affect competition, capital flows, and the monetary autonomy of weaker-currency jurisdictions. Institutional use should therefore be supported by identifiable operators, reserve verification, redemption planning, segregation of client assets, operational redundancy, incident management, and continuous monitoring of both transaction and validator concentration (Lokhava et al., 2019; Zhuo et al., 2023).

In the European Union, these institutional roles need to be assessed under the Markets in Crypto-assets Regulation (MiCA). Classification depends on the economic characteristics of a Stellar-based token rather than on the network on which it is issued. A token referring to one official currency may qualify as an e-money token, whereas a token stabilized by reference to other assets or a combination of values may fall within the asset-referenced-token regime.

Crypto-assets qualifying as financial instruments are excluded from MiCA and remain subject to the existing financial-services framework. The professional provision of crypto-asset services generally requires authorization or eligible financial-entity status; certain financial entities, including credit institutions, may provide specified services after the required notification. MiCA further imposes requirements relating to prudential safeguards, governance, custody and segregation of client assets, and issuance and redemption. Cooperation between Stellar-based providers and banks must therefore be organized around a case-specific determination of the token, issuer, service, custody model, and competent supervisory authority (Regulation (EU) 2023/1114, Arts. 2–3, 48–49, 59–60, 67–68 and 75).

MiCA narrows several legal gaps but does not eliminate the boundary and supervisory problems revealed by the empirical analysis. Public addresses do not by themselves identify the institution performing an issuer, exchange, custody, or settlement function. Moreover, MiCA distinguishes services attributable to identifiable intermediaries from services provided in a fully decentralized manner without an intermediary, and it requires further assessment of the regulatory treatment of decentralized finance. Cross-border stablecoin arrangements also operate across jurisdictions whose classifications, reserve standards, and enforcement capacity may differ (Zhuo et al., 2023). Effective supervision therefore depends on linking on-chain activity to legally accountable entities, coordinating oversight across borders, monitoring concentration and transaction flows, verifying reserve and redemption arrangements, and assessing operational resilience and outsourcing dependencies. These measures become particularly important when the scale of a token or the concentration of gateways could affect client protection, market integrity, the continuity of payment services, or financial stability. Overall, Stellar offers a technically credible platform for financial innovation, but its institutional value depends on governance, liquidity, legal accountability, and regulatory compliance developing alongside network adoption (Regulation (EU) 2023/1114, recitals 8, 22 and 73; Arts. 46–49 and 141–142).

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Krzysztof Świeszczak https://orcid.org/0000-0002-2286-7778
PhD, Faculty of Economics and Sociology, University of Lodz, e-mail: krzysztof.swieszczak@uni.lodz.pl

CZYNNIKI EKONOMICZNE JAKO DETERMINANTY ATRAKCYJNOŚCI OFERTY SEKTORA FINTECH DLA KLIENTÓW INDYWIDUALNYCH BANKÓW

Economic factors as determinants of the attractiveness of the fintech sector's offer for individual clients of banks

Abstract

The purpose of the article. The aim of this publication is to analyze the importance of economic factors for assessing the attractiveness of the FinTech sector's offer among individual clients of the banking sector and the banking sector and the FinTech sector. The following hypothesis was put forward in the article: the average level of importance of economic factors for assessing the attractiveness of the FinTech sector's offer does not differ statistically significantly for individual customers of the banking sector and individual customers of the banking sector and the FinTech sector.

Methodology. To verify the hypothesis and achieve the purpose of the study, 240 PAPI interviews were conducted among banking-sector customers. The sample comprised:

- 120 individual banking-sector customers who had not yet used FinTech services.
- 120 individual banking-sector customers with experience using FinTech services.

The questionnaire survey was preceded by in-depth interviews with experts, academics researching FinTech, and owners and co-owners of FinTech businesses.

Results of the research. The research found that individual banking-sector clients who had not yet used FinTech services were more likely to agree that higher monthly expenditure, creditworthiness, income, and savings were associated with a higher assessment of the attractiveness of the FinTech sector's offer. No statistically significant differences were found for the remaining statement. The results positively verify the hypothesis that the average importance of economic factors in assessing the attractiveness of the FinTech sector's offer does not differ significantly between banking-sector clients and clients using both banking and FinTech services.

Keywords: bank, fintech, offer, purchasing decisions, attractiveness determinants
JEL Class: G21, G23, G29, D81, D91

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Wstęp

Konieczność podejmowania decyzji jest nierozerwalnie związana z funkcjonowaniem każdej jednostki. Zarówno w życiu prywatnym, jak i zawodowym, na każdym etapie życia dokonywane są liczne wybory, co wpływa na fakt, iż jest to jedno z najczęściej realizowanych działań. Wynika to z częstotliwości podejmowania decyzji – oprócz tych o kluczowym charakterze dla przyszłości jednostki, każdego dnia podejmowane są liczne decyzje, w tym zakupowe, które związane są z funkcjonowaniem jednostki w określonym ładzie społeczno-gospodarczym.

Decyzja, traktowana jako ostateczny akt dokonania określonego wyboru, jest zwieńczeniem procesu podejmowania decyzji (procesu decyzyjnego). Proces ten obejmuje całokształt powiązanych ze sobą operacji myślowych i/lub obliczeniowych, które w swojej istocie mają doprowadzić do rozwiązania określonego problemu decyzyjnego. Należy przy tym zauważyć, iż decyzja może sprowadzać się zarówno do wyboru jednej z wielu dostępnych aktywności czy czynności, jak i odstąpienia od jakichkolwiek działań w następstwie procesu decyzyjnego.

Specyfika decyzji o charakterze finansowym, a w szczególności ich wpływ na sytuację finansową jednostki, sprawia, iż w procesie decyzyjnym branych jest pod uwagę wiele czynników, które determinują dokonywane wybory. Wśród nich wyróżnić można zarówno czynniki o charakterze egzogenicznym, jak i endogenicznym, jednakże w kontekście procesu decyzyjnego, w którym oprócz operacji myślowych, realizowane są operacje obliczeniowe, kluczowe w wielu sytuacjach mogą okazać się faktory ekonomiczne, należące do pierwszej w wymienionych grup. Determinanty takie jak poziom dochodów, wydatków, oszczędności, a także zdolność kredytowa jednostki, czy stopień dywersyfikacji aktywów w bardzo istotny sposób wpływają na decyzję jednostek, w tym również na ocenę atrakcyjności oferty sektora FinTech dla klientów indywidualnych banków, którzy coraz częściej stają w obliczu wyboru instytucji, z usług której będą korzystać. Alternatywę dla tradycyjnych instytucji finansowych stanowią przedsiębiorstwa należące do sektora FinTech, których popularność w ostatnich latach znacznie wzrosła.

Warto zauważyć, że analizowana problematyka wpisuje się w nurt szeroko zakrojonych badań nad konkurencją i współzależnościami pomiędzy tradycyjnym sektorem bankowym a branżą FinTech. W literaturze przedmiotu wskazuje się, że dojrzałość rynków finansowych oraz stopień cyfryzacji społeczeństwa stanowią istotne determinanty sukcesu podmiotów FinTech. Badania porównawcze prowadzone m.in. w krajach Europy Zachodniej (Baba i in., 2020, ss. 4–9) oraz Ameryki Północnej (Clements, 2021, ss. 4–6) dowodzą, że czynniki ekonomiczne i technologiczne wpływają na motywacje konsumentów w sposób zróżnicowany w zależności od poziomu rozwoju lokalnego systemu bankowego. Choć niniejsze opracowanie koncentruje się na specyfice polskiego rynku finansowego, odniesienie uzyskanych wyników do koncepcji obecnych w międzynarodowej literaturze przedmiotu pozwala na uchwy-

cenie uniwersalnych wzorców zachowań klientów indywidualnych w obliczu transformacji cyfrowej usług finansowych.

Celem niniejszej publikacji jest analiza znaczenia uwarunkowań o charakterze ekonomicznym dla oceny atrakcyjności oferty sektora FinTech wśród klientów indywidualnych sektora bankowego oraz sektora bankowego i sektora FinTech.

Istota procesu decyzyjnego

Literatura przedmiotu charakteryzuje proces podejmowania decyzji najczęściej przez pryzmat logicznie powiązanego ciągu operacji myślowych, przyjmującego postać procedury definiowanej uporządkowanymi etapami realizowanymi w określonym czasie (Bagchi, 2010, s. 73). Zwraca się również uwagę na fakt, iż ów proces decyzyjny, a w szczególności jego fazy, mają charakter przyczynowo-skutkowy, co akcentuje znaczenie poszczególnych elementów tego konstruktu (Hester & Adams, 2017, s. 347).

Proces decyzyjny oparty jest na trzech filarach, do których zalicza się preferencje, alternatywy oraz informacje. Pierwszy z filarów związany jest z dobrami i usługami, które zaspokajają potrzeby jednostki. Jednocześnie bardzo istotne jest to, że preferencje mają osobisty charakter w przypadku każdej osoby podejmującej decyzje. Alternatywy rozumiane są jako opcje, warianty i możliwości, które pojawiają się w procesach podejmowania decyzji. Ostatni z filarów, informacje, związany jest z poziomem wiedzy posiadanym przez jednostkę w momencie podejmowania decyzji (Bresnick & Periu, 2022, ss. 3–4).

Ze względu na liczbę podejmowanych przez każdą jednostkę decyzji, a także złożoność procesów poprzedzających ich podjęcie, zidentyfikowano następujące etapy procesów decyzyjnych (Stoner i in., 2001, ss. 248–253):

1. Identyfikacja problemu decyzyjnego.
2. Identyfikacja możliwości rozwiązania problemu decyzyjnego.
3. Analiza dostępnych wariantów z perspektywy możliwości wykonania określonych działań, poziomu zadowolenia, a także korzyści będących następstwem dokonanych wyborów.
4. Podjęcie decyzji rozumianej jako wprowadzenie w życie wyselekcjonowanej możliwości rozwiązania problemu decyzyjnego.
5. Obserwacja oraz analiza efektów wprowadzenia w życie wyselekcjonowanej możliwości rozwiązania problemu decyzyjnego.

W tym kontekście należy zauważyć, iż zwieńczeniem analizowanego procesu jest decyzja, będąca wyborem konkretnego działania, wybranego spośród pewnej puli możliwych działań (alternatyw) w danym okresie lub wyborem, skutkującym brakiem działania, wynikającym ze świadomego powstrzymania się od jego dokonania. W konsekwencji podjętej

decyzji pojawia się określony rezultat, który może być oceniany w następujący sposób (Christiansen & Lechman, 2016, s. 123):

- pozytywnie – na podstawie analizy, w wyniku której korzyści przewyższają nakłady,
- negatywnie – na podstawie analizy, w wyniku której nakłady przewyższają korzyści,
- neutralnie – nie ma możliwości przeprowadzenia analizy efektu działania lub analiza ta nie daje możliwości jednoznacznej oceny konsekwencji.

Niezależnie od oceny rezultatu, w każdym procesie podejmowania decyzji występują:

- Decydent – osoba podejmująca decyzję. Należy przy tym zauważyć, iż o ile decydentem może być zarówno osoba fizyczna, jak i prawna (rozumiana jako organizacja), o tyle, nawet w przypadku drugiej ze wspomnianych kategorii, za każdą decyzją organizacji stoi decyzja osoby nią zarządzającej (Harvey i in., 2022, s. 6).
- Zbiór dopuszczalnych sposobów działania – wszelkie możliwe warianty umożliwiające rozwiązanie problemu decyzyjnego. W praktyce oznacza to, że w procesie decyzyjnym jednostka ma alternatywne możliwości w zakresie sposobu działania i co szczególnie istotne, jednym ze sposobów jest niepodejmowanie żadnych decyzji (Kaul, 2015, s. 121).
- Zbiór stanów świata zewnętrznego – otoczenie decydenta mogące w sposób pośredni lub bezpośredni determinować podejmowane decyzje i dokonywane wybory przez decydenta. Należy przy tym zauważyć, iż zmiany zachodzące w otoczeniu jednostki mają charakter dynamiczny, co w sposób istotny wpływa na proces decyzyjny (Nikoi & Boateng, 2014, s. 220).
- Funkcja użyteczności – funkcja ta umożliwia wartościowanie poszczególnych możliwości rozwiązania problemu decyzyjnego oraz ich priorytetyzację (Yildiz, 2006, s. 400).
- Niepewność stanu świata zewnętrznego – każda decyzja obarczona jest zdarzeniami mającymi charakter losowy, co oznacza, że zarówno prawdopodobieństwo ich wystąpienia, a tym bardziej ich potencjalne konsekwencje są niezwykle trudne lub niemożliwe do przewidzenia (Arend, 2024, s. 49).

Ze względu na analizowaną problematykę (atrakcyjność oferty sektora FinTech dla klientów indywidualnych banków), w dalszej części publikacji dominować będzie podejście normatywne do procesów decyzyjnych, które w odróżnieniu od podejścia deskryptywnego, koncentruje się na rozwiązaniu problemu oraz jego rezultacie w szczególności w kontekście możliwości zaspokojenia określonych potrzeb finansowych (Bradley, 2014, ss. 1–3).

Przyjęcie normatywnego podejścia do procesu decyzyjnego stanowi bezpośrednie uzasadnienie metodologiczne dla podjętej analizy empirycznej uwarunkowań ekonomicznych. Przyjmując założenie, że konsument dąży do optymalizacji wyborów finansowych na podstawie kryterium użyteczności oraz bilansu korzyści i nakładów, to czynniki takie jak poziom dochodów,

wydatków czy zdolność kredytowa stają się wymiernymi parametrami tej funkcji. Tym samym przedstawione wyżej etapy i elementy procesu decyzyjnego tworzą ramy pojęciowe wyjaśniające proces oceny atrakcyjności alternatywnych ofert – w tym przypadków, gdy tradycyjne usługi bankowe są zastępowane lub uzupełniane przez rozwiązania sektora FinTech.

Uwarunkowania decyzji konsumentów

Procesy podejmowania decyzji mogą stanowić skomplikowane oraz wielopoziomowe konstrukty (Liczmańska, 2015, s. 108). Każdy konsument w trakcie swojego życia podejmuje wiele decyzji. Co oczywiste, ze statystycznego punktu widzenia dominują te o charakterze rutynowym, powtarzalnym oraz spontanicznym, dla których wspólnym mianownikiem zazwyczaj jest ograniczony wpływ dokonywanych wyborów na przyszłość jednostek. Należy jednak pamiętać, iż w zasadzie każdy konsument na pewnym etapie życia staje w obliczu konieczności podjęcia decyzji, której znaczenie będzie mieć fundamentalne wpływ na finanse osobiste zarówno tej osoby, jak i jej najbliższych.

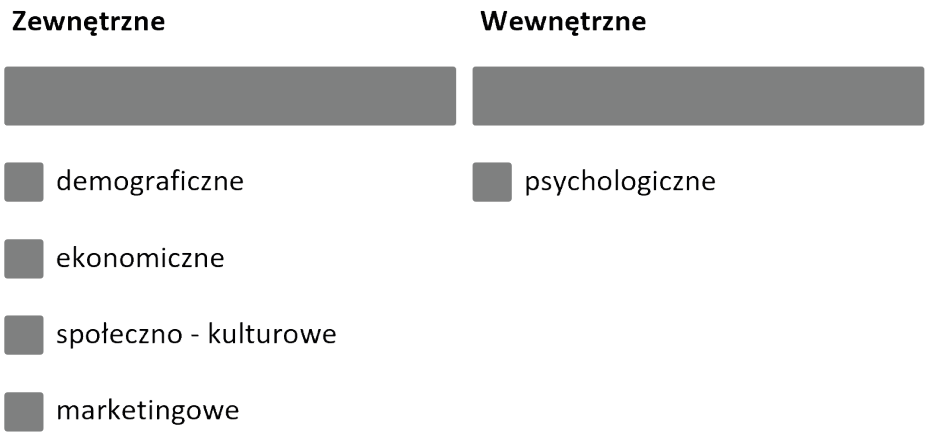
Abstrahując od liczby decyzji podejmowanych przez konsumentów w trakcie całego życia, należy zauważyć, iż każda z nich może być determinowana wieloma czynnikami (Korneta & Lotko, 2021, s. 3), wśród których znajdują się m.in. faktory o charakterze (Kieżel, 2000, s. 104):

- Zewnętrznym – związanym z otoczeniem (zarówno bliższym, jak i dalszym) konsumenta, odwołującym się do następujących obszarów:
  - społeczno-kulturowego – wynikającego z faktu, iż jednostka jest częścią określonej zbiorowości,
  - demograficznego i społecznego – determinowanego cechami jednostki, takimi jak wiek, płeć oraz miejsce zamieszkania,
  - marketingu-mix – związanego z oddziaływaniem organizacji na konsumentów za pomocą narzędzi, które koncentrują się na produkcie, cenie, dystrybucji oraz promocji.
- Wewnętrznym – odwołującym się do specyficznych cech każdej jednostki, wśród których wymienić należy m.in. osobowość, doświadczenia, potrzeby, poziom akceptacji ryzyka, motywy podejmowania wszelkich działań oraz preferencje konsumenta (Kozłowska, 2016, ss. 129–133).

Alternatywna typologia uwarunkowań decyzji konsumentów wyróżnia zarówno czynniki o charakterze egzogenicznym (demograficzne, ekonomiczne, społeczno-kulturowe oraz marketingowe), jak i czynnik o charakterze endogenicznym (psychologiczny) – Rysunek 1.

Rysunek 1

Uwarunkowania zachowań konsumentów



Źródło: opracowanie własne na podstawie Kieżel, 2000, s. 104.

Charakterystyczny dla procesów decyzyjnych jest fakt współwystępowania jednocześnie wielu faktorów, które wzajemnie na siebie oddziałują (Zjawin, 2018, ss. 234–236). Sytuacja taka w sposób istotny wpływa na poziom złożoności oraz wielopłaszczyznowość wyborów dokonywanych przez jednostki, w wielu przypadkach sprawiając, iż proces podejmowania decyzji wydłuża się oraz staje się trudniejszy dla konsumenta.

Spośród szerokiego katalogu egzogenicznych i endogenicznych uwarunkowań decyzji konsumenckich, w przypadku rynków finansowych kluczową rolę odgrywa komponent ekonomiczny. Podczas gdy czynniki psychologiczne czy społeczno-kulturowe rzutują na ogólny poziom akceptacji innowacji technicznych, sytuacja materialna (mikrootoczenie konsumenta) wyznacza faktyczny zakres swobody decyzyjnej oraz stopień wrażliwości na korzyści cenowe i kosztowe. Z tego powodu w dalszych badaniach empirycznych wyizolowano uwarunkowania ekonomiczne (m.in. dochody, oszczędności, wydatki), traktując je jako bezpośrednie determinanty oceniania oferty FinTech w zestawieniu z tradycyjną ofertą bankową.

Biorąc pod uwagę podobną konstrukcję produktów i usług oferowanych przez sektor bankowy oraz FinTech, a w szczególnych przypadkach (ze względu na możliwość zaspokojenia określonych potrzeb finansowych klientów poprzez nabycie różnych dóbr) ich substytucyjny charakter, w dalszej części rozważań skoncentrowano się na uwarunkowaniach atrakcyjności oferty sektora FinTech. Na podstawie wywiadów pogłębionych przeprowadzonych z ekspertami, będącymi przedstawicielami środowiska naukowego zajmującymi się zawodowo badaniem sposobu funkcjonowania przedsiębiorstw FinTech oraz właścicielami

i współwłaścicielami podmiotów gospodarczych należących do sektora FinTech, zidentyfikowano potrzebę eksploracji obszaru uwarunkowań ekonomicznych w procesie oceny atrakcyjności oferty sektora FinTech.

Uwarunkowania o charakterze ekonomicznym

Uwarunkowania ekonomiczne (uwarunkowania o charakterze egzogenicznym) są związane z niezwykle istotnymi determinantami odwołującymi się do otoczenia jednostki, zarówno dalszego, jak i bliższego.

Pierwsza z kategorii, określana w literaturze przedmiotu również mianem makrootoczenia, wywiera pośredni wpływ na podejmowane decyzje oraz wybory dokonywane przez jednostki. Co szczególnie istotne, otoczenie dalsze kreuje identyczne warunki dla procesów decyzyjnych wszystkich jednostek należących do tej samej zbiorowości, ze względu na fakt, iż jest ono kształtowane przez władzę ustawodawczą i wykonawczą (Woś i in., 2011, s. 49). Warunki, o których mowa, mogą w istotny sposób wpływać na decyzje podejmowane przez klientów sektora finansowego, ze względu na ich znaczenie dla podaży produktów i usług finansowych (np. konieczność posiadania rachunku bankowego w przypadku chęci skorzystania z dotacji lub programów socjalnych oraz dofinansowanie spłaty rat kredytów hipotecznych w przypadku spełnienia określonych wymogów formalnych).

Bliższe otoczenie, określane w literaturze przedmiotu również mianem mikrootoczenia, definiuje sytuację materialną jednostki. Jest ona charakteryzowana przez analizę czynników bezpośrednio związanych z konsumentem, do których należą m.in. jego dochody, wydatki, zgromadzone oszczędności, zdolność kredytowa determinująca możliwość pozyskania środków finansowych z zewnętrznych źródeł oraz struktura posiadanych składników majątku. Czynniki te mają fundamentalne znaczenie dla zakresu swobody w podejmowaniu wszelkich decyzji zakupowych, w tym nabywaniu produktów i usług finansowych (Kusińska, 2005, s. 71).

Znaczenie uwarunkowań ekonomicznych w procesie ewaluacji i adopcji usług FinTech znajduje potwierdzenie także w badaniach o charakterze międzynarodowym. Jak wskazują wielorynkowe analizy porównawcze, czynniki takie jak poziom dochodów rozporządzalnych, koszt alternatywny korzystania z tradycyjnej bankowości czy poziom oszczędności stanowią uniwersalne determinanty przechodzenia klientów do alternatywnych dostawców usług finansowych (Deng i in., 2019, s. 12). W krajach o wyższym stopniu rozwoju gospodarczego klienci częściej traktują FinTech jako uzupełnienie (komplementarność) dotychczasowego portfela usług bankowych, podczas gdy na rynkach wschodzących oferta ta stanowi bezpośrednią alternatywę (substytucyjność). Osadzenie perspektywy polskiego rynku w tym szerokim kontekście

międzynarodowym pozwala lepiej zrozumieć mechanizmy, które determinują subiektywną ocenę atrakcyjności oferty FinTech przez klientów banków o różnej strukturze dochodowej i finansowej.

Metodologia badawcza[1]

W związku z realizacją celu badawczego sformułowano następującą hipotezę: przeciętna ocena znaczenia uwarunkowań ekonomicznych dla atrakcyjności oferty FinTech nie różni się w sposób istotny statystycznie między klientami korzystającymi wyłącznie z usług bankowych a klientami łączącymi korzystanie z usług banków i podmiotów FinTech.

Weryfikację empiryczną przeprowadzono na podstawie badań ilościowych z wykorzystaniem techniki wywiadów kwestionariuszowych (PAPI) zrealizowanych na próbie N = 240 respondentów (losowy dobór respondentów). Dla zapewnienia porównywalności wyników próba została podzielona na dwa równe podzbiory (n1 = 120 – osoby bez doświadczenia w FinTech; n2 = 120 – klienci z doświadczeniem w FinTech). Proces badawczy został poprzedzony fazą jakościową w postaci wywiadów pogłębionych (IDI) z ekspertami rynkowymi i naukowymi, co pozwoliło na właściwy dobór zmiennych ekonomicznych do kwestionariusza.

Kwestionariusz badawczy składał się z kilku części, wśród których istotne znaczenie miały komponenty związane z uwarunkowaniami ekonomicznymi. Wszystkie pytania wymagały udzielenia odpowiedzi wyrażającej stopień akceptacji określonego stwierdzenia, plasującego się na siedmiostopniowej skali Likerta (całkowicie się nie zgadzam, nie zgadzam się, raczej się nie zgadzam, trudno powiedzieć, raczej się zgadzam, zgadzam się, zdecydowanie się zgadzam). W budowie ostatecznej wersji narzędzia uwzględnione zostały wyniki wykonanych badań pilotażowych na grupie 40 osób. Badanie zostało zrealizowane w okresie od lutego 2024 r. do sierpnia 2024 r.

Charakterystyka badanych grup respondentów

Ze względu na realizację badań w ramach szerszego projektu badawczego, w niniejszym artykule wykorzystano tę samą próby badawczą (N=240), której szczegółowa struktura psychologiczno-społeczna została omówiona w K. Świeszczak (2023). Niniejsze opracowanie ogranicza opis próby do kontekstu analizy czynników ekonomicznych. Jak wskazano wcześniej, w badaniu uczestniczyło:

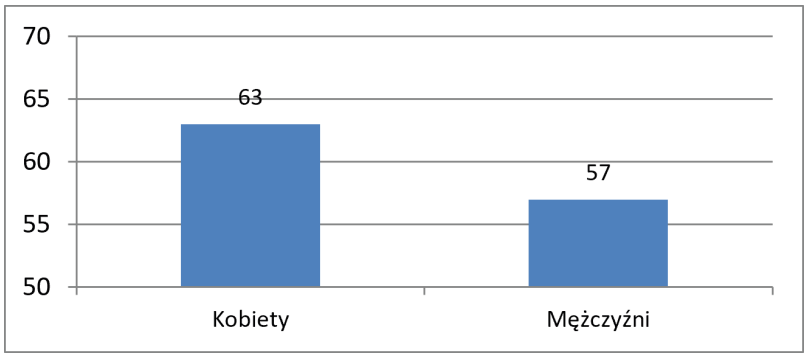
[1] Niniejszy artykuł stanowi część szerszego projektu badawczego dotyczącego uwarunkowań atrakcyjności oferty sektora FinTech dla klientów indywidualnych banków. Wyniki dotyczące uwarunkowań psychologicznych oraz zaufania społecznego zostały przedstawione we wcześniejszej publikacji: K. Świeszczak, *Zaufanie społeczne a uwarunkowania psychologiczne atrakcyjności oferty sektora FinTech wśród klientów indywidualnych banków*, „internetowy Kwartalnik Antymonopolowy i Regulacyjny" 2023, nr 6(12), s. 31–49, DOI: 10.7172/2299-5749.IKAR.6.12.3. W niniejszym opracowaniu analizie poddano odrębny obszar badawczy dotyczący uwarunkowań ekonomicznych (dochody, wydatki, oszczędności, zdolność kredytowa).

- 120 klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech;
- 120 klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech.

Pierwsza z wymienionych grup respondentów składała się z 63 kobiet i 57 mężczyzn (Wykres 1), w tym były w niej 4 osoby urodzone w latach 1950–1959, 6 osób w latach 1960–1969, 45 osób w latach 1970–1979, 48 osób w latach 1980–1989, 15 osób w latach 1990–1999 oraz 2 w latach 2000–2009 (Wykres 2).

Wykres 1

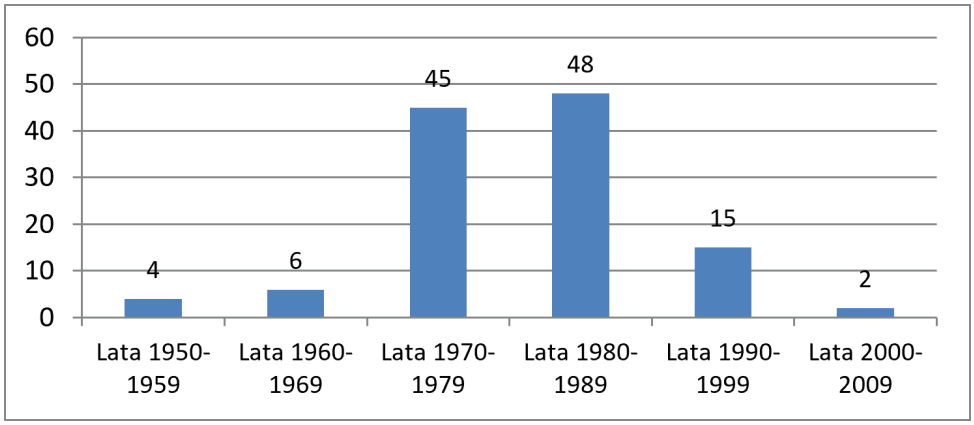
Struktura klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech ze względu na płeć



Źródło: Opracowanie własne.

Wykres 2

Struktura klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech ze względu na rok urodzenia

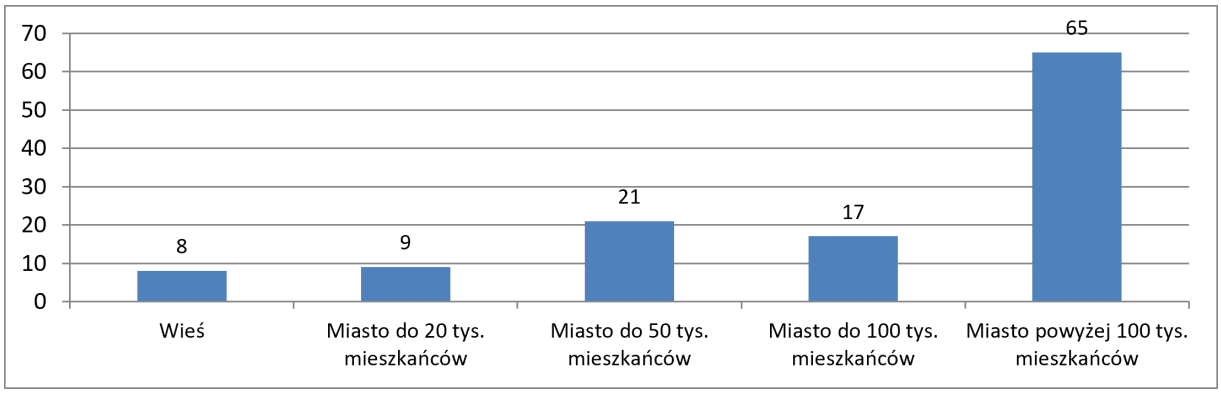


Źródło: Opracowanie własne.

Na obszarach wiejskich mieszkało 8 respondentów, 9 – w mieście do 20 tys. mieszkańców, 21 – w mieście do 50 tys. mieszkańców, 17 – w mieście do 100 tys. mieszkańców, a 65 – w mieście powyżej 100 tys. mieszkańców (wykres 3).

Wykres 3

Struktura klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech ze względu na miejsce zamieszkania

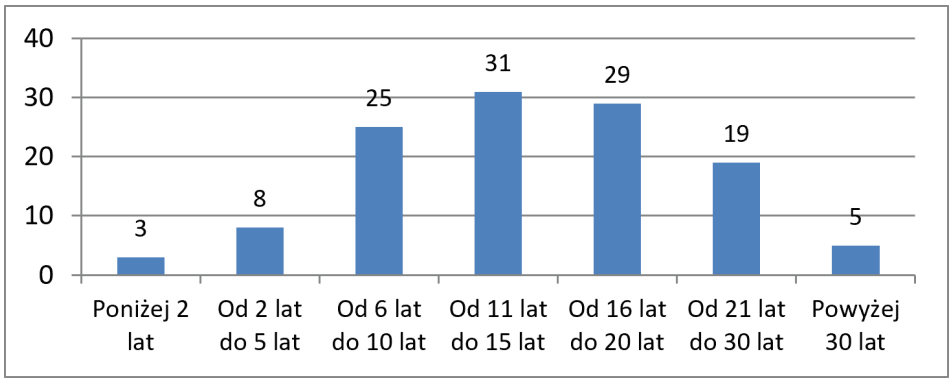


Źródło: Opracowanie własne.

Doświadczenie w korzystaniu z oferty bankowej w okresie poniżej 2 lat posiadało 3 respondentów, 8 respondentów – w okresie od 2 lat do 5 lat, 25 respondentów – w okresie od 6 lat do 10 lat, 31 respondentów – w okresie od 11 lat do 15 lat, 29 respondentów – w okresie od 16 lat do 20 lat, 19 respondentów – w okresie od 21 lat do 30 lat, 5 respondentów – w okresie powyżej 30 lat (Wykres 4).

Wykres 4

Struktura klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech ze względu na doświadczenie w korzystaniu z oferty banków

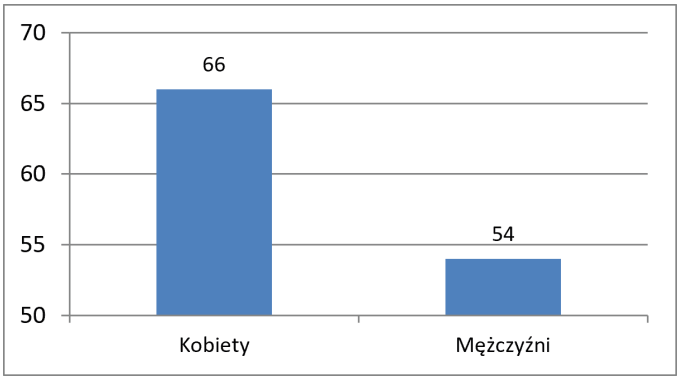


Źródło: Opracowanie własne.

W przypadku drugiej z wymienionych grup respondentów, było w niej 66 kobiet i 54 mężczyzn (Wykres 5), w tym 1 osoba urodzona w latach 1950–1959, 5 osób – w latach 1960–1969, 43 osoby – w latach 1970–1979, 56 osób – w latach 1980–1989, 13 osób – w latach 1990–1999 oraz 2 – w latach 2000–2009 (Wykres 6).

Wykres 5

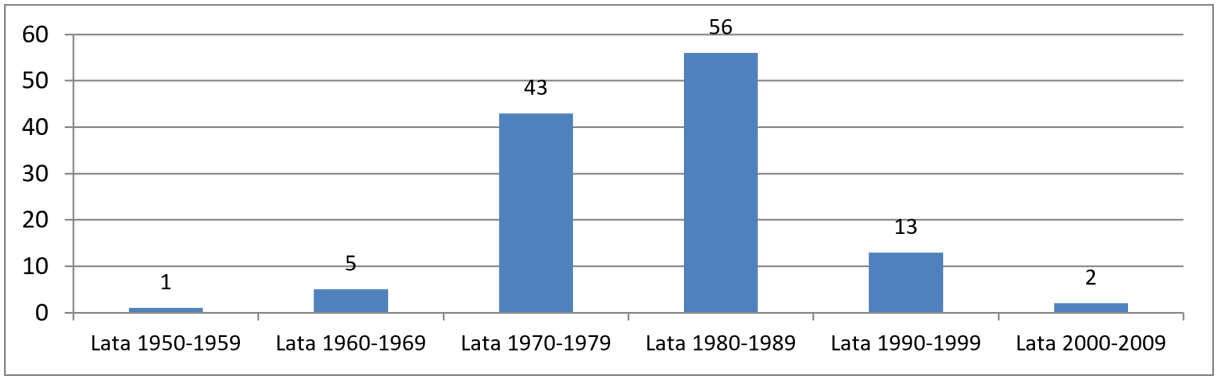
Struktura klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech ze względu na płeć



Źródło: Opracowanie własne.

Wykres 6

Struktura klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech ze względu na rok urodzenia

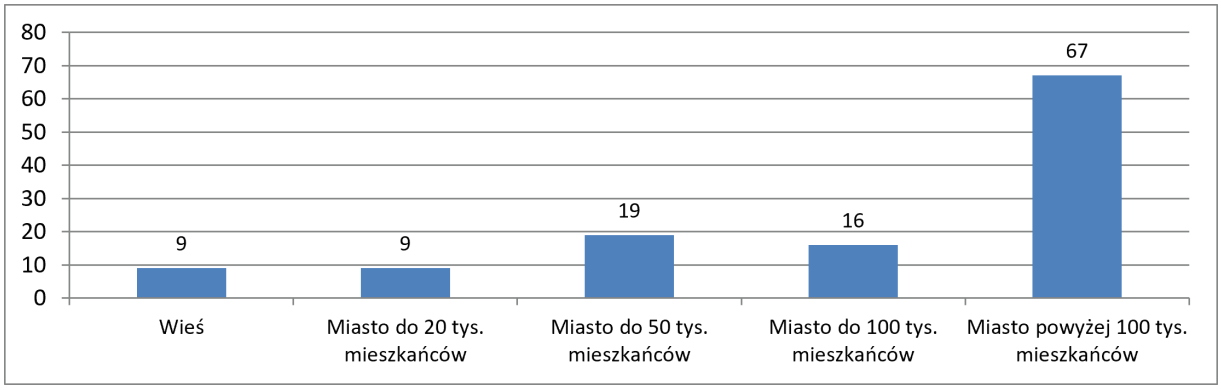


Źródło: Opracowanie własne.

Na obszarach wiejskich mieszkało 9 respondentów, 9 – w mieście do 20 tys. mieszkańców, 19 – w mieście do 50 tys. mieszkańców, 16 – w mieście do 100 tys. mieszkańców, a 67 – w mieście powyżej 100 tys. mieszkańców (wykres 7).

Wykres 7

Struktura klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech ze względu na miejsce zamieszkania

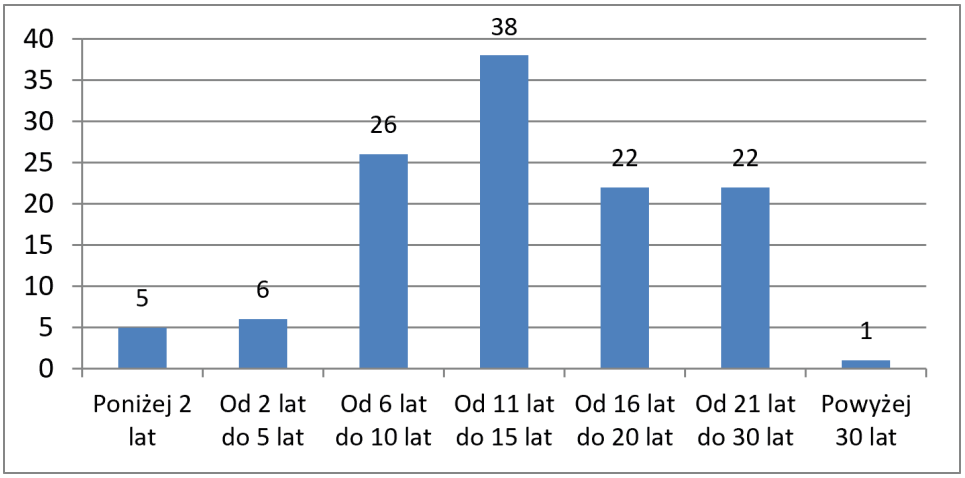


Źródło: Opracowanie własne.

Doświadczenie w korzystaniu z oferty bankowej w okresie poniżej 2 lat posiadało 5 respondentów, 6 respondentów – w okresie od 2 lat do 5 lat, 26 respondentów – w okresie od 6 lat do 10 lat, 38 respondentów – w okresie od 11 lat do 15 lat, 22 respondentów – w okresie od 16 lat do 20 lat, 22 respondentów – w okresie od 21 lat do 30 lat, natomiast 1 respondent – w okresie powyżej 30 lat (Wykres 8).

Wykres 8

Struktura klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech ze względu na doświadczenie w korzystaniu z oferty banków

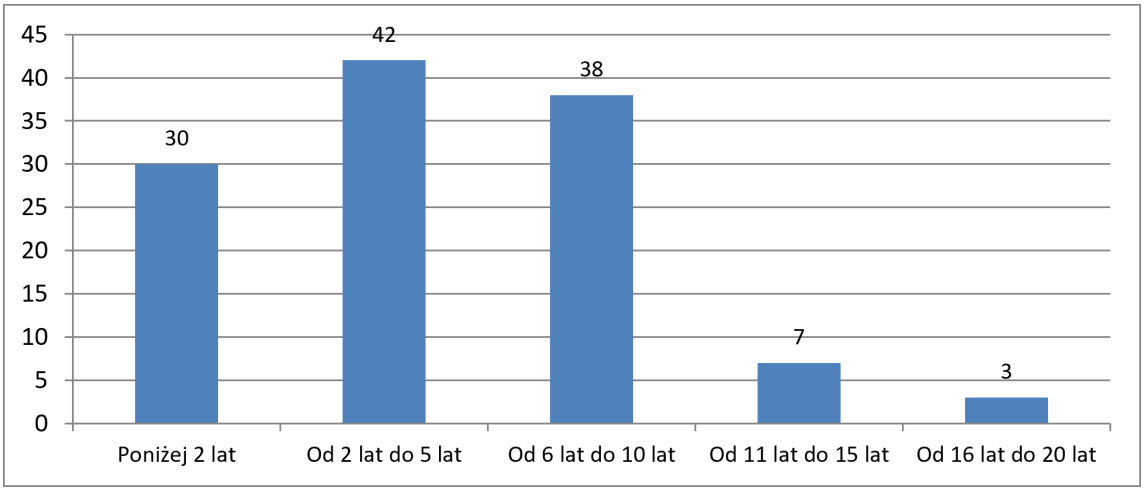


Źródło: Opracowanie własne.

Ddoświadczenie w korzystaniu z oferty sektora FinTech w okresie poniżej 2 lat posiadało 30 respondentów, 42 respondentów – w okresie od 2 lat do 5 lat, 38 respondentów – w okresie od 6 lat do 10 lat, 7 respondentów – w okresie od 11 lat do 15 lat, 3 respondentów – w okresie od 16 lat do 20 lat (wykres 9).

Wykres 9

Struktura klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech ze względu na doświadczenie w korzystaniu z oferty banków



Źródło: Opracowanie własne.

Uwarunkowania ekonomiczne atrakcyjności oferty sektora fintech

Pomiar tego, która z badanych grup (klienci indywidualni sektora bankowego, dotychczas niekorzystający z oferty sektora FinTech oraz klienci indywidualni sektora bankowego, mający doświadczenie w korzystaniu z oferty sektora FinTech) wyżej ocenia znaczenie uwarunkowań o charakterze społeczno-kulturowym dla oceny atrakcyjności oferty sektora FinTech, nastąpił za pomocą pytania rozpoczynającego się od następującej instrukcji: „Chciałbym się teraz dowiedzieć czegoś na temat Pana/Pani oceny wpływu wskazanych czynników ekonomicznych na atrakcyjność oferty sektora FinTech. Odnosząc się do stwierdzeń proszę korzystać ze skali od −3 do 3, gdzie −3 oznacza, że się Pan/i z danym stwierdzeniem nie zgadza, a 3 oznacza, że się Pan/i z tym stwierdzeniem całkowicie zgadza".

Tym samym uznano, że dla zbadania różnic w sposobie postrzegania analizowanej determinanty przez klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech oraz klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech, należy wykorzystać następujące stwierdzenia:

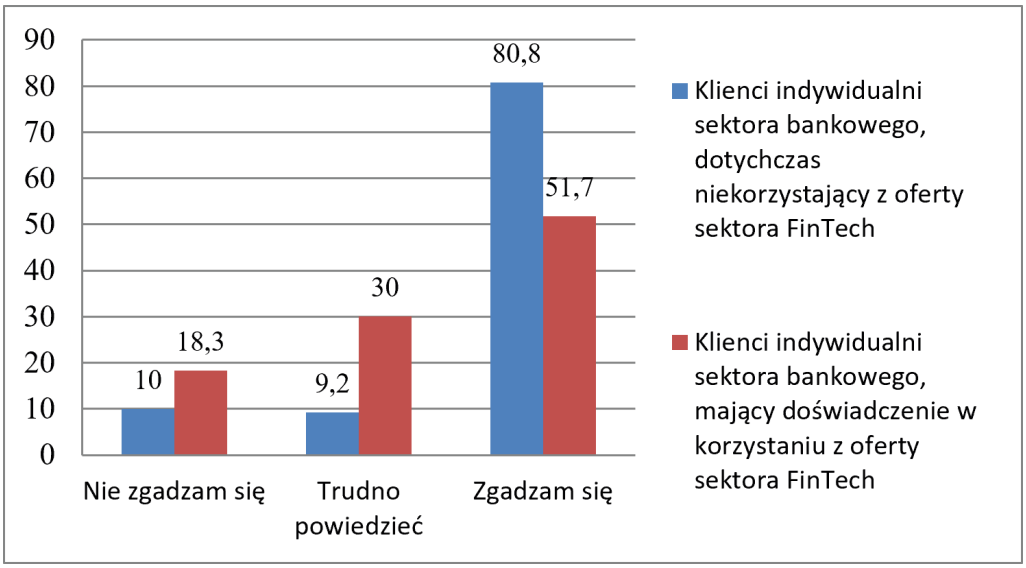
1. Im wyższy poziom dochodów klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech.
2. Im wyższy poziom miesięcznych wydatków klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech.
3. Im wyższy poziom oszczędności klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech.
4. Im wyższy poziom zdolności kredytowej, tym wyższa ocena atrakcyjności oferty sektora FinTech.
5. Im bardziej zdywersyfikowane aktywa posiada klient banku, tym wyższa ocena atrakcyjności oferty sektora FinTech.

W przypadku pierwszego stwierdzenia wśród obu typów respondentów najbardziej liczną grupę stanowiły osoby, które zgadzały się ze stwierdzeniem, że im wyższy poziom dochodów klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech (takiej odpowiedzi udzieliło 80,8% klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech oraz 51,7% klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech) – Wykres 10. Uzyskany wynik może świadczyć o tym, że klienci indywidualni sektora bankowego (zarówno ci dotychczas niekorzystający z oferty sektora FinTech, jak i ci mający doświadczenie w korzystaniu z oferty sektora FinTech) tym wyżej oceniają atrakcyjność oferty podmiotów FinTech, im wyższy poziom dochodów osiągają. Co za tym idzie, należy przyjąć, iż część klientów sektora bankowego, wraz z rosnącym poziomem dochodów, będzie skłonna poszukiwać alternatywy dla oferty banków, a tym samym zainteresować się ofertą sektora FinTech. Co interesujące, blisko co dziesiąty klient indywidualny sektora bankowego, dotychczas niekorzystający z oferty sektora FinTech oraz blisko co trzeci (30%) klient indywidualny sektora bankowego, mający doświadczenie w korzystaniu z oferty sektora FinTech, nie mieli zdania.

Większość respondentów w przypadku obu analizowanych grup uważa, że im wyższy poziom miesięcznych wydatków klienta banku, tym wyższa jest ocena atrakcyjności oferty sektora FinTech – takiej odpowiedzi udzieliło 75,8% klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech oraz 70% klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech (Wykres 11).

Wykres 10

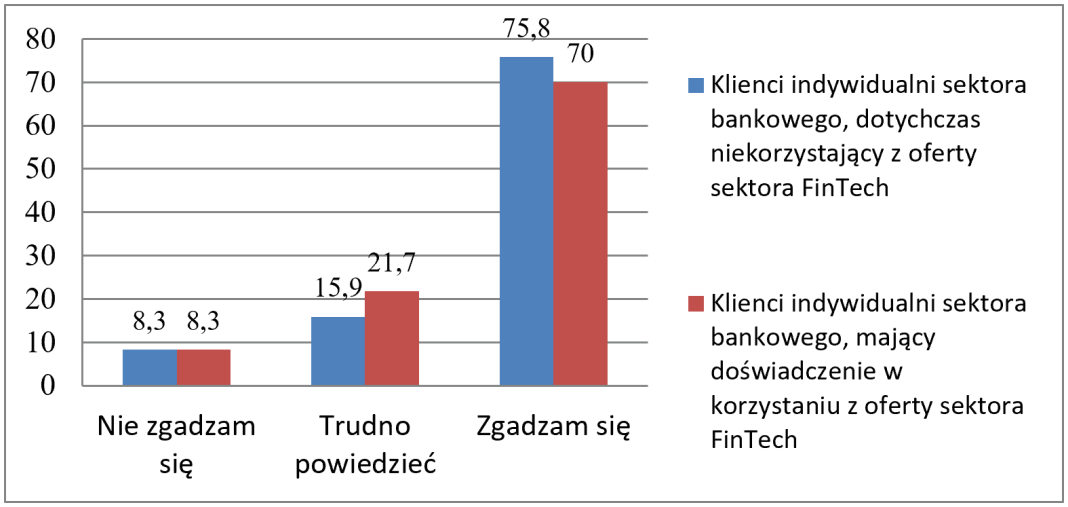
Opinie respondentów na temat tego, czy im wyższy poziom dochodów klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech (w proc. odpowiedzi)



Źródło: Opracowanie własne.

Wykres 11

Opinie respondentów na temat tego, czy im wyższy poziom miesięcznych wydatków klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech (w proc. odpowiedzi)

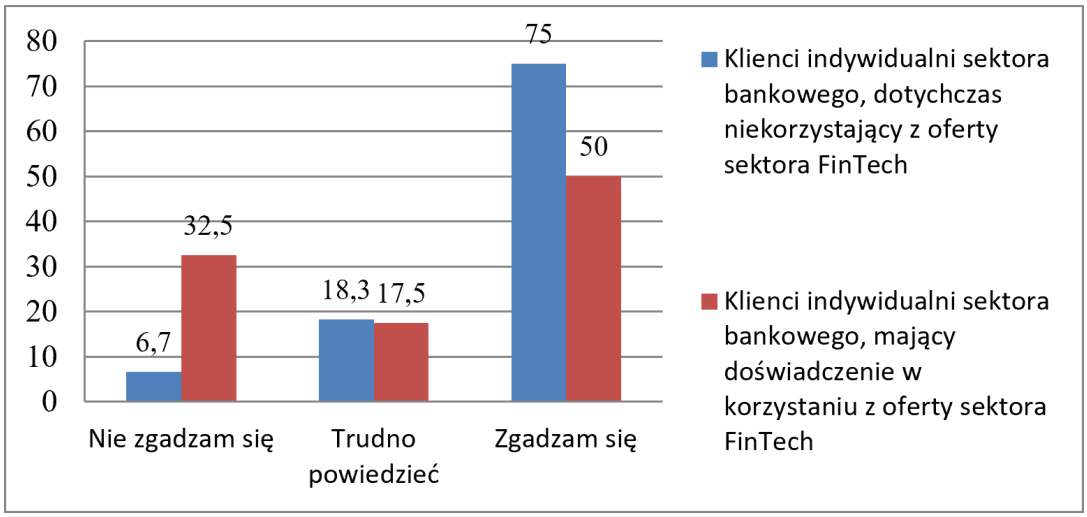


Źródło: Opracowanie własne.

Trzech na czterech klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech uważa, że im wyższy poziom oszczędności klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech. Dla porównania w przypadku klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech, odsetek ten jest istotnie niższy (co drugi respondent). Należy przy tym zauważyć, iż blisko pięć razy więcej klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech niż klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech nie zgadzało się analizowanym stwierdzeniem (Wykres 12).

Wykres 12

Opinie respondentów na temat tego, czy im wyższy poziom oszczędności klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech. (w proc. odpowiedzi)

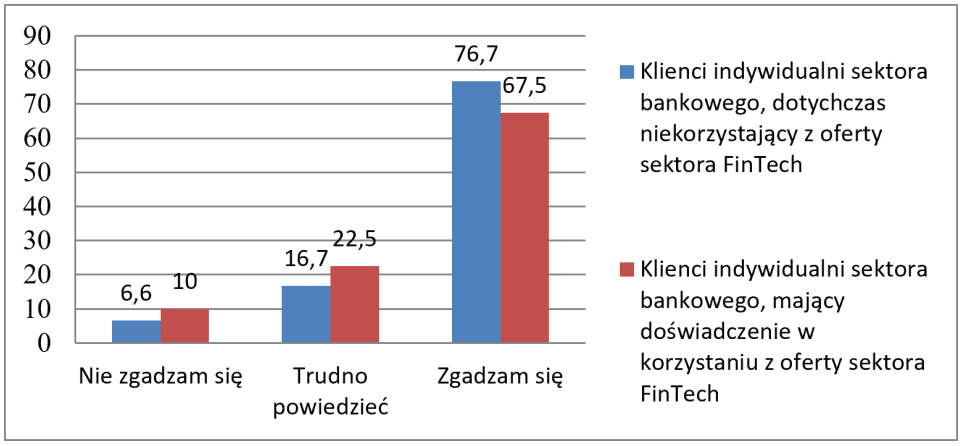


Źródło: Opracowanie własne.

Również w przypadku stwierdzenia, że im wyższy poziom zdolności kredytowej, tym wyższa ocena atrakcyjności oferty sektora FinTech, zaobserwować można pewne różnice w opinii respondentów. Ze stwierdzeniem tym zgadza się 76,7% klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech oraz blisko dwie trzecie klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech (67,5% respondentów). Na uwagę zasługuje fakt, iż co dziesiąty klient indywidualny sektora bankowego, mający doświadczenie w korzystaniu z oferty sektora FinTech nie zgadza się z analizowanym stwierdzeniem (10% respondentów) – Wykres 13.

Wykres 13

Opinie respondentów na temat tego, czy im wyższy poziom zdolności kredytowej, tym wyższa ocena atrakcyjności oferty sektora FinTech (w proc. odpowiedzi)

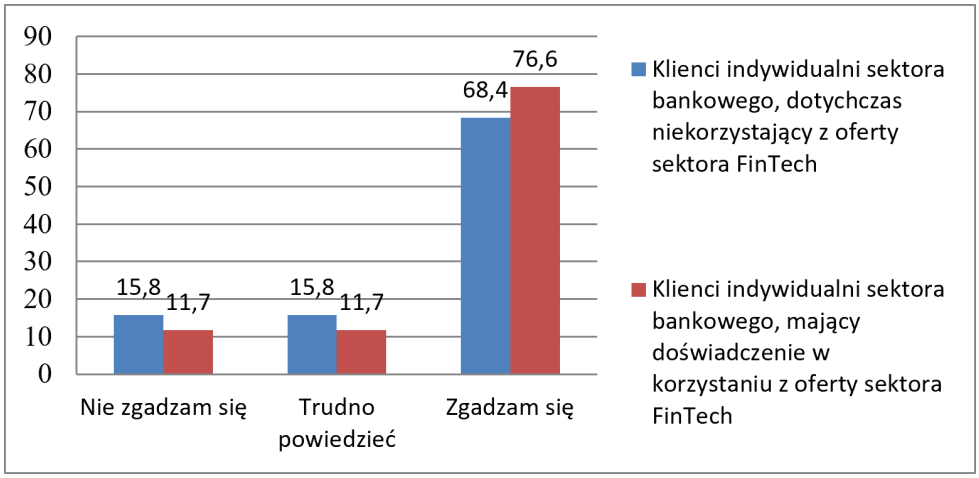


Źródło: Opracowanie własne.

W przypadku ostatniego z analizowanych stwierdzeń (im bardziej zdywersyfikowane aktywa posiada klient banku, tym wyższa ocena atrakcyjności oferty sektora FinTech), nie wystąpiły istotne różnice w opiniach respondentów. Ze stwierdzeniem tym zgodziło się 68,4% klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech oraz 76,6% klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech (Wykres 14).

Wykres 14

Opinie respondentów na temat tego, czy im bardziej zdywersyfikowane aktywa posiada klient banku, tym wyższa ocena atrakcyjności oferty sektora FinTech (w proc. odpowiedzi)



Źródło: Opracowanie własne.

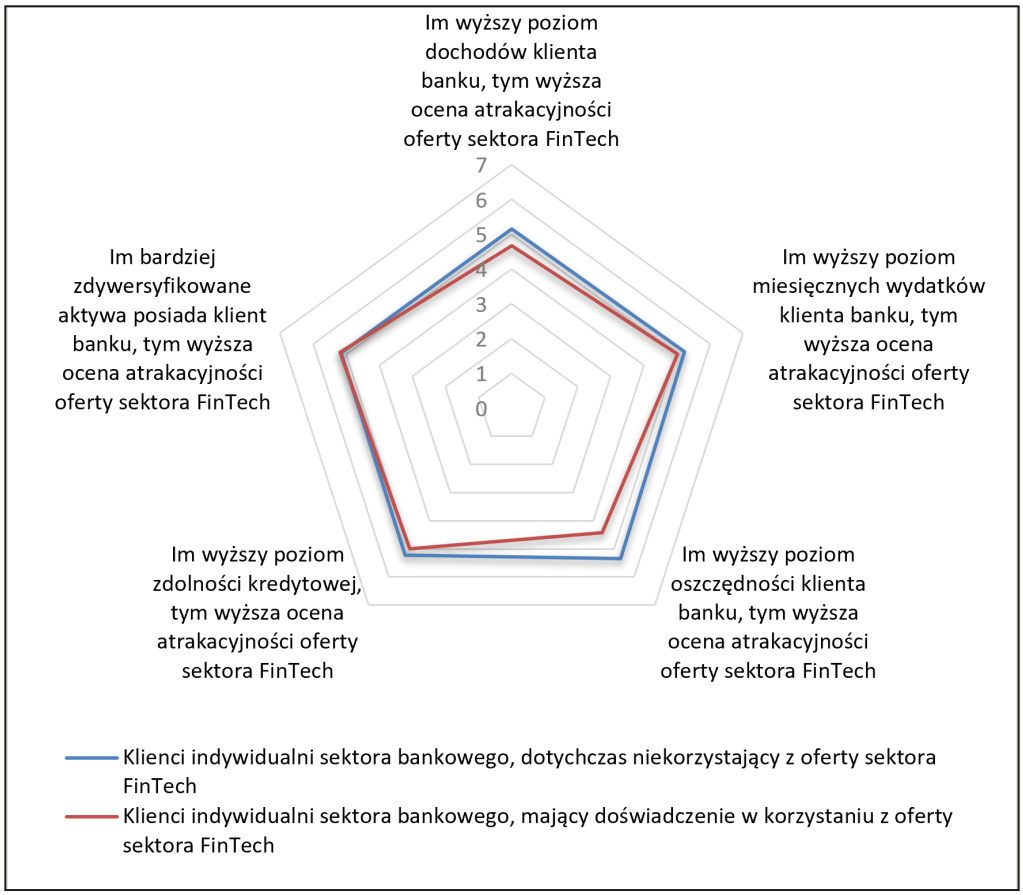
Odwołując się do wartości średnich, reprezentujących przeciętną wartość punktową wskazaną przez badaną populację klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech oraz klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech, zauważyć można, że pierwsza z przytoczonych grup częściej zgadzała się z czterema stwierdzeniami, tj. im wyższy poziom miesięcznych wydatków klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech, im wyższy poziom zdolności kredytowej, tym wyższa ocena atrakcyjności oferty sektora FinTech, im wyższy poziom dochodów klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech oraz im wyższy poziom oszczędności klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech. Należy przy tym zauważyć, iż w przypadku dwóch ostatnich stwierdzeń z wymienionych, różnice w ocenie obu grup były istotne statystycznie. W przypadku odpowiedzi na stwierdzenie „im bardziej zdywersyfikowane aktywa posiada klient banku, tym wyższa ocena atrakcyjności oferty sektora FinTech" nie odnotowano różnic istotnych statystycznie (Wykres 15 – s. 205).

Zaobserwowane różnice w ocenach między grupami respondentów znajdują uzasadnienie w zaprezentowanym wcześniej modelu teoretycznym procesu decyzyjnego. Klienci nieposiadający doświadczenia z FinTech w większym stopniu bazują na postrzeganiu uwarunkowań ekonomicznych (dochodów, oszczędności, wydatków) jako barier lub stymulantów wejścia na nowy rynek. Z kolei dla konsumentów z doświadczeniem w sektorze FinTech, rola samych uwarunkowań ekonomicznych ulega osłabieniu, co wynika z faktu, że w ich procesie decyzyjnym większe znaczenie odgrywają czynniki operacyjne i doświadczenie.

Zastosowane stwierdzenia pozwoliły na zbudowanie zmiennej, będącej kategorią zbiorczą obrazującą opinie respondentów dotyczące uwarunkowań ekonomicznych. Nowopowstała zmienna została nazwana w sposób następujący: **znaczenie uwarunkowania o charakterze ekonomicznym dla oceny atrakcyjności oferty sektora FinTech**, natomiast z danych pochodzących z przeprowadzonego badania wynika, że zbudowana w ten sposób skala okazała się rzetelna. Wartość współczynnika alfa Cronbacha w przypadku klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech wyniosła $\alpha = 0{,}732$, zaś w przypadku klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech wyniosła $\alpha = 0{,}747$. Przedmiotem analizy uczyniono średnią jej wartość, mieszczącą się w przedziale od −3 do 3. Im była ona wyższa, tym badany przypisywał większe znaczenie uwarunkowaniom o charakterze ekonomicznym dla oceny atrakcyjności oferty sektora FinTech.

Wykres 15

Różnice w opiniach klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech oraz klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech w zakresie uwarunkowań ekonomicznych (średnie wartości punktowe odzwierciedlające skalę odpowiedzi)



Źródło: Opracowanie własne.

W celu lepszego zrozumienia czynników determinujących obszar uwarunkowań ekonomicznych, w dalszej części przeprowadzono również analizę wariancji. Celem niniejszej analizy było wyjaśnienie, z jakim prawdopodobieństwem zmienna jaką jest płeć może być powodem różnic między obserwowanymi średnimi dla obu grup (klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech oraz klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech).

Tym samym przedmiotem uwagi uczyniono znaczenie uwarunkowania o charakterze ekonomicznym dla oceny atrakcyjności oferty sektora FinTech wśród kobiet oraz mężczyzn. Aby zidentyfikować różnice w tym względzie zastosowano jednoczynnikową analizę wariancji

(ANOVA). Z uzyskanych danych wynika, że pomiędzy grupami nie ma różnic istotnych statystycznie ($p > 0,05$) zarówno w przypadku klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech, jak i klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech (Tabela 1 oraz Tabela 2).

Tabela 1

Średni poziom znaczenia uwarunkowania o charakterze ekonomicznym dla oceny atrakcyjności oferty sektora FinTech wśród klientów indywidualnych sektora bankowego, dotychczas niekorzystających z oferty sektora FinTech w zależności od płci

Płeć	N	Średnia	Odch. stand.	Błąd stand.	95% przedział ufności dla średniej		Min.	Maks.
					Dolna g.	Górna g.		
Kobieta	63	5,2032	0,81794	,10305	4,9972	5,4092	3,00	6,60
Mężczyzna	57	5,2386	0,71956	,09531	5,0477	5,4295	3,00	6,60
Ogółem	120	5,2200	0,76976	,07027	5,0809	5,3591	3,00	6,60

Źródło: Opracowanie własne.

Tabela 2

Średni poziom znaczenia uwarunkowania o charakterze ekonomicznym dla oceny atrakcyjności oferty sektora FinTech wśród klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech w zależności od płci

Płeć	N	Średnia	Odch. stand.	Błąd stand.	95% przedział ufności dla średniej		Min.	Maks.
					Dolna g.	Górna g.		
Kobieta	66	4,8909	0,81538	,10037	4,6905	5,0914	2,60	6,60
Mężczyzna	54	4,8185	0,83803	,11404	4,5898	5,0473	2,00	7,00
Ogółem	120	4,8583	0,82295	,07512	4,7096	5,0071	2,00	7,00

Źródło: Opracowanie własne.

Podsumowanie

Proces podejmowania decyzji, jakkolwiek towarzyszy jednostce na każdym etapie życia, może charakteryzować się różnym przebiegiem ze względu m.in. na poziom istotności dokonywanych wyborów, ich częstotliwość oraz stopień złożoności. Proces decyzyjny determinowany jest wieloma czynnikami (zarówno zewnętrznymi, do których należą faktory demograficzne, ekonomiczne, społeczno-kulturowe oraz marketingowe, jak i wewnętrznymi, o charakterze psychologicznym), które, co szczególnie istotne, mogą na siebie wzajemnie oddziaływać.

Zgodnie z oceną ekspercką (wywiady pogłębione przeprowadzone z ekspertami, będącymi przedstawicielami środowiska naukowego zajmującymi się zawodowo badaniem sposobu funkcjonowania przedsiębiorstw FinTech oraz właścicielami i współwłaścicielami podmiotów gospodarczych należących do sektora FinTech), w procesie oceny atrakcyjności oferty sektora FinTech kluczową rolę odgrywają uwarunkowania o charakterze ekonomicznym. Tym samym, z perspektywy atrakcyjności oferty, a w konsekwencji w kontekście wyboru tradycyjnej instytucji finansowej (reprezentowanej przez bank) lub nietradycyjnej instytucji finansowej (reprezentowanej przez podmiot należący do sektora FinTech) istotne znaczenie mogą mieć czynniki, do których należą poziom dochodów, wydatków, oszczędności, a także zdolność kredytowa jednostki, czy stopień dywersyfikacji aktywów.

Odwołując się do wyników przeprowadzonego badania, należy zauważyć, iż klienci indywidualni sektora bankowego, dotychczas niekorzystający z oferty sektora FinTech znacznie częściej zgadzają się z czterema stwierdzeniami (w porównaniu do klientów indywidualnych sektora bankowego, mających doświadczenie w korzystaniu z oferty sektora FinTech), tj. im wyższy poziom miesięcznych wydatków klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech, im wyższy poziom zdolności kredytowej, tym wyższa ocena atrakcyjności oferty sektora FinTech, im wyższy poziom dochodów klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech oraz im wyższy poziom oszczędności klienta banku, tym wyższa ocena atrakcyjności oferty sektora FinTech.

W procesie pozyskiwania klientów, dla których kluczowym buforem bezpieczeństwa pozostaje poziom bieżących dochodów i zgromadzonych oszczędności, podmioty z sektora FinTech powinny skoncentrować działania marketingowe na przejrzystości struktur opłat, eksponowaniu certyfikatów bezpieczeństwa oraz gwarancji depozytowych, co pozwala skutecznie redukować postrzegane ryzyko finansowe. Z kolei w odniesieniu do segmentu charakteryzującego się wyższą zdolnością kredytową i większym wolumenem wydatków – który wykazuje najwyższy poziom akceptacji dla innowacji finansowych – wskazane jest wdrażanie zautomatyzowanych narzędzi oceny ryzyka opartych na analizie strumieni pieniężnych w czasie rzeczywistym oraz rozwój elastycznych produktów typu *Buy Now, Pay*

Later (BNPL) skrojonych pod indywidualny profil klienta. Ponadto, z uwagi na silną korelację między wysokim poziomem oszczędności a popytem na alternatywne formy pomnażania oszczędności, oferty podmiotów FinTech powinny zostać rozbudowane o zaawansowane mechanizmy automatycznego doradztwa inwestycyjnego (ang. *robo-advisory*), narzędzia mikroinwestycji oraz niskomarżowe platformy wielowalutowe.

W obliczu rosnącej skłonności zamożniejszych i bardziej aktywnych klientów do testowania alternatywnych rozwiązań rynkowych, banki komercyjne muszą wdrożyć skuteczne działania retencyjne, integrując kluczowe funkcjonalności sektora FinTech – takie jak płatności P2P, zaawansowane systemy zarządzania finansami osobistymi (PFM) czy natychmiastowe transakcje walutowe – bezpośrednio w ramach własnych aplikacji mobilnych. Ochrona najbardziej dochodowej bazy klientów wymaga również odpowiedzi na wyraźnie widoczną orientację konsumentów na optymalizację kosztową i płynnościową. W tym celu tradycyjne instytucje finansowe powinny implementować elastyczne programy lojalnościowe, systemy cashback oraz dynamiczne mechanizmy zwolnień z opłat operacyjnych uzależnione od wolumenu generowanych obrotów, co pozwoli na skuteczną neutralizację przewag konkurencyjnych podmiotów technologicznych.

Rezultatem analiz przeprowadzonych w niniejszym artykule jest pozytywna weryfikacja hipotezy badawczej, w myśl której średni poziom znaczenia uwarunkowań o charakterze ekonomicznym dla oceny atrakcyjności oferty sektora FinTech nie różni się w sposób istotny statystycznie dla klientów indywidualnych sektora bankowego i klientów indywidualnych sektora bankowego oraz sektora FinTech.

Pomimo że przeprowadzone badania empiryczne koncentrowały się na perspektywie polskiego rynku finansowego, sformułowane wnioski posiadają walor uniwersalny i wpisują się w konkluzje płynące z międzynarodowych badań porównawczych nad relacjami banków i sektorów technologii finansowych. Uzyskane wyniki potwierdzają, że ekonomiczne determinanty decyzji konsumenckich odgrywają spójną rolę niezależnie od geograficznego obszaru analizy. Głównym ograniczeniem badania pozostaje jego zasięg terytorialny, co wyznacza zarazem pożądany kierunek przyszłych prac badawczych, którymi powinny być międzynarodowe analizy porównawcze uwzględniające specyfikę systemów bankowych i poziom rozwoju FinTech w różnych krajach, w szczególności regionu Europy Środkowo-Wschodniej.

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Cezary Bolek https://orcid.org/0000-0002-4509-8262
dr, Katedra Informatyki, Wydział Zarządzania, Uniwersytet Łódzki, e-mail: cezary.bolek@uni.lodz.pl

Monika Bolek https://orcid.org/0000-0001-9376-1105
dr hab., prof UŁ, Katedra Finansów Korporacji, Wydział Ekonomiczno-Socjologiczny, Uniwersytet Łódzki, e-mail: monika.bolek@uni.lodz.pl

SPREADY W KURSACH WALUTOWYCH CHF/PLN WYBRANYCH BANKÓW OFERUJĄCYCH KREDYTY HIPOTECZNE W POLSCE

CHF/PLN exchange rates spreads of selected banks offering mortgage loans in Poland

Abstract

The purpose of the article. The aim of the article is to assess the spreads on CHF/PLN exchange rates at selected banks offering mortgage loans in Poland in terms of their level, symmetry, and significant differences between the surveyed banks.

Methodology. The analysis of spreads for CHF/PLN exchange rates was conducted in the Python environment using tools for examining Reference Rate Deviation from Midpoint Spread Coefficient and for the preliminary assessment of differences between spreads offered by the selected banks.

Results of the research. It was found that the spread policies in banks were subject to changes and that differences existed between the surveyed entities in terms of setting bid and ask rates, and consequently, the currency spreads differences.

Limitations: The limitations of the presented article are related to the research sample, which includes rates set by 6 selected banks offering mortgage loans on the Polish market. This limitation stems from a lack of access to the remaining data. Moreover, the assessment of spread differences is only a preliminary judgment; further tests with panel data and fixed effects analysis are necessary for final conclusions.

Keywords: CHF/PLN spread, Reference Rate Deviation from Midpoint Spread Coefficient, banks
JEL Class: D53, F21, F31

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Wstęp

Niniejszy artykuł jest poświęcony analizie różnicy kursów sprzedaży i kupna franka szwajcarskiego (CHF/PLN) w PLN oferowanych przez wybrane banki w Polsce w latach 2001–2025. Spready na rynku walutowym odgrywają kluczową rolę, wywierając istotny wpływ zarówno na sektor bankowy i kredytobiorców, jak i na ogólną stabilność finansową (Mielus, 2017). Istota spreadu walutowego, definiowanego m.in. jako różnica między kursem sprzedaży a kursem kupna danej pary walutowej, wykracza poza techniczną definicję marży transakcyjnej, stanowi bowiem odzwierciedlenie kosztów, ryzyka oraz strategii cenowej instytucji finansowych, takich jak banki czy kantory walutowe.

W literaturze przedmiotu za czynnik kluczowy kształtujący poziom spreadów uznaje się zmienność kursów wymiany. Badania empiryczne potwierdzają, że spread walutowy może być dodatnio skorelowany z ryzykiem (Bollerslev i Melvin, 1994), a wyższa zmienność prowadzi wprost do jego rozszerzenia, gdyż podmioty kwotujące ceny walut zabezpieczają się przed gwałtownymi zmianami na rynku. Istotnym elementem modeli teoretycznych wyjaśniających to zjawisko jest również asymetria informacji, która może prowadzić do poszerzenia spreadów, szczególnie na rynkach o mniejszej płynności. W prowadzonych badaniach zidentyfikowano również szereg innych, istotnych czynników wpływających na spready. Wyższe koszty operacyjne lub niższa jakość zarządzania banku mogą prowadzić do wyższych marż, a na ich wzrost wpływa także kumulacja ryzyk: kredytowego, płynności, stopy procentowej oraz ryzyka niewykonania zobowiązania. Na wysokość marż oddziałują również interwencje banków centralnych, które mogą (w zależności od charakteru interwencji) zwiększać lub zmniejszać niepewność rynkową. Istotnymi czynnikami są także siła i koncentracja rynkowa banków komercyjnych (bądź instytucji finansowych), które wpływają na stopień konkurencyjności sektora, a tym samym na zdolność podmiotów do kształtowania poziomu marż i spreadów. Jako istotne determinanty spreadu wyróżnia się także globalizację oraz kryzysy bankowe, które mogą znacząco determinować decyzje banków w obszarze różnic między kursami sprzedaży i kupna.

Spready walutowe stanowią istotne źródło dochodu dla sektora bankowego (Jeżewski, 2010), a gdy banki działają jako dealerzy (market makerzy), marża kupna-sprzedaży jest bezpośrednim odzwierciedleniem ich zysku z transakcji (Offiong i in., 2016). Znaczenie tego źródła przychodów rośnie w okresach spowolnienia akcji kredytowej, gdy ograniczone są tradycyjne dochody, np. odsetkowe. Zależność tę zaobserwowano z dużą wyrazistością w Polsce podczas kryzysu finansowego w latach 2008–2009. W obliczu pogorszenia kondycji portfela kredytowego i utraty płynności na międzynarodowym rynku finansowania, banki ograniczyły akcję kredytową, jednocześnie dążąc do poprawy wyników finansowych poprzez podnoszenie spreadów walutowych. Mechanizm ten ma bezpośrednie przełożenie na sytuację kredytobiorców, szczególnie w kontekście kredytów hipotecznych indeksowanych lub denominowanych do wa-

luty obcej, np. franka szwajcarskiego. W konstrukcji tych umów kwota kredytu jest wypłacana (przeliczana) po kursie kupna waluty, natomiast jego spłata odbywa się po kursie sprzedaży ustalanym przez bank. Oznacza to, że kredytobiorca jest zobowiązany do spłaty kapitału powiększonego o pełny koszt spreadu walutowego. Wzrost tej marży przekłada się zatem wprost na wyższą ratę kredytową, zwiększając obciążenie gospodarstwa domowego.

Kwestia spreadów stała się w Polsce przedmiotem licznych analiz oraz rozważań w orzecznictwie sądowym, co stanowi główną motywację do przygotowania niniejszego artykułu. Celem badania jest analiza i ocena spreadów w kursach walutowych CHF/PLN w PLN wybranych banków oferujących kredyty hipoteczne w Polsce pod względem wysokości oraz różnic między analizowanymi bankami. Teza badawcza zakłada ograniczoną heterogeniczność polityk cenowych banków, skutkującą zbliżonym poziomem spreadów. Do badania wytypowano sześć największych banków w Polsce (mBank SA, ING SA, BPH SA, Pekao SA, PKO BP SA, Santander SA), które po 2000 r. udzielały i rozliczały najwięcej kredytów walutowych denominowanych lub indeksowanych do CHF. Badanie obejmuje okres 2001–2025, przy czym ze względu na zróżnicowaną dostępność danych archiwalnych zakres czasowy obserwacji nie jest jednakowy dla wszystkich analizowanych banków i rozpoczyna się, w zależności od instytucji, w latach 2001–2007, natomiast kończy w marcu 2025 r. Do oceny heterogeniczności polityk cenowych banków wykorzystano zaproponowany przez autorów współczynnik odchylenia kursu referencyjnego od środka spreadu, który pozwala określić, czy marże doliczane do kursów kupna i sprzedaży były symetryczne względem środka spreadu. Dodatkowo zbadano wstępnie, czy spready różniły się między poszczególnymi bankami. Analiza spreadów kursu wymiany CHF/PLN została przeprowadzona w środowisku Python z wykorzystaniem narzędzi do badania zmienności kursów walut oraz oceny spreadów oferowanych przez wybrane banki. Wstępną ocenę różnic między średnimi spreadami w badanych podmiotach przeprowadzono za pomocą testu t dla prób o nierównej liczności, traktując uzyskane rezultaty jako analizę eksploracyjną o charakterze opisowym, ze względu na zróżnicowane horyzonty czasowe danych dla poszczególnych instytucji.

Artykuł obejmuje wstęp, przegląd literatury, część dotyczącą danych i metody badawczej, wyniki badań, dyskusję oraz podsumowanie.

Przegląd literatury

Definicja i podstawowe determinanty wysokości spreadu walutowego

W literaturze przedmiotu spread walutowy definiowany jest jako różnica (bezwzględna lub względna) między ceną sprzedaży a ceną kupna danej pary walutowej. Ponadto w badaniach wyróżnia się specyficzne rodzaje spreadów, które pełnią funkcję barometru nastrojów

rynkowych. Mielus (2012) wskazuje m.in. na spread konwergencyjny (odzwierciedlający zaufanie do stabilności waluty), spread bazowy (wskazujący na ryzyko płynności) oraz spread kredytowy (mierzony za pomocą instrumentów CDS jako ocena wiarygodności emitenta). Rosnące wartości tych spreadów są szczególnie charakterystyczne dla okresów nasilonej niepewności i kryzysów. Rola spreadu jest istotna również w ujęciu teorii finansów – w warunkach zabezpieczonego parytetu stóp procentowych jego wysokość często uniemożliwia przeprowadzenie zyskownego arbitrażu, ponieważ potencjalny zysk zostaje w całości pochłonięty przez koszty transakcyjne (Mielus, 2017).

Spread jest jednym z dwóch fundamentalnych czynników kształtujących kursy walut (Czech, 2016). Podkreśla to jego rolę w dynamicznej analizie rynków i wyjaśnia, dlaczego relacje między zmiennymi na rynku walutowym często przybierają charakter nieliniowy. Badania Jasiniak (2022) potwierdzają, że spread wykazuje zmienność w cyklu dziennym, z wyższymi wartościami notowanymi na początku sesji, co jest bezpośrednio powiązane z podwyższoną niepewnością rynkową. Bollerslev i Melvin (1994) wykazali z kolei istnienie silnej, dodatniej korelacji między bazową niepewnością kursu a wielkością spreadu. Ich analiza dowodzi, że to zwiększona zmienność – rozumiana jako niepewność co do przyszłego kursu – prowadzi do poszerzenia spreadu. W obliczu podwyższonego ryzyka, animatorzy rynku rekompensują sobie niepewność, zwiększając różnicę między ceną sprzedaży a kupna. Spread jest zatem reakcją rynku na zmienność, a nie jej przyczyną. Z kolei Lee (1994) wykazał, że spread z poprzedniego okresu jest statystycznie istotnym czynnikiem objaśniającym zmienność.

Kolejną fundamentalną determinantą wysokości spreadu jest płynność rynku. Adam (2016) podkreśla, że duża różnica między ceną sprzedaży a kupna jest bezpośrednim wskaźnikiem niskiej płynności i wysokich kosztów transakcyjnych. W okresach kryzysowych, gdy awersja do ryzyka rośnie, płynność na rynkach drastycznie spada, co prowadzi do dynamicznego poszerzania się spreadów. Następnym kluczowym czynnikiem w kształtowaniu spreadów jest asymetria informacji. W obliczu zwiększonego ryzyka związanego z handlowaniem z lepiej poinformowanymi uczestnikami, animatorzy rynku poszerzają spready (Bollerslev i Melvin, 1994).

O ile zmienność i płynność stanowią ogólnorynkowe determinanty wysokości spreadu, o tyle w literaturze pojawia się również szereg czynników specyficznych dla sektora bankowego oraz polityki państwa. Dwumfour (2019), analizując marżę odsetkową netto w krajach rozwijających się, wskazał na czynniki silnie skorelowane z polityką cenową banków. Większe banki zazwyczaj pobierają niższe marże, natomiast mniejsza konkurencja (wyższa koncentracja rynku) prowadzi do wyższych marż, co wskazuje na mniejszą efektywność systemu bankowego. W związku z powyższym stymulowanie konkurencji oraz wzrostu banków (np. przez fuzje) powinno prowadzić do obniżenia marż i wspierania wzrostu gospodarczego.

Wpływ na spready mają również interwencje banków centralnych. Ich oddziaływanie jest jednak niejednoznaczne i zależy od charakteru komunikacji. Mirkov i in. (2019), badając interwencje werbalne Szwajcarskiego Banku Narodowego (SNB) w latach 2011–2015, wykazali, że komunikaty o „największej determinacji" obniżały miary niepewności i pozytywnie wpływały na płynność, zmniejszając średnie spready. Z kolei Fatum i in. (2013) na przykładzie Danii stwierdzili, że interwencje kupna słabej waluty zazwyczaj zmniejszają spready, podczas gdy interwencje sprzedaży – poszerzają je.

Wpływ siły rynkowej i koncentracji sektora na wysokość spreadów pozostaje niejednoznaczny – w niektórych regionach większa koncentracja prowadzi do niższych spreadów, podczas gdy w innych do wyższych. Wpływ koncentracji sektora na wysokość spreadów walutowych jest złożonym zagadnieniem, interpretowanym w literaturze ekonomicznej poprzez dwa przeciwstawne mechanizmy. Z jednej strony, zgodnie z paradygmatem Struktura-Zachowanie-Wyniki (SCP)[1] oraz hipotezą siły rynkowej, dominacja niewielkiej liczby instytucji w sektorze może prowadzić do ograniczenia konkurencji, co pozwala bankom na monopolistyczne kształtowanie cen i narzucanie klientom mniej korzystnych, wyższych spreadów. Z drugiej strony, hipoteza efektywnościowej struktury rynku (ESH)[2] sugeruje, że wysoka koncentracja sprzyja osiąganiu korzyści skali oraz optymalizacji kosztów operacyjnych dzięki zaawansowanej technologii, co w sprzyjających warunkach rynkowych pozwala na przenoszenie tych oszczędności na klientów w formie niższych spreadów. Niejednoznaczność tych zależności wynika w dużej mierze ze specyfiki rynku walutowego, gdzie wpływ koncentracji na koszty transakcyjne różni się w zależności od tego, czy rozpatrujemy wysoce płynny rynek hurtowy, na którym skala działania największych dealerów sprzyja obniżaniu spreadów, czy też rynki detaliczne i lokalne, gdzie ograniczony dostęp do alternatyw sprzyja utrzymywaniu wyższych marż (Narodowy Bank Polski, 2014; Urząd Komisji Nadzoru Finansowego, 2016).

W literaturze można również znaleźć badania nad wpływem polityki monetarnej na rynki walutowe. Lubiński (2015) wskazuje, że ekspansywna polityka monetarna w krajach rozwiniętych, prowadząc do obniżenia stóp procentowych, zwiększa spready w porównaniu z rynkami wschodzącymi.

[1] Paradygmat Struktura-Zachowanie-Wyniki (ang. *Structure-Conduct-Performance – SCP*) to klasyczny model analityczny wywodzący się z ekonomii przemysłowej. Został sformułowany w połowie XX w., a jego głównymi pionierami byli Mason (1939) oraz Bain (1956). Model ten służy do wyjaśniania, jak charakterystyka rynku wpływa na decyzje podejmowane przez przedsiębiorstwa, co z kolei przekłada się na wyniki ekonomiczne całego sektora lub gospodarki.

[2] Hipoteza efektywnościowej struktury (ang. *Efficient Structure Hypothesis*, ESH) to koncepcja w ekonomii przemysłowej i finansach, która stanowi alternatywę dla tradycyjnego podejścia opartego na paradygmacie Struktura-Zachowanie-Wyniki (Demsetz, 1973; Peltzman, 1977).

Spready walutowe w kontekście kredytów hipotecznych w Polsce

Szczególnym i istotnym społecznie przypadkiem zastosowania spreadów walutowych jest rynek kredytów hipotecznych denominowanych lub indeksowanych do walut obcych, zwłaszcza franka szwajcarskiego (CHF) w Polsce. W literaturze podkreśla się (Jeżewski, 2010; Kalinowski, 2011), że w tym kontekście spread walutowy przestał być jedynie kosztem transakcyjnym, a stał się istotnym, dodatkowym źródłem dochodu dla banków. Mechanizm ten był strukturalnie niekorzystny dla kredytobiorców w Polsce na początku XXI w., jak wskazują Mielus (2017) oraz Buszko (2010), bank wypłacał kredyt w złotych polskich po niższym kursie kupna waluty, natomiast klient spłacał raty po wyższym kursie sprzedaży, ustalanym często w sposób arbitralny przez bank. Problem eskalował w okresie kryzysu finansowego po 2008 r. W obliczu spowolnienia gospodarczego i ograniczenia tradycyjnej akcji kredytowej, banki w Polsce zaczęły masowo podnosić spready walutowe, aby zrekompensować utracone przychody odsetkowe. Jeżewski (2010) wskazuje, że w niektórych przypadkach podwyżki te przekraczały nawet 200% w stosunku do poprzedniego roku. Praktyka ta, określana jako „ukryty koszt" (Kalinowski, 2011), doprowadziła do znacznego wzrostu realnego obciążenia kredytobiorców i wywołała reakcję regulatorów. W odpowiedzi na te praktyki Komisja Nadzoru Finansowego w 2008 r. wydała Rekomendację S (II), zobowiązując banki do lepszego informowania klientów. Kluczową zmianą legislacyjną była jednak tzw. ustawa antyspreadowa z 2011 r. (Główka, 2009; Buszko, 2010), która dała kredytobiorcom prawo do spłacania kredytu bezpośrednio w walucie obcej, co pozwoliło im ominąć marżę bankową i kupować walutę po bardziej konkurencyjnym kursie, np. w kantorach internetowych. Jak zauważa Główka (2009), mimo że ustawa była krokiem w dobrym kierunku, jej realna efektywność zależała od rozwoju pozabankowego rynku wymiany walut i ewentualnych dodatkowych kosztów transakcyjnych.

Niezależnie od interwencji regulacyjnych, kluczowym problemem stała się prawna strona umów. Kobylski (2019) przeprowadził analizę abuzywnego charakteru klauzul umownych, które pozwalały bankom jednostronnie ustalać kursy wymiany walut w tabelach bankowych, rażąco naruszając interesy konsumentów i zasady współżycia społecznego.

Dane i metoda badawcza

Dane wykorzystane do badania stanowią dzienne kursy kupna i sprzedaży pochodzące z archiwów kursów udostępnianych na portalach internetowych wybranych banków działających w Polsce: mBank SA, ING SA, BPH SA, Pekao SA, PKO BP SA i Santander SA, na których publikowały one kursy wykorzystywane m.in. do rozliczeń kredytów (mBank SA, n.d.; ING Bank Śląski SA, n.d.; Bank BPH SA, n.d.; Bank Pekao SA, n.d.; PKO Bank Polski SA, n.d.; Santander Consumer Bank SA, n.d.). W przypadku gdy danego dnia bank publikował więcej

niż jeden kurs, wybierano ten ostatni. Zakres danych obejmuje następujące okresy dla poszczególnych banków:

- mBank SA: 2001-01-02 – 2025-03-12,
- ING SA: 2006-01-02 – 2025-03-06,
- Pekao SA: 2005-01-17 – 2025-03-06,
- PKO BP SA: 2005-01-03 – 2025-03-06,
- BPH SA: 2004-07-01 – 2025-03-07,
- Santander SA: 2007-11-06 – 2025-03-06.

Wybór analizowanych banków wynikał również z dostępności ich archiwalnych danych kursowych. W przypadku pozostałych banków możliwość automatycznego pozyskania porównywalnych danych była ograniczona.

Kurs Forex (Stooq, n.d.), określany również jako kurs międzybankowy lub referencyjny, jest traktowany w badaniu jako zewnętrzny, niezależny punkt odniesienia (kurs rynkowy), wokół którego oscylują stawki oferowane przez poszczególne banki. W badaniu kurs Forex posłużył jako baza do analizy polityki cenowej banków, które do kursu rynkowego doliczają własną marżę (tworząc kursy kupna i sprzedaży oraz wynikający z nich spread walutowy). Serie danych wykorzystanych w analizie pomijają dni wolne od pracy.

Spread bezwzględny (1), czyli prosta różnica między ceną sprzedaży a ceną kupna waluty, wyraża w badaniu koszt transakcji w złotych polskich. Jednakże, aby efektywnie porównywać koszty między walutami o różnych cenach, stosuje się także spread względny (2), który przedstawia tę różnicę jako procent ceny odniesienia. Oba wskaźniki są kluczowe dla klientów oceniających atrakcyjność ofert banków, przy czym spread względny jest szczególnie przydatny do porównywania kosztów transakcyjnych na różnorodnych rynkach.

W badaniu przyjęto następujące oznaczenia i symbole zmiennych:

- P_{sell} – kurs sprzedaży waluty oferowany przez bank,
- P_{buy} – kurs kupna waluty oferowany przez bank,
- P_f – rynkowy kurs referencyjny (Forex), stanowiący punkt odniesienia,
- P_{max} oraz P_{min} – odpowiednio maksymalna i minimalna cena (lub skrajne wartości kursu) w badanym okresie,
- r_a – współczynnik odchylenia kursu referencyjnego od środka spreadu.

Spread bezwzględny (S_{bezW}) zdefiniowano jako różnicę pomiędzy kursem sprzedaży a kursem kupna waluty oferowanym przez bank:

$$S_{bezW} = P_{sell} - P_{buy} \tag{1}$$

Konwencja znaków zakłada wartości dodatnie, ponieważ kurs sprzedaży banku (P_{sell}) jest zawsze wyższy od kursu kupna (P_{buy}).

Spread względny (S_{wzg}) wyrażono w procentach jako relację różnicy kursów do ich średniej arytmetycznej (midpointu), co bezpośrednio odpowiada zastosowanej implementacji w środowisku Python:

$$S_{wzg} = \frac{2 \times (P_{sell} - P_{buy})}{P_{sell} + P_{buy}} \tag{2}$$

Tak zdefiniowany wskaźnik pozwala na odzwierciedlenie relatywnego obciążenia transakcyjnego stosowanego przez poszczególne instytucje finansowe, uwzględniając skalę cenową badanej waluty.

W analizie wykorzystano codzienne notowania kursów walutowych dla pary CHF/PLN obejmujące okres od 2001 r. do 2025 r. Podstawowym źródłem historycznych danych rynkowych (kursów referencyjnych Forex) były zasoby platformy Stooq. Badaniem objęto instrument o symbolu CHF/PLN dla danych rynkowych oraz analogiczne symbole identyfikujące kursy oferowane przez poszczególne instytucje. Analiza bazuje na notowaniach dziennych (dane typu *End of Day* – EOD), rejestrowanych według stałej strefy czasowej właściwej dla notowań rynkowych Europy Środkowej (CET/CEST).

Ze względu na zróżnicowane kalendarze publikacji notowań oraz dni wolne od pracy (święta krajowe i giełdowe), w środowisku Python wdrożono rygorystyczną procedurę dopasowania kalendarzowego. Łączenie zewnętrznych szeregów rynkowych z danymi bankowymi zrealizowano za pomocą operacji *inner join* po unikalnych datach kalendarzowych.

W niniejszej analizie spreadów w kursie CHF/PLN w PLN zaproponowano współczynnik odchylenia kursu referencyjnego od środka spreadu (r_a), który pozwala ocenić, czy marże doliczane do kursów kupna i do kursów sprzedaży były takie same. Współczynnik odchylenia kursu referencyjnego od środka spreadu można zaprezentować następująco:

$$r_a = \frac{2P_f - P_{sell} - P_{buy}}{P_{sell} - P_{buy}} \tag{3}$$

Współczynnik odchylenia kursu referencyjnego od środka spreadu r_a dla ceny waluty P mierzy odległość kursu Forex od midpointu przeskalowaną przez szerokość spreadu P_f (kurs Forex) w odniesieniu do jej ekstremalnych wartości P_{max} i P_{min} w danym okresie. Wartość współczynnika odchylenia kursu referencyjnego od środka spreadu (r_a) należy interpretować w sposób następujący:

- $r_a = 0$ oznacza, że kurs referencyjny P_f znajduje się dokładnie w połowie odległości między ceną minimalną (P_{min}) a maksymalną (P_{max}) w danym okresie (tj. idealnie pokrywa się z midpointem spreadu);
- $r_a > 0$ wskazuje, że kurs referencyjny P_f znajduje się bliżej ceny minimalnej (P_{min}) niż maksymalnej (P_{max}) w relacji do całkowitej rozpiętości cenowej, co oznacza, że środek spreadu przesunięty jest powyżej kursu rynkowego Forex;
- $r_a < 0$ wskazuje, że kurs referencyjny P_f znajduje się bliżej ceny maksymalnej (P_{max}) niż minimalnej (P_{min}) w relacji do całkowitej rozpiętości cenowej, co oznacza, że środek spreadu przesunięty jest poniżej kursu rynkowego Forex.

Wprowadzenie kursu Forex jako wartości referencyjnej (P_f) wynika z faktu, że stanowi on niezależny, obiektywny punkt odniesienia (kurs międzybankowy), względem którego banki komercyjne kształtują własne kursy kupna i sprzedaży. Przyjęcie kursu Forex pozwala zmierzyć, czy polityka cenowa w odniesieniu do marż w kursach kupna i sprzedaży była zbliżona względem oficjalnych notowań rynkowych, czy też marże wykazywały odchylenie w kierunku kursu kupna lub sprzedaży.

Wrażliwość analizy położenia kursu referencyjnego zależy bezpośrednio od przyjęcia konkretnego punktu odniesienia (P_f), ponieważ miara ta bada pozycję tego punktu względem skrajnych wartości minimalnych (P_{min}) i maksymalnych (P_{max}) w danym okresie. Zmiana definicji punktu odniesienia wpływa zatem na interpretację wskaźnika – w zależności od wyboru punktu odniesienia, wynik może pokazywać odchylenia. Wybór kursu Forex jako punktu odniesienia we współczynniku rzutuje na wyniki i interpretację badania, a wrażliwość uzyskanych rezultatów na zmianę tego punktu odniesienia wiąże się z kilkoma kluczowymi aspektami:

- przyjęcie kursu Forex (międzybankowego) – użycie kursu Forex jako wartości referencyjnej pozwala na zmierzenie odchylenia marż komercyjnych bezpośrednio względem obiektywnego, rynkowego kosztu pieniądza. Dzięki temu współczynnik odchylenia kursu referencyjnego od środka spreadu pokazuje, czy banki podobnie obciążały klientów ryzykiem w górę i w dół od cen rynkowych;
- potencjalne przyjęcie średniej ceny bankowej jako P_f – gdyby zamiast kursu Forex za punkt odniesienia przyjęto średnią arytmetyczną z kursów kupna i sprzedaży danego banku, wyniki ukazywałyby odchylenia wewnętrzne polityki konkretnej instytucji, a nie jej relację do rynku zewnętrznego. W efekcie większość wskaźników mogłaby wskazywać na sztuczne wycentrowanie wokół własnej bazy kosztowej, zacierając różnice w tym, jak mocno dany kurs odbiega od stawek międzybankowych;
- potencjalne przyjęcie ceny z poprzedniego okresu jako P_f – zastosowanie opóźnionej ceny jako punktu odniesienia zwiększyłoby wrażliwość współczynnika na dynamikę zmian

w czasie (krótkoterminowy trend), silniej akcentując momenty, w których banki gwałtownie aktualizowały tabele kursowe (np. w okresach kryzysowych w 2008 r. lub 2020 r.). Mogłoby to prowadzić do częstszego rejestrowania asymetrii kierunkowych (lewostronnej lub prawostronnej).

W celu weryfikacji istotności różnic między średnimi spreadami – zarówno względnymi, jak i bezwzględnymi – zastosowano test t-Studenta dla prób niezależnych, co miało charakter eksploratacyjny. Pozwoliło to na wstępne określenie dysproporcji w wysokości marż pomiędzy badanymi instytucjami. Ze względu na dużą liczność próby, obejmującą od około 4000 do ponad 6000 obserwacji dla każdego banku, test t-Studenta wykazuje dużą odporność na odchylenia od rozkładu normalnego, umożliwiając uzyskanie wartości p-value jako podstawy weryfikacji hipotez przy poziomie istotności $\alpha < 0{,}05$. Należy jednak podkreślić, że ze względu na naturę danych finansowych, charakteryzujących się autokorelacją, heteroskedastycznością oraz występowaniem strukturalnych punktów zwrotnych (np. w okresach kryzysowych), wyniki testów parametrycznych należy traktować jako narzędzie eksploracyjne, wskazujące na ogólne tendencje w zróżnicowaniu marż. Istotnym ograniczeniem zastosowanego podejścia, wynikającym z odmiennych horyzontów czasowych danych dla poszczególnych banków, jest nałożenie się efektów instytucjonalnych na zmienne efekty czasowe. W dalszych, pogłębionych badaniach kwestie te zostaną rozwinięte w postaci odpowiedniego modelowania uwzględniającego efekty stałe, związane z okresami oraz poszczególnymi obiektami w analizowanej próbie badawczej.

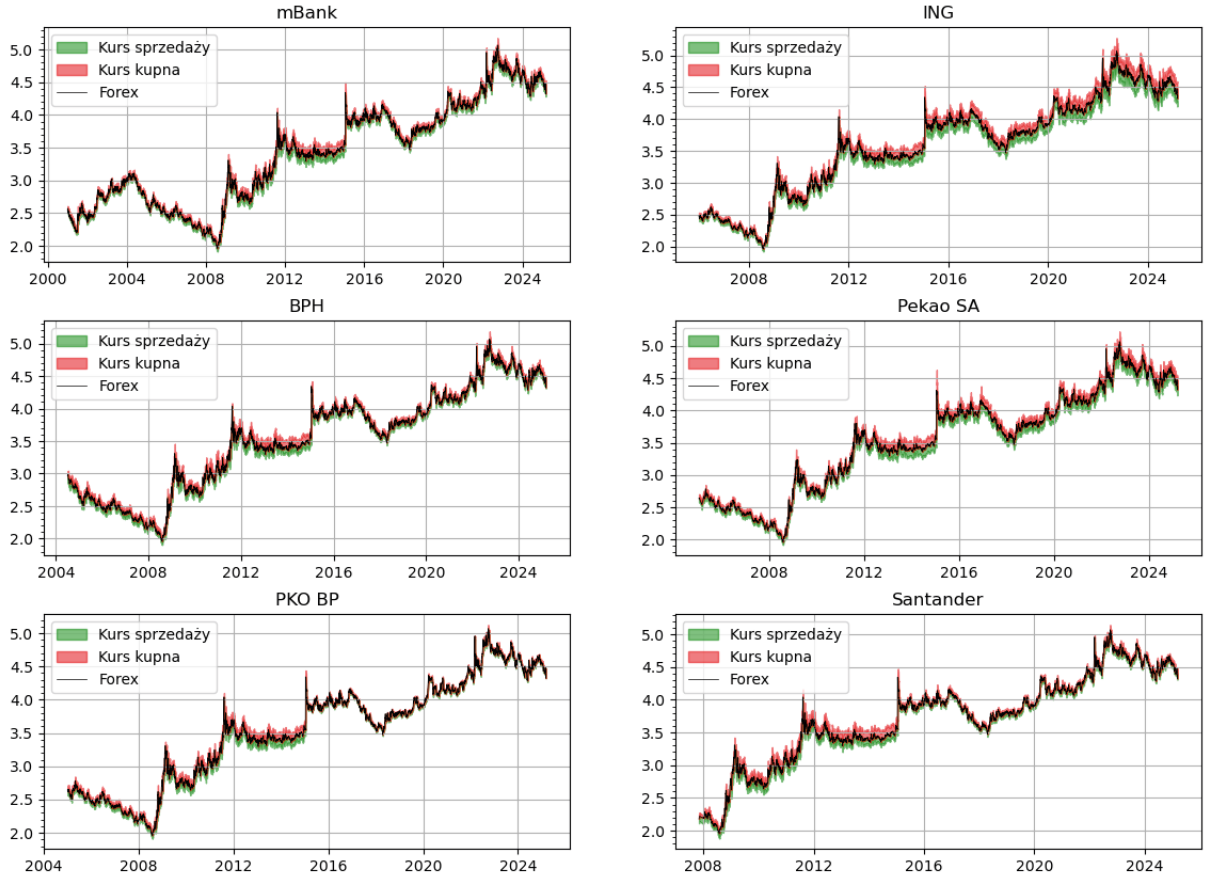
Analizę przeprowadzono w środowisku programistycznym Python, wykorzystując szereg bibliotek i metod statystycznych w celu zbadania zmienności kursów walut oraz oceny wielkości i struktury marż stosowanych przez banki. Dane zbierane z portali internetowych banków pozyskano w oparciu o biblioteki *requests* i *BeautifulSoup*. Analizę statystyczną przeprowadzono w oparciu o bibliotekę *SciPy* wraz modułami *stats* i *optimize* oraz bibliotekę *statsmodels*. Do przetwarzania danych wykorzystano pakiety *NumPy* oraz *Pandas*, wizualizację zaś zrealizowano z wykorzystaniem biblioteki *Seaborn*. W Załączniku 1 przedstawiono fragment kodu analizy danych.

Wyniki badań

W niniejszym punkcie zaprezentowano wyniki badań dotyczące spreadów walutowych w wybranych bankach w Polsce. Na Wykresie 1 przedstawiono poziomy kursów kupna i sprzedaży CHF/PLN w PLN w analizowanych instytucjach.

Wykres 1

Kursy kupna i sprzedaży w analizowanych bankach oraz kurs Forex CHF/PLN w latach 2001–2025 (PLN)



Legenda: kolor zielony (kurs sprzedaży) – cena, po której bank sprzedaje walutę klientowi; kolor czerwony (kurs kupna) – cena, po której bank kupuje walutę od klienta; kolor czarny (kurs Forex) – kurs międzybankowy (referencyjny).

Źródło: badania własne.

Na Wykresie 1 przedstawiono porównanie poziomów kursów walutowych CHF/PLN w PLN, oferowanych przez wybrane banki działające w Polsce w odniesieniu do kursu Forex. Widoczna jest zbieżność wszystkich rodzajów analizowanych kursów pod względem ich wahań, a różnice związane są z wysokością marż.

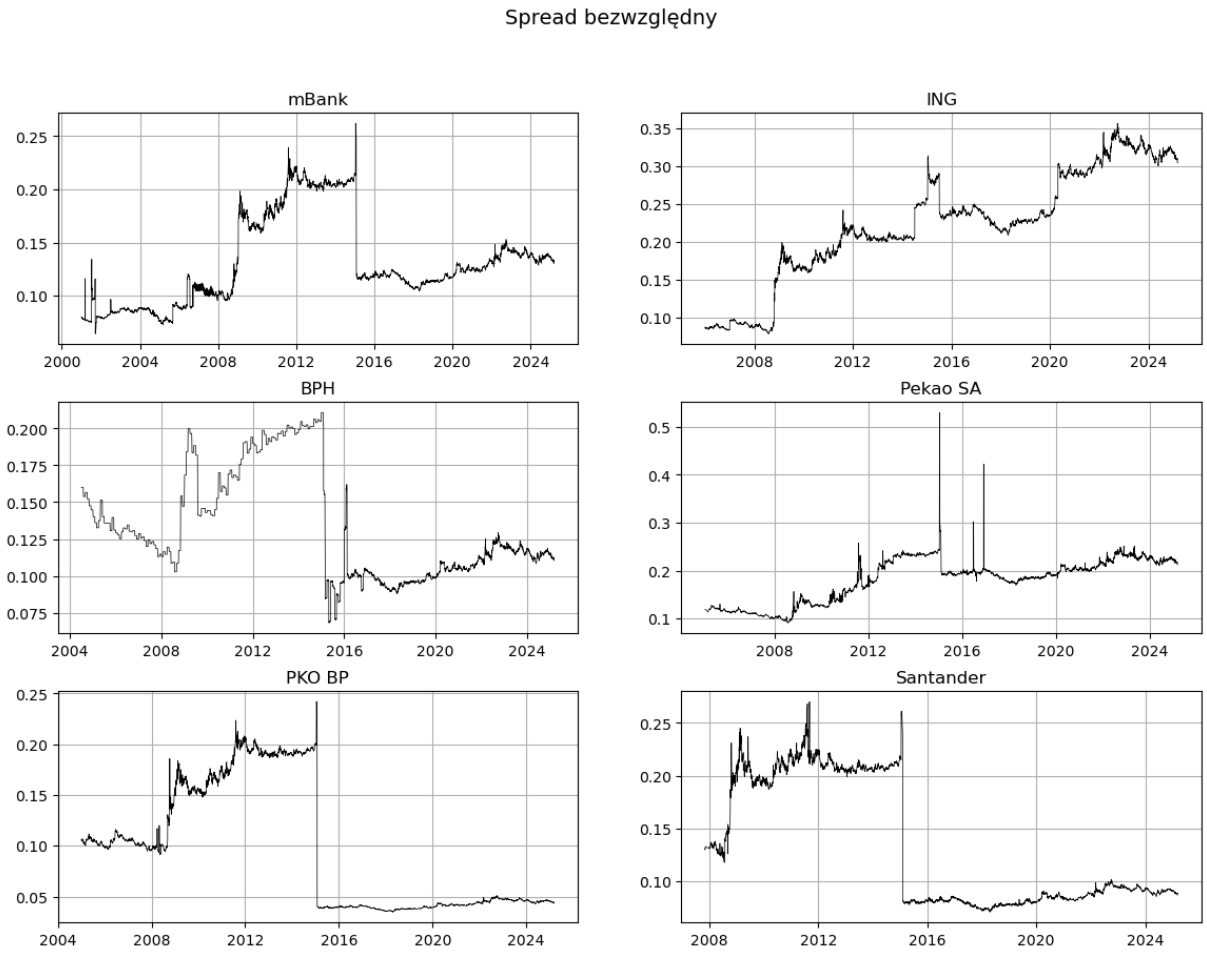
Analiza spreadów walutowych w kursie CHF/PLN w PLN w wybranych bankach działających w Polsce ujawnia kilka obserwacji. Po pierwsze, wszystkie instytucje finansowe utrzymują różnicę między kursem sprzedaży a kursem kupna, czyli spread. Chociaż spread ten generalnie charakteryzuje się względną stabilnością, w okresach rynkowej niepewności, takich jak kryzysy finansowe (np. 2008 r.), nagłe wydarzenia (np. pandemia w 2020 r.) czy konflikty geopolityczne (np. wojna w Ukrainie od 2022 r.), można zaobserwować jego

czasowe poszerzenie. Kursy oferowane przez banki oscylują wokół rynkowego kursu Forex, jednak z wbudowaną marżą, co potwierdza ich model biznesowy oparty na różnicy kursowej. Pomimo różnic w wartościach kursów, ich dynamika w czasie jest spójna i wykazuje związek z ogólnymi trendami rynkowymi, w tym długoterminowym osłabieniem złotego względem franka szwajcarskiego oraz gwałtownymi skokami w okresach kryzysowych, co odzwierciedla wpływ globalnych wydarzeń na politykę kursową wszystkich badanych banków.

Na Wykresie 2 przedstawiono spready bezwzględne w kursie CHF/PLN w PLN w analizowanych bankach.

Wykres 2

Spready bezwzględne w kursie CHF/PLN w analizowanych bankach w okresie 2001–2025 (PLN)



Źródło: badania własne.

Szczegółowa analiza bezwzględnych spreadów walutowych w poszczególnych bankach ujawnia różnice w ich polityce kursowej na przestrzeni lat. W mBanku po 2010 r. zaobserwowano wzrost spreadu do około 0,20 zł, który następnie ukształtował się od 2015 r. na poziomie 0,13–0,15 zł. ING wyróżniał się najwyższym spreadem wśród analizowanych instytucji, osiągając nawet 0,35 zł po 2020 r., z tendencją wzrostową widoczną już od 2011 r. BPH charakteryzował się największymi wahaniami spreadu w latach 2008–2016, po czym nastąpił znaczący spadek i stabilizacja na poziomie 0,10–0,12 zł po 2016 r. Pekao odnotował bardzo wysokie i gwałtowne skoki spreadu w latach 2012-2016, z lokalnymi ekstremami przekraczającymi nawet 0,4 zł, a po 2016 r., mimo stabilizacji, spread utrzymywał się na relatywnie wysokim poziomie 0,20–0,22 zł. PKO BP do 2015 r. utrzymywał spread w przedziale 0,15–0,20 zł, po czym nastąpił nagły spadek do około 0,05 zł i stabilizacja, co oznaczało jedną z najkorzystniejszych ofert pod względem spreadu po 2016 r. Podobną zmianę odnotowano w Santander. Przed 2016 r. spread sięgał 0,25 zł, po 2016 r. został obniżony do około 0,10 zł i utrzymywano stabilność na tym korzystnym dla klienta poziomie do końca okresu badawczego. W 2016 r. wiele banków radykalnie obniżyło spread – co mogło być spowodowane regulacjami KNF, wzrostem konkurencji na rynku lub innymi czynnikami systemowymi. Zestawienie wysokości spreadu bezwzględnego w badanych instytucjach w okresie przed 2016 r. oraz od 2016 r. przedstawiono w Tabeli 1.

Tabela 1

Zestawienie średnich wysokości spreadów bezwzględnych w analizowanych bankach (PLN)

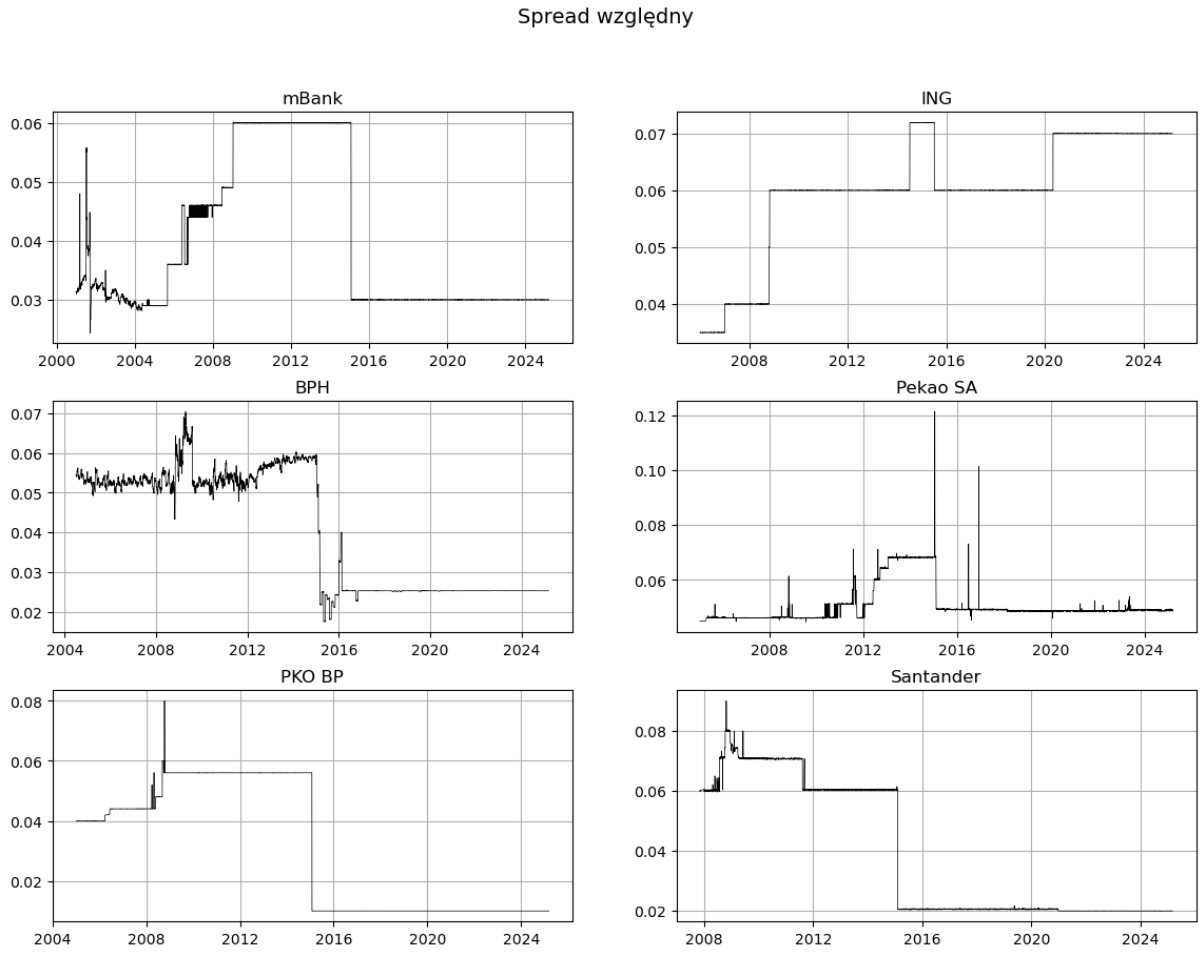
Bank	Przed 2016	Od 2016
mBank	ok.0,18–0,25	ok.0,13–0,15
ING	ok.0,20–0,30	ok.0,30–0,35
BPH	ok.0,20	ok.0,10–0,12
Pekao	ok.0,20–0,40+	ok.0,20–0,22
PKO BP	ok.0,15–0,20	ok.0,04–0,05
Santander	ok.0,20–0,25	ok.0,08–0,10

Źródło: badania własne.

Na Wykresie 3 przedstawiono spready względne dla CHF/PLN w analizowanych bankach.

Wykres 3

Spready względne dla CHF/PLN w analizowanych bankach w okresie 2001–2025 (w proc.)



Źródło: badania własne.

Analiza względnych spreadów walutowych w poszczególnych bankach zaprezentowana na Wykresie 3 ujawnia różnice i zmiany w ich polityce kursowej na przestrzeni lat. Spread względny mBanku wzrósł z początkowego poziomu 3–4% do 5–6% w latach 2008–2015, by od 2015 r. gwałtownie spaść do poziomu około 3%. ING charakteryzował się stopniowym wzrostem spreadu z 3,5% w 2007 r. do 6%, a następnie nawet 7% od 2016 r., co czyni go bankiem z najmniej korzystną ofertą pod względem względnego spreadu. BPH utrzymywał wysoki i stabilny spread na poziomie około 6% do 2016 r., po czym nastąpił nagły spadek do 2–3%, co znacząco poprawiło warunki dla klienta. Pekao wyróżniał się dużą zmiennością spreadu, z licz-

nymi ekstremami sięgającymi nawet 12%, a średni spread utrzymywał się w przedziale 5–6%. PKO BP do 2015 r. oferował wysoki spread na poziomie 6–7%, po czym nastąpił gwałtowny spadek do około 1,5%, co uczyniło go bankiem z najniższym względnym spreadem i najbardziej korzystną ofertą po 2016 r. Santander, podobnie jak PKO BP, obniżył swój wysoki spread z poziomu 7-8% do około 2,5% po 2015 r., stając się również bardzo korzystną opcją dla klientów. Zestawienie spreadów względnych przed 2016 r. i od 2016 r. przedstawiono w Tabeli 2.

Tabela 2

Spread względny CHF/PLN w analizowanych bankach (w proc.)

Bank	Przed 2016	Od 2016
mBank	3,5–6,0	ok.3,0
ING	3,5–6,0	ok.7,0
BPH	ok. 6,0	2,5 –3,0
Pekao	4,0–10,0	ok.5,0 –6,0
PKO BP	ok.6,0 –7,0	ok.1,5
Santander	ok.7,0–8,0	ok.2,5

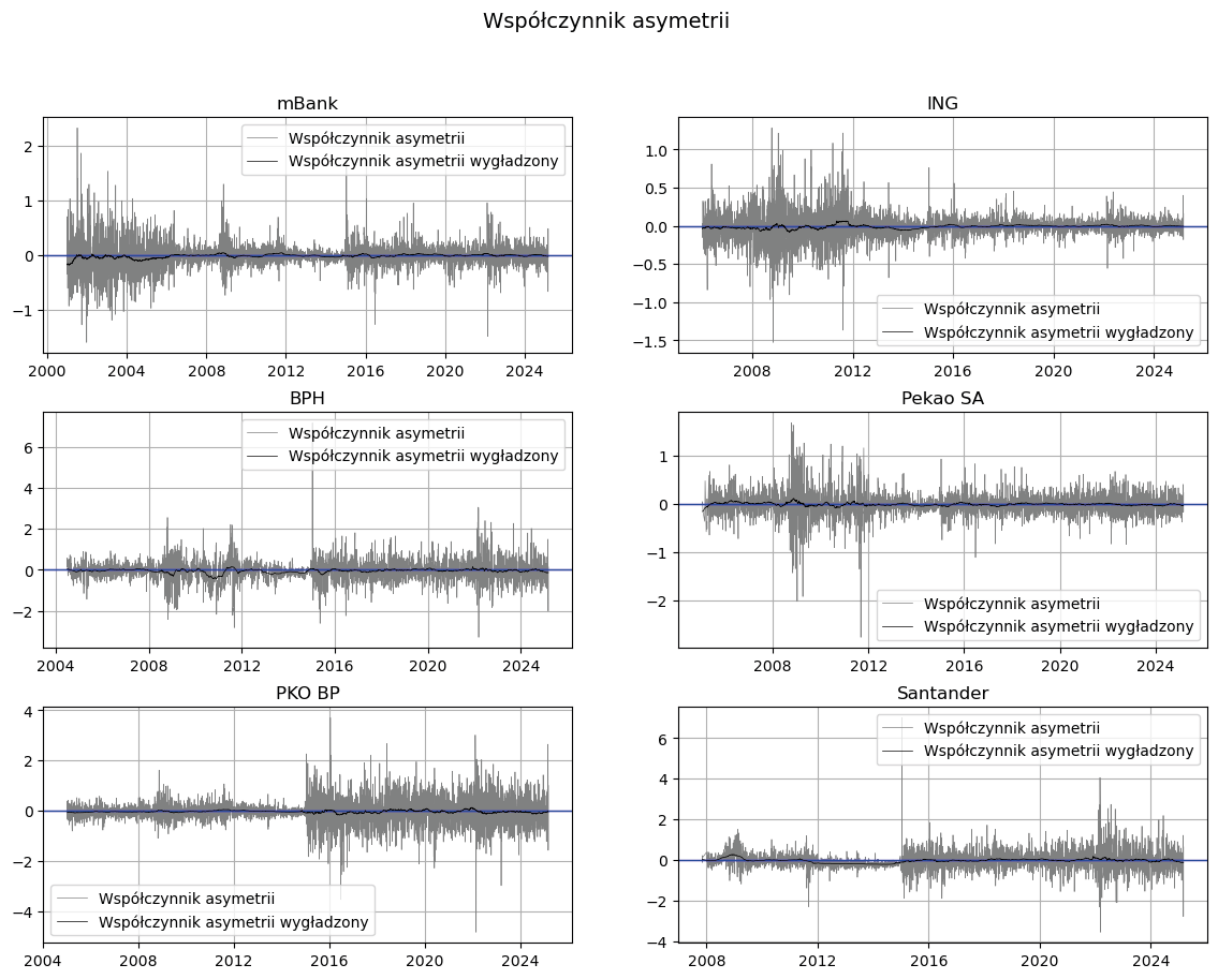
Źródło: badania własne.

Na Wykresie 4 (s. 226) przedstawiono zachowanie współczynnika odchylenia kursu referencyjnego od środka spreadu.

Analiza wykresu współczynnika odchylenia kursu referencyjnego od środka spreadu dla mBanku, ING, BPH, Pekao, PKO BP i Santander w latach 2001–2025 wskazuje, że dla wszystkich instytucji wartości wskaźnika oscylowały wokół zera, co oznacza brak trwałego przechylenia kursu referencyjnego w stronę cen maksymalnych lub minimalnych w długim okresie. Oznacza to, że ekstremalnie wysokie i niskie wartości spreadów występowały z podobną częstotliwością, co sugeruje brak systematycznego odchylenia warunków wymiany walut w kierunku kursu kupna albo sprzedaży. Choć w poszczególnych okresach obserwowano odchylenia od idealnego wypośrodkowania, wskazujące na chwilową przewagę korzystniejszych lub mniej korzystnych spreadów, tendencje te nie utrzymywały się długoterminowo. Warto zauważyć, że w przypadku Pekao dynamika zmian współczynnika odchylenia kursu referencyjnego od środka spreadu była bardziej wyraźna, zwłaszcza w latach 2012–2016, co koresponduje z wcześniejszymi wnioskami o większej zmienności spreadu w tym banku. Ogólnie jednak wykres pokazuje, że wskaźnik ten stabilizował się wokół wartości neutralnych.

Wykres 4

Współczynnik odchylenia kursu referencyjnego od środka spreadu dla kursów oferowanych przez badane banki w okresie 2001–2025



Źródło: badania własne.

W Tabeli 3 przedstawiono dane dotyczące wysokości spreadów bezwzględnych i względnych.

Tabela 3

Spready względne i bezwzględne w badanych bankach w okresie 2001–2025

Bank	Śr. spread wzgl. (%)	Std. spread wzgl.	Śr. spread bezwzgl. (zł)	Std. spread bezwzgl. (zł)	Wielkość próby
mBank	3,95	1,28	0,13	0,04	6091
ING	6,00	1,02	0,22	0,07	4827
BPH	4,04	1,50	0,13	0,04	5263

Bank	Śr. spread wzgl. (%)	Std. spread wzgl.	Śr. spread bezwzgl. (zł)	Std. spread bezwzgl. (zł)	Wielkość próby
Pekao	5,07	0,66	0,18	0,04	4259
PKO BP	3,06	2,12	0,10	0,06	5078
Santander	3,89	2,24	0,13	0,06	4358

Źródło: badania własne.

Analiza istotności różnic dla spreadów względnych i bezwzględnych (pola zaznaczone na szary kolor) została przedstawiona w Tabeli 4.

Tabela 4

Różnice między spreadami względnymi i bezwzględnymi w badanych bankach w okresie 2001–2025

	mBank	ING	BPH	Pekao	PKO BP	Santander
mBank	1	p-value 0,0001	p-value 1	p-value 0,0001	p-value 0,0001	p-value 1
ING	p-value 0,0001	1	p-value 0,0001	p-value 0,0001	p-value 0,0001	p-value 0,0001
BPH	p-value 0,0001	p-value 0,0001	1	p-value 0,0001	p-value 0,0001	p-value 1
Pekao	p-value 0,0001	p-value 0,0001	p-value 0,0001	1	p-value 0,0001	p-value 0,0001
PKO BP	p-value 0,0001	p-value 0,0001	p-value 0,0001	p-value 0,0001	1	p-value 0,0001
Santander	p-value 0,0833	p-value 0,0001	p-value 0,0001	p-value 0,0001	p-value 0,0001	1

Uwaga: szare pola dotyczą spreadów bezwzględnych.

Źródło: badania własne.

Dla p-value < 0,05 różnica jest uważana za istotną statystycznie. W przeważającej liczbie przypadków różnice w średnich spreadach pomiędzy bankami można wstępnie uznać za istotne statystycznie w ramach zastosowanego testu. Spready względne między mBank i Santander oraz spready bezwzględne między mBank i Santander oraz BPH i Santander można wstępnie uznać za podobne.

Wyniki badania istotności różnic między współczynnikami odchylenia kursu referencyjnego od środka spreadu zostały przedstawione w Tabeli 5.

Tabela 5

Istotność różnic między współczynnikami odchylenia kursu referencyjnego od środka spreadu w badanych bankach w okresie 2001–2025

	mBank	**ING**	**BPH**	**Pekao**	**PKO BP**
mBank	1				
ING	p-value 0,0093	1			
BPH	p-value 0,0001	p-value 0,0244	1		
Pekao	p-value 0,0001	p-value 0,0170	p-value 0,0001	1	
PKO BP	p-value 0,1462	p-value 0,0062	p-value 0,0381	p-value 0,0002	1
Santander	p-value 0,1397	p-value 0,0049	p-value 0,0429	p-value 0,0002	p-value 1

Źródło: badania własne.

Dla p-value < 0,05 różnice są istotne statystycznie, w związku z czym brak różnic odnotowano wyłącznie między mBankiem a PKO BP oraz między mBankiem a Santanderem. W pozostałych przypadkach występują różnice między współczynnikami odchylenia kursu referencyjnego od środka spreadu. Można zatem wstępnie wnioskować, że banki ustalały kursy kupna i sprzedaży względem rynku Forex w sposób zbliżony, ale niejednorodny.

Dyskusja

Ekonomiczna interpretacja wyników w zakresie kosztu dla kredytobiorcy frankowego wyrażona w PLN układa się w następujące wnioski:

- w konstrukcji kredytów denominowanych lub indeksowanych do walut obcych kredytobiorca wypłacał lub otrzymywał kapitał po niższym kursie kupna, natomiast spłacał raty po wyższym kursie sprzedaży ustalanym przez bank, co oznaczało, że cała różnica kursowa (spread) stanowiła bezpośredni i dodatkowy ciężar finansowy dla klientów banków;

- w momentach zawirowań rynkowych (takich jak kryzys finansowy w 2008 r. czy wydarzenia po 2020 r.) banki poszerzały spready, co przekładało się na skokowy, realny wzrost rat kredytowych niezależnie od samej zmiany stóp procentowych;
- ze względu na różnice w polityce cenowej poszczególnych podmiotów, całkowity koszt ponoszony przez kredytobiorców różnił się w zależności od wybranej instytucji;
- wysokie koszty spreadów nakładanych przez banki doprowadziły do interwencji regulatorów oraz uchwalenia tzw. ustawy antyspreadowej w 2011 r., która dała kredytobiorcom prawo do zakupu waluty poza bankiem (np. w kantorach internetowych po korzystniejszych kursach) i unikania arbitralnych marż bankowych.

Poniżej przedstawiono powiązanie wyników przeprowadzonego badania ze zmieniającymi się warunkami rynkowymi oraz regulacjami na rynku bankowym w Polsce:

- okres przed kryzysem finansowym 2008–2009 – banki stosunkowo swobodnie kształtowały tabele kursowe, traktując spread walutowy jako ukryte i wysoce zyskowne źródło dochodu przy oferowaniu kredytów hipotecznych CHF/PLN;
- kryzys finansowy (2008–2009) – w obliczu spowolnienia gospodarczego i problemów z płynnością na międzynarodowych rynkach, instytucje finansowe podnosiły spready, co drastycznie zwiększyło realne koszty obsługi zadłużenia dla kredytobiorców;
- przełom lat 2011–2016 – w reakcji na praktyki banków Komisja Nadzoru Finansowego wydała Rekomendację S (II), a w 2011 r. uchwalono tzw. ustawę antyspreadową, która dała klientom prawo do spłaty kredytów bezpośrednio w walucie obcej. Zmiany te, połączone ze wzrostem presji konkurencyjnej, zmusiły wiele banków (np. PKO BP, BPH, Santander) do obniżenia spreadów po 2016 r.;
- okres po 2016 r. – mimo czynników systemowych i regulacyjnych, na rynku utrzymały się różnice między bankami, co w połączeniu z abuzywnością klauzul kursowych stało się fundamentem masowych sporów sądowych wytaczanych przez kredytobiorców.

Przeprowadzone badania empiryczne nad spreadami walutowymi oraz położeniem kursów referencyjnych w relacji do środka zakresu w wybranych bankach komercyjnych w Polsce dostarczają istotnych wniosków poznawczych. Wyniki wskazują, że mimo długookresowej stabilizacji współczynników odchylenia wokół wartości neutralnych, polityka marżowa banków w zakresie wysokości spreadów bezwzględnych i względnych podlegała wyraźnym przeobrażeniom – szczególnie w okolicach 2016 r., co zbiega się z rosnącą presją konkurencyjną oraz otoczeniem regulacyjnym.

Zauważone różnice w średnich poziomach spreadów pomiędzy poszczególnymi instytucjami dowodzą, że banki w odmienny sposób kształtowały swoją politykę cenową w obrocie walutowym. Przekłada się to bezpośrednio na koszty ponoszone przez klientów obsługujących zobowiązania denominowane lub indeksowane do walut obcych.

W celu lepszego zilustrowania skali tych różnic w realiach obsługi zadłużenia, posłużono się szacunkowym przykładem analitycznym opartym na średnich wartościach spreadów bezwzględnych wyznaczonych w badaniu.

Przyjęte założenia w obliczeniu ilustracyjnym:

- stały poziom kursu bazowego w momencie dokonywania przeliczenia raty;
- niezmienność pozostałych składowych raty kapitałowo-odsetkowej oraz brak uwzględnienia dodatkowych prowizji w danym miesiącu;
- statyczne ujęcie średniego spreadu bezwzględnego wyznaczonego dla poszczególnych banków w ujęciu długookresowym.

Dla kredytu hipotecznego o saldzie zadłużenia wymagającym zakupu 500 CHF w racie miesięcznej, różnica między bankiem charakteryzującym się najniższym średnim spreadem bezwzględnym w badanym okresie (np. PKO BP z poziomem ok. 0,10 zł) a bankiem o wyższym średnim spreadzie (np. ING z poziomem ok. 0,22 zł) generuje rozpiętość rzędu 60 gr na każdym franku w skali porównawczej, co przy racie 500 CHF daje wymierną różnicę kosztową wynoszącą około 60 PLN miesięcznie.

Powyższy przykład potwierdza, że optymalizacja kosztów obsługi zobowiązań walutowych w dużej mierze zależy od struktury i wysokości marż transakcyjnych stosowanych przez konkretnego kredytodawcę, a nie wyłącznie od wahań samej ceny bazowej waluty na rynku międzynarodowym.

Podsumowanie

Celem artykułu była analiza i ocena spreadów w kursach walutowych CHF/PLN w PLN wybranych banków oferujących kredyty hipoteczne w Polsce pod względem wysokości oraz różnic między badanymi bankami. Wyniki pozwoliły na określenie polityki kształtowania spreadów (zarówno względnych, jak i bezwzględnych) przez sześć wybranych banków w Polsce oferujących kredyty hipoteczne w latach 2001–2025 (mBank SA, ING SA, BPH SA, Pekao SA, PKO BP SA, Santander SA). Analiza potwierdziła, że polityka spreadów w badanych bankach ulegała zmianom na przestrzeni lat, zwłaszcza widoczne było to w radykalnym obniżeniu spreadów po 2016 r. w wielu bankach (np. PKO BP, Santander, BPH). Stwierdzono, że istniały istotne różnice między badanymi podmiotami pod względem kształtowania kursów kupna i sprzedaży, a co za tym idzie spreadów walutowych. Jedynymi wyjątkami były spready

względne między mBank i Santander oraz spready bezwzględne między mBank i Santander oraz BPH i Santander. Oznacza to, że rynek ten nie funkcjonował w sposób homogeniczny pod względem oferowanych marż.

W artykule zaproponowano i wykorzystano współczynnik odchylenia kursu referencyjnego od środka spreadu do oceny, czy marże doliczane do kursów kupna i sprzedaży były podobne. Stwierdzono, że dla wszystkich instytucji wskaźnik odchylenia kursu referencyjnego od środka spreadu oscylował wokół wartości neutralnych, co sugeruje brak systematycznego przechylenia warunków wymiany walut w stronę kursu kupna albo sprzedaży w długim terminie.

Wyniki wskazują na potrzebę zwiększenia przez banki przejrzystości zasad ustalania kursów kupna i sprzedaży walut, ujednolicenia wewnętrznych procedur ustalania marż walutowych, ograniczenia arbitralności tabel kursowych, szczególnie w okresach podwyższonej zmienności rynkowej. Dla organów nadzorczych i regulacyjnych, w tym Komisji Nadzoru Finansowego (UKNF) oraz Urzędu Ochrony Konkurencji i Konsumentów (UOKiK), uzyskane wyniki mogą stanowić podstawę do monitorowania skali i dynamiki spreadów walutowych stosowanych przez banki, oceny skuteczności dotychczasowych regulacji (np. Rekomendacji S oraz ustawy antyspreadowej), a także rozważenia potrzeby dalszych działań zwiększających transparentność kosztów walutowych ponoszonych przez konsumentów. Dla kredytobiorców posiadających kredyty indeksowane lub denominowane do franka szwajcarskiego wyniki dostarczają informacji o skali zróżnicowania kosztów, pozwalają lepiej ocenić historyczne obciążenie wynikające z polityki kursowej banków oraz dostarczają argumentów za korzystaniem z alternatywnych kanałów wymiany walut.

Uzyskane rezultaty należy traktować jako wstępną przesłankę do dalszych, bardziej zaawansowanych analiz. W kolejnych etapach badań, w celu wyeliminowania wspomnianych ryzyk metodologicznych, zasadne będzie zastosowanie modelowania panelowego opartego na ujednoliconych oknach czasowych, z wykorzystaniem estymatorów odpornych na autokorelację i heteroskedastyczność. Takie podejście pozwoli oddzielić efekty specyficzne dla poszczególnych banków od wpływu zewnętrznych szoków rynkowych, co stanowi istotną ścieżkę dalszej weryfikacji postawionej tezy badawczej.

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Załącznik 1

Fragment kodu analizy danych

```
def formData(forexdata, bankdata):
 df_forex_lastInDay = forexdata.groupby(forexdata.index.date).last()
 df_bank_lastInDay = bankdata.groupby(bankdata.index.date).last()
 df_bank = df_forex_lastInDay.merge(
 df_bank_lastInDay,
 left_index=True,
 right_index=True,
 how=”inner”
 )
 df_bank[,spread’] = df_bank[,sell’] - df_bank[,buy’]
 df_bank[,spread-rel’] = (
 2 * (df_bank[,sell’] - df_bank[,buy’])
 / (df_bank[,sell’] + df_bank[,buy’])
 )
 df_bank.index = pd.DatetimeIndex(df_bank.index)
 df_bank[,asymmetry’] = (
 (2 * df_bank[,forex’] - df_bank[,sell’] - df_bank[,buy’])
 / (df_bank[,sell’] - df_bank[,buy’])
 )
 df_bank[,rolling’] = df_bank[,asymmetry’].rolling(
 datetime.timedelta(days=180),
 center=True,
 on=df_bank.index
 ).mean()
 return df_bank

df_mbank = formData(df_forex, df_mbank)
# ...
```

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Krzysztof Kil https://orcid.org/0000-0002-2575-7806
PhD, Department of Banking and Global Financial System, Krakow University of Economics,
e-mail: kilk@uek.krakow.pl

CREDIT REPORTING SYSTEMS, CREDIT RISK AND ACCESS TO CREDIT: EVIDENCE FROM EUROPEAN UNION COUNTRIES

Abstract

The purpose of the art cle. This paper analyses the impact of credit information exchange systems on banks' credit risk and the availability of credit in European Union countries. The aim of the study was to assess the relationship between selected characteristics of credit information exchange systems – in particular, the scope of data processed and the level of population coverage by private credit bureaus and public registers – and the quality of banks' loan portfolios and access to finance (taking into account the cost of bank credit).
Methodology. The research covered the banking sectors of European Union countries over 2014–2024. Linear regression was used to examine the relationship between CRS characteristics, non-per-forming loans (NPLs), and credit availability. Dynamic panel data models were estimated using the GMM-SYS method, while static random-effects models were used to analyse credit spreads. The explanatory variables included credit data completeness, information on consumer income and insolvencies, and population coverage by private and public credit registers. Macroeconomic and sectoral indicators identified through a literature review were used as control variables.
Results of the research. Research findings indicate that comprehensive credit information systems, including data on consumer insolvency, are associated with lower credit risk materialization and credit spreads. Broader coverage by private credit bureaus is linked to lower NPL levels and greater access to credit, whereas a greater role for public credit registers is associated with more limited access to finance. The development of CRS systems may also lead to more rigorous borrower selection, reducing the number of borrowers and credit accounts while improving loan portfolio quality. The findings indicate that data completeness is more important for credit market efficiency than the model used to build the information infrastructure. The inclusion of ESG data and BNPL liabilities in credit information is associated with changes in credit availability and pricing, but does not reduce credit risk.
Keywords: credit reporting systems, credit risk, access to credit, credit information agencies, the cost of credit
JEL Class: G21, G28

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Introduction

Credit reporting systems (CRS) constitute a key element of the infrastructure supporting access to credit, financial inclusion, prudential supervision and financial stability (World Bank, 2022, pp. 1, 11). Credit reporting systems comprise the institutions, individuals, rules, procedures, standards and technologies that enable the flow of information supporting credit-granting decisions. Credit reporting service providers (CRSPs) – institutions or agencies that collect, process and disseminate data on borrowers and manage credit information sharing systems – provide lenders and businesses with key information on credit ratings, credit histories and cases of fraud. This category includes commercial credit bureaus, public credit registries, business information providers and alternative credit reporting service providers that use innovative methodologies and non-conventional data (World Bank, 2022, p. 15). However, their activities entail significant risks – strategic, operational, cyber, model, reputational, and legal, regulatory and compliance risks – and the use of innovative technologies and alternative data sources further increases the level of risk.

Risk assessment and applicant verification are particularly important for consumer credit, whose portfolios usually comprise a large number of low-value contracts, often with limited collateral effectiveness. Information on how a prospective borrower has met past obligations enables lenders to assess credit risk more accurately, mitigating problems related to adverse selection. Given the high degree of interconnectedness in the financial sector, the absence of a well-developed credit reporting infrastructure may seriously disrupt the functioning of credit markets and, consequently, threaten financial stability at both the national and global levels (World Bank, 2022).

Globally, there are considerable variations in the models of credit reporting systems, both from the institutional perspective and in terms of the scope of data aggregated and processed in the lending transactions. The architecture of the system may be an important factor affecting the ability of banking sector entities to manage credit risk effectively and may influence the direction of banks' lending policies.

The aim of this article is therefore to assess the relationships between selected characteristics of credit information sharing systems (in particular, the scope of the data they process and the population coverage by private and public credit bureaus) and the level of non-performing loans (as a measure of the effectiveness of credit risk management) and access to credit, including its cost. The empirical analysis covers the countries of the European Union in the years 2014–2024. The main hypothesis states that the model of the credit information sharing system (the scope of the data collected in terms of borrowers and products, and the coverage of the population by private and public credit bureaus) is significantly correlated with the effectiveness of bank credit risk management (measured by the level of non-performing loans) and with access to bank credit.

The auxiliary hypotheses specify the direction of this relationship for selected characteristics of the system. Hypothesis 1 (H1) states that a higher level of completeness of the credit information sharing system, understood as reporting covering the full range of entities (individuals, SMEs and large enterprises) and the processing of information on consumer bankruptcy, is associated with a lower level of non-performing loans and lower credit margins. Hypothesis 2 (H2) states that a higher level of completeness of the credit information sharing system is associated with narrower access to credit, measured by the number of borrowers and credit accounts per 1,000 adults and by the ratio of household loans to GDP, which is consistent with a mechanism of tighter borrower selection. According to Hypothesis 3 (H3), higher population coverage by private credit bureaus is associated with a lower level of non-performing loans and broader access to credit, whereas higher coverage by public registries is not associated with the quality of the loan portfolio but is associated with narrower access to credit.

The verification of hypotheses involves an econometric verification of the relationship between the characteristics of credit information exchange systems and measures of risk, access, and the cost of credit.

The importance of an effective credit information sharing market

A fundamental obstacle to the effective functioning of credit markets is information asymmetry between lender and borrower. Two phenomena that are well described in the literature follow from it: adverse selection, consisting in the systematic crowding out of creditworthy applicants from the credit market by high-risk ones, and moral hazard, manifested in changes in the borrower's behavior after the loan agreement has been concluded. Institutional mechanisms for sharing credit information are one of the most effective tools for overcoming this asymmetry (Jappelli & Pagano, 2002). Empirical studies consistently confirm a positive relationship between the existence and quality of credit information systems and the availability and cost of financing.

An effective credit information sharing market has a favorable effect on the cost of debt financing and allows lenders to differentiate risk rationally, which also makes it possible to extend the credit offer to groups of entities previously excluded from the market because of the lack of a credit history or its unverifiability. This is particularly important for so-called credit invisibles – persons without an adequate credit history in databases – and for entities with a limited (thin-file) credit history that does not allow a reliable risk assessment (Fosu et al., 2023). Credit information sharing systems foster growth in the volume of loans granted. The International Finance Corporation (IFC), based on an analysis of 60 countries for 2004–2017, showed a positive relationship between the development of the credit information market and access to credit, bank profitability and broadly understood economic development (Masunda, 2026). Better verification and early-warning analytics reduce the number of non-performing loans

(NPLs), strengthening the resilience of the banking system. Adequate access to credit for small and medium-sized enterprises (SMEs), which are among the groups traditionally hit hardest by credit rationing, is particularly important for financial policy (Masunda, 2026).

An important mechanism through which CRSPs affect access to credit is the creation of reputational incentives. A borrower who is aware that his or her repayment history is recorded and made available to potential future lenders has a stronger incentive to settle obligations on time. In turn, a lender with access to a verifiable history is inclined to offer more favorable financing terms. In sum, credit information sharing mitigates the problems of adverse selection, moral hazard and agency costs, which ultimately leads to lower default rates in credit markets.

Effectiveness of credit information sharing systems

The effectiveness of credit information systems in increasing the efficiency of risk management and access to credit is not automatic and depends on several institutional, legal and technological factors. The literature points to the following key determinants of CRSP effectiveness (World Bank, 2019):

- scope and completeness of data – systems reporting only negative information (delays, debt collection) are much less effective in supporting financial inclusion than full-file reporting systems, which cover both positive and negative information. Negative-only reporting perpetuates a situation in which the reliable repayment of obligations does not translate into an improvement in the borrower's position in the market;
- population coverage – the analytical value of a system is limited when it covers only part of the borrowers. An increase in the number of entities registered raises the informational value of the system for all its participants (network effect) and, at the same time, widens the range of entities to which the system can facilitate access to financing;
- data quality and timeliness – continuously updated data are a condition of the reliability of credit assessments; outdated or erroneous data can lead to both type I errors (refusing credit to a creditworthy entity) and type II errors (granting credit to an entity that is in fact not creditworthy);
- legal framework and personal data protection – the implementation of credit information systems requires coherent regulations guaranteeing the rights of data subjects (access to one's own history, the right to correct erroneous entries, data retention periods) while enabling effective data exchange between system participants.

From the perspective of a banking institution, credit information systems perform an infrastructural function throughout the life cycle of a credit exposure, from the initial assessment of an application, through portfolio monitoring, to the management of distressed receivables. The quality and completeness of the data obtained from CRSPs directly determine the accura-

cy of credit decisions and thereby shape the bank's risk profile at the level of both individual exposures and the entire portfolio (Li et al., 2024). The role of credit information systems is not limited to the application-acceptance phase; their function in the ongoing monitoring of the loan portfolio is equally important. An increase in a client's debt with other institutions, the appearance of new credit inquiries or a deterioration in the limit utilization ratio are signals that allow preventive action: renegotiation of terms, reduction of the available limit, strengthening of collateral or initiation of a restructuring process.

Despite their undeniable benefits, credit information systems also generate specific challenges for risk management in banks. The first is procyclicality risk: scoring models calibrated on historical data may systematically underestimate risk in phases of credit expansion and overestimate it in recessions, thereby amplifying cyclical fluctuations in lending. The second important challenge is the quality and consistency of data in CRSP systems, especially in a cross-border context. The third area of risk is dependence on historical data in the face of structural changes in macroeconomic conditions.

In sum, credit information supports access to financing mainly because it makes it possible to reduce, in part, the weight of collateral requirements and to assess client risk better; this does not, however, mean an automatic increase in lending, but rather the possibility of distinguishing more accurately between entities that are genuinely able to repay and those whose risk profile justifies a refusal of financing or more cautious credit terms (Morscher et al., 2017; Ndoye & Barajas, 2023).

The role of data scope and sources in the proper functioning of the credit information exchange system

Data from credit information systems allow banks to assess not only the situation declared by the client but also his or her actual payment behavior in relations with other lenders. Information on repayment history, the number of active liabilities, the level of debt, limit utilization, arrears and the length of the credit history enables a better estimation of both repayment capacity and creditworthiness. These data reduce the risk of taking decisions solely on the basis of information supplied by the client (Ferretti, 2015; Miller, 2000). The importance of these categories of information is well illustrated by Global Findex data, according to which in low- and middle-income economies a significant share of borrowing continued to take place outside the formal financial sector. This shows that credit inclusion should be analyzed not only through the prism of general access to financial services but also through the possibility of obtaining responsibly granted credit on the basis of sufficient, reliable and verifiable information about the client (Klapper et al., 2025). The quality of the data used in credit reporting systems is particularly important. The report of the World Bank and the International Committee on Credit Reporting (ICCR)

emphasized that integrated reporting mechanisms, such as credit bureaus and credit registries, as a rule ensure higher data quality, greater usefulness of information and greater efficiency than ad hoc, unstructured inquiries addressed directly to individual financial institutions. For the credit process this means that the value of information from credit bureaus derives not only from its scope but also from the way it is organized and updated and from the possibility of comparing it across lenders (World Bank Group & International Committee on Credit Reporting, 2015).

The importance of data in the credit process should be considered not only through the prism of their scope but also of the way they are obtained, processed, integrated and controlled. The effectiveness of scoring and rating models depends not only on the availability of information about the client but also on the quality of the data infrastructure, the rules for integrating sources, documenting data provenance, tracking their transformations and ensuring compliance with privacy and security requirements (Blazquez & Domenech, 2018). The level of granularity of the data used in credit assessment is also important. Data quality consists not only in completeness and timeliness but also in an appropriate observation frequency, which makes it possible to capture changes in the client's financial behavior over time (Goldmann et al., 2025).

Data from credit bureaus are used not only at the stage of the decision to grant credit but also in the broader management of the client relationship and the loan portfolio (Furletti, 2002). The inclusion of alternative data in credit assessment can support credit inclusion primarily because the traditional assessment model based on repayment history creates a barrier to access for clients with a short or non-existent credit history. The World Bank and the ICCR indicate that this problem concerns in particular young people, immigrants, women, minorities, small and medium-sized enterprises and entities operating in the informal sector. The lack of an adequate credit history may limit access to formal financing even though potential borrowers leave other traces of economic activity, e.g., in the form of payments for telephone, utilities and rent, activity on digital platforms, e-commerce, or data related to online settlements. In this perspective, alternative data can reduce the effects of "credit invisibility", but their use should be supplementary and subject to quality control, proportionality and compliance with clients' rights (World Bank Group & International Committee on Credit Reporting, 2025, p. 10).

The importance of information quality is particularly visible in scoring models, in which input data are transformed into a synthetic assessment of client risk. Models used by credit bureaus therefore evolve continuously, as illustrated, among others, by the new scoring model of the Credit Information Bureau (Biuro Informacji Kredytowej, BIK), whose rollout began in 2026. The new model is based on three key groups of data: timeliness of repayments, activity in the financial market and experience in repaying obligations. The first group includes, among others, information on delays in the repayment of loans, amounts of arrears and debt collection or enforcement proceedings. The second concerns amounts of loans, amounts outstanding

and the amount and utilization of credit limits. The third covers the length of the credit history. At the same time, BIK indicates that the new model does not use data from credit applications that did not result in financing, and that credit inquiries are automatically deleted after 14 days if they do not result in financing (BIK, 2025).

The BIK example illustrates that in scoring practice particular weight is attached to information on actual use of credit and its repayment, rather than to the mere fact of applying for financing. Data from credit bureaus have high decision value only when they are complete, up to date, consistent and properly integrated with other information used by the bank (Siddiqi, 2017). Modern credit models increasingly use not only traditional financial data and information on repayment history but also a wider set of data derived from, among others, corporate databases, transaction sources, earlier payment delays, corporate network links or publicly available information. Such a scope of data may increase the models' ability to identify complex risk patterns but at the same time raises requirements for the selection, quality, interpretability and proportionality of the information used.

Digitalization, whose pace was accelerated by the pandemic, has caused an exponential growth in the number and diversity of alternative data sources (World Bank Group & International Committee on Credit Reporting, 2025, p. 10). The use of alternative data in credit risk assessment creates new opportunities but also entails risks and challenges. The main benefits include greater transparency and a more comprehensive picture of potential borrowers, especially consumers with a limited or no credit history, which improves access to services for social groups with limited access to financial services. The use of alternative data may, however, introduce bias, leading to discriminatory outcomes and the perpetuation of inequalities. Therefore, although alternative data can improve financial inclusion, they also carry the risk of deepening inequalities with respect to marginalized groups, including women and minorities (World Bank Group & International Committee on Credit Reporting, 2025).

The more complex the models used in the credit process, the greater the role played by their comprehensibility, transparency and the possibility of explaining the result from a supervisory and organizational perspective (Andriosopoulos et al., 2019). On the other hand, many reports point to the need for a cautious approach to alternative data; their actual use therefore remains limited, and the scale of benefits depends on data quality, their predictive power and control of the risks related to discrimination, privacy and the explainability of credit decisions (Government Accountability Office, 2021). Alternative data can play a supplementary role in assessing clients who are less visible in traditional credit databases, but they do not replace information on the actual history of repayment of obligations (Muñoz-Cancino et al., 2023).

The requirement of data quality control is also confirmed in regulatory guidelines. The EBA guidelines stress the need to ensure the quality, traceability, verifiability, robustness and

resilience of input data and a regular assessment of the quality of model outputs. In practice this means the need to check data correctness, monitor model performance, verify their historical effectiveness and document assumptions, limitations and changes (EBA, 2020). Incomplete data may lead to two basic types of decision errors. The first is false acceptance, i.e., granting a loan to a client who in fact does not have a lasting ability to repay it. The second is false rejection, i.e., refusing financing to a client who would in fact be able to service the obligation on time. In such a case the lack of information may be wrongly equated with high risk, even though the client's actual profile would justify granting financing (Stiglitz & Weiss, 1981; Carroll & Rehmani, 2017). Incomplete data also affect the pricing terms of financing. From the client's perspective, data quality thus affects not only access to financing but also its cost and terms. From the bank's perspective, it determines the accuracy of risk pricing and the efficiency of capital allocation (Müller et al., 2024; Perrotta et al., 2023).

In sum, data quality is one of the basic conditions for an accurate assessment of creditworthiness and credibility. Even extensive procedures, scoring models and analytical tools cannot ensure a correct credit decision if they rely on incomplete, outdated, inconsistent or low-quality information (Basel Committee on Banking Supervision, 2025).

Diversity of credit information sharing systems

There is no single optimal pattern of organizing a CRS. Hybrid models dominate and are constantly transforming, as is the tendency to rely on full data (negative and positive) and to extend their scope to include alternative data. This market is important for key stakeholders (FCA, 2023): credit information agencies (CRAs), data providers and users of credit information, credit information service providers and consumers. Three main models of organizing this market can be distinguished:

- a centralized model, based on the monopoly of a public registry or of a private credit agency/bureau;
- a decentralized model, based on an oligopoly of several agencies with partly different mandates;
- a hybrid model.

Private credit bureaus are commercial entities whose activity focuses on collecting detailed data on borrowers. Public credit registries, which are institutions operating at central banks or financial supervisory authorities, are oriented primarily toward regulatory and supervisory needs. Public registries usually cover loans above a certain threshold amount, which may limit their effectiveness with respect to individuals and small businesses (Ferretti, 2017). In the centralized model, one national (or supranational) institution collects, stores and makes available credit information on all borrowers, e.g., the public credit registry run by the Banque de France.

The advantages of such a model are the comprehensiveness and standardization of data, lower costs owing to the absence of data duplication, and better regulatory oversight of data quality and security. The disadvantages are the potentially severe consequences of a systemic failure, limited competition that may lead to slower introduction of innovations, and the absence of pressure to improve service quality or reduce costs for lenders. A state agency may also be under pressure to place the pursuit of political goals above market efficiency. In the decentralized model, many private credit bureaus compete with one another in collecting and selling credit information. Examples are Experian, Equifax, CRIF and Creditreform, operating in different EU member states. The advantages of the model are innovation driven by competitive pressure, greater resilience to cyberattacks owing to dispersed data, and considerable flexibility and specialization – niche operators can develop expertise in particular sectors. The disadvantages are fragmentation – data on borrowers may be split among many bureaus, which gives each of them an incomplete picture and leaves persistent information asymmetry – as well as gaps in coverage and inconsistent standards that make comparisons between bureaus difficult. This model also entails greater regulatory complexity and inequality in access to data.

Most EU member states use hybrid systems – a public credit registry run by the central bank (usually covering large exposures) and private credit bureaus dealing with retail and SME loans. This solution combines supervisory advantages with concern for market efficiency but creates challenges of coordination and oversight.

The credit information sharing market in the United States is the most mature and most developed system of this kind in the world. Its architecture rests on an oligopoly of three dominant private credit bureaus – Equifax, Experian and TransUnion, known as the Big Three or NCRAs (*nationwide consumer reporting agencies*) – supplemented by specialized entities. According to CFPB data, more than 90% of American adults have active credit reports at one of the three main bureaus. The reporting model is full-information (*full-file reporting*). A key role in operationalizing credit data for lenders' decisions is played by the FICO score (Fair Isaac Corporation), whose successive versions are the industry standard. Since October 2022 the Federal Housing Finance Agency has approved the VantageScore 4.0 model alongside FICO for use in mortgages backed by the federal government, which marks the first significant breaking of FICO's monopoly in this segment in decades (CFPB, n.d.; Board of Governors of the Federal Reserve System et al., 2019). The regulatory framework of the system is set by the Fair Credit Reporting Act (FCRA) of 1970 (amended many times) and the Equal Credit Opportunity Act of 1974, which impose on the bureaus obligations regarding data accuracy, the consumer's right of access to his or her own report and procedures for disputing erroneous entries. Supervision of credit agencies is exercised by the Consumer Financial Protection Bureau (CFPB) (Board of Governors of the Federal Reserve System et al., 2019). The main weakness of the

system, repeatedly documented by the Consumer Financial Protection Bureau and consumer organizations, remains the high share of errors in credit reports.

The British system is the most technically advanced, has the richest data, the most competitive market and the strongest infrastructure for credit assessment. Three global credit information agencies operate in parallel: Experian, Equifax and TransUnion, and competition drives innovation. Beyond them, about 20 smaller entities with the powers of credit reference agencies (CRAs) operate in the market, focusing on niche segments, often using alternative data and open-banking-based models. Banks and lenders use their own internal models based on data from one or all three credit information agencies. The British system is full-information (both positive and negative information is reported) and covers a wide range of data, including bank account history, court judgments, electoral roll data used to verify identity, and obligations toward utility and telecom providers. Regulations do not oblige lenders to submit data to all three agencies – the lender decides which agency's services to use, which may put at a disadvantage consumers who must check all three databases to understand their full credit profile.

A key turning point for sector regulation is the Credit Information Market Study published in December 2023 by the Financial Conduct Authority (FCA), (FCA, 2023). The FCA found that the credit information sector is undergoing its deepest transformation in decades and announced a package of measures centered on four areas: governance, data quality, scope of reporting and consumer engagement. A central element of the reform is the establishment of a new industry oversight body, the Credit Reporting Governance Body (CRGB), replacing the existing self-regulatory committee SCOR (Steering Committee on Reciprocity). As part of the work leading to the full implementation of the CRGB, the three largest credit bureaus began joint work on a standardized data reporting format (Standard Industry Reporting Format, SIRF), intended to improve the consistency and quality of data in the system. A particularly dynamic area of development of the British market is the integration of traditional credit data with open banking data, implemented in the United Kingdom more widely and earlier than in many countries of continental Europe. In 2026 the FCA launched a consultation on further modifications to the reporting system (FCA, 2023, 2026).

The Italian credit information system is distinguished by a clear institutional dualism: a public credit register supervised by the central bank and private credit information systems operate in parallel, and the two have different scopes, reporting thresholds and legal bases (Banca d'Italia, n.d.-a). Banca d'Italia provides registered intermediaries with a monthly aggregate statement of each client's total indebtedness in the banking system, enabling an assessment of concentration risk. It is important that the register is not a scoring system – it supplies raw quantitative data, which are then interpreted by credit institutions in their own risk models (Banca d'Italia, n.d.-b). A limitation of the public system is the high reporting threshold. This gap is filled by private

credit information systems, of which EURISC, a system managed by the CRIF group (Damiani, 2026), holds the dominant position; it integrates positive and negative information on individuals and entrepreneurs, is fed with data from more than 500 market participants and has no amount threshold. CRIF, founded in 1988 in Bologna with the participation of six credit institutions from the Emilia-Romagna region, has grown into a global player. It now operates in more than 50 countries, serves more than 6,500 banks and financial institutions, earns revenue exceeding EUR 500 million a year and in Poland is active especially in the economic information market (CRIF, 2026). A characteristic weakness of the Italian system is the relatively low standardization of data across the individual systems and the absence of a uniform, commonly used scoring model – Italian banks rely on their own models to a greater extent than their Anglo-Saxon counterparts.

The German credit information system is dominated by Schufa (Schutzgemeinschaft für allgemeine Kreditsicherung), a private company owned by banks, retailers and credit card companies. It operates within a broader ecosystem that includes Creditreform (focusing on corporate credit), Bürgel and CRIF. Schufa collects data from more than 10,000 reporting entities, including banks, mobile operators, insurance companies and utility providers, so that its reach extends well beyond the financial sector alone (SCHUFA, 2026). It holds data on the vast majority of adult residents of Germany, which makes it one of the most comprehensive consumer databases in Europe. Schufa was criticized in the past for using opaque methods of calculating the credit score. The 2026 reform introduced a new, simpler credit rating (Huertas, 2026). The reform was partly forced by the case law of the Court of Justice of the European Union, which considered cases in which consumers had been refused credit and Schufa had provided them only with a score and general information without disclosing the exact calculation method.

France represents the most centralized model among the countries analyzed, based on registers run directly by the Banque de France (Banque de France, n.d.). The registers run by the central bank concern:

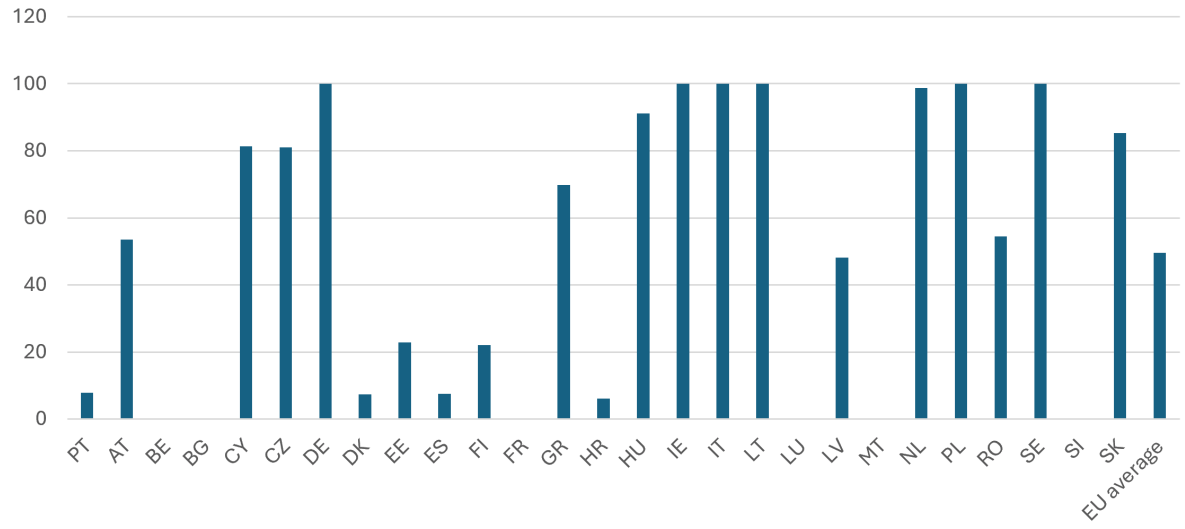
- FICP (Fichier National des Incidents de Remboursement des Crédits aux Particuliers) – insolvency and over-indebtedness in consumer credit;
- FCC (Fichier Central des Chèques) – records cheque fraud and payment incidents;
- FIBEN (Fichier Bancaire des Entreprises) – a database on enterprises, covering firms with turnover above EUR 750,000. FIBEN performs the rarely encountered function of a public creditworthiness assessment system for SMEs.

The French public model offers a high degree of regulatory integrity and coverage of SMEs but is structurally weaker in terms of credit information on retail clients because of its restriction to negative entries only (ACCIS, 2020). Empirical studies show (Brown et al., 2009; Haas Ornelas et al., 2025; Jappelli & Pagano, 2002) that collecting repayment data significantly improves the effectiveness of the database.

Historical information (up to 2020) on the scope of credit bureau activity was also published by the World Bank. Figure 1 presents the credit bureau coverage indicator, while Figure 2 presents the level of coverage by public credit registries.

Figure 1

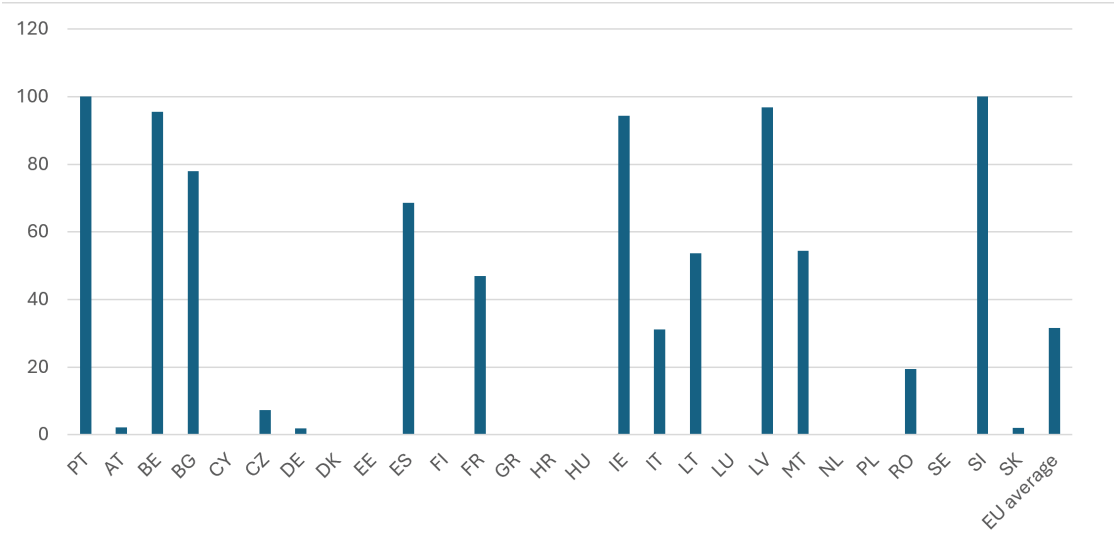
Coverage of private credit bureaus (number of persons for whom credit information is processed, as % of adults) in 2020



Source: own elaboration based on World Bank Group data.

Figure 2

Coverage of public credit registries (number of persons for whom credit information is processed, as % of adults) in 2020



Source: own elaboration based on World Bank Group data.

According to World Bank data, Poland is assessed as a country with full information scope in terms of the data processed. Based on estimates, the depth of credit information index of the credit information sharing system in Poland reached the maximum level of 8 in 2014–2020 (as one of three EU countries). The Polish credit information sharing system took shape in less than three decades and today is among the most mature and comprehensive systems of this kind in Central and Eastern Europe. The leading private credit information agency is BIK (Biuro Informacji Kredytowej, the Credit Information Bureau), founded in 1997 by the Polish Bank Association and commercial banks. It serves as the central point for collecting data on consumer loans and on loans to small and medium-sized enterprises. Separate private agencies focus on negative information, concerning mainly enterprises and non-bank creditors such as telecommunications operators, utility providers and leasing companies (payment arrears, indebtedness) – for example BIG InfoMonitor and KRD (Krajowy Rejestr Długów, the National Debt Register). The National Bank of Poland runs a public credit register, but with a fairly high reporting threshold (exposures ≥ PLN 500,000 for non-financial entities and ≥ PLN 200,000 for individuals), so it plays a macroprudential rather than a credit-decision-support role in the retail sector. This means that BIK effectively performs the role that in some countries (France, Spain, Italy) is performed by the central bank's public registry.

The credit information exchange system model and credit risk in the light of an econometric study

An important element of the analysis was a statistical assessment of the significance of relationships between selected characteristics of credit information sharing system models in European Union countries and the scale of credit risk materialization in banks, as well as access to credit and its cost. The core period of analysis is 2014–2024. The set of variables used in the econometric study is described in Appendix 1, and descriptive statistics are given in Appendix 2. The analysis was carried out using dynamic panel data models estimated with the GMM-SYS estimator (Blundell-Bond). The lags of the dependent variable were instrumented by their available further lags and other possibly endogenous variables were instrumented also by their available further lags. The Arellano-Bond test in the prepared models indicates the presence of first-order autocorrelation and the absence of second-order autocorrelation, which confirms the correct specification of the dynamic models. The Hansen test does not reject the hypothesis of instrument validity. The number of instruments remains lower than the number of cross-sectional units, which limits the risk of instrument proliferation.

The general form of the models is given by the formula:

$$CM_{i,t} = const + {}_{a1}CM_{i,t-1} + {}_{a2}CRS_{i,t} + {}_{a3}MACRO_{i,t} + {}_{a4}SECT_{i,t} + {}_{vit} \quad (1)$$

where: CM – a selected characteristic of the credit market, covering one of two areas – the materialization of credit risk as a measure of the effectiveness of credit risk management, or access to credit, measured by the ratio of loans to GDP, the number of borrowers and credit accounts per 1,000 adults and credit margins; CRS – a selected characteristic of the credit information sharing system model, including features such as the scope of data collected in terms of borrowers and products, the detail and completeness of data, and the level of data coverage in public and private registries; MACRO – a vector of macroeconomic control variables; SECT – a vector of sector-level control variables. In static models (credit margins) the lagged dependent variable was omitted.

The results of the econometric models for credit risk management are presented in Appendix 3. The econometric analysis of the relationship between credit information sharing system models and the level of credit risk materialization (models 1A, 1B, 1C) makes it possible to indicate, based on the estimation results, that:

- the scale of credit risk materialization in the loan portfolio (total, households and enterprises) is strongly determined by its past (the lagged variable is significant at the 1% level in all models), and adjustments occur slowly and with a delay; the highest persistence is observed for household loans;
- the negative and statistically significant coefficient of the variable SEG_COMPL in all NPL models (at the 5% level) indicates that in countries where credit information systems cover the full spectrum of borrowers (households, SMEs and large enterprises), the NPL level is lower, which is consistent with a mechanism of reducing information asymmetry, improving the quality of the creditworthiness assessment process and reducing the risk of adverse selection. The coefficient is largest in absolute value in the segment of loans to enterprises, but differences between segments were not tested, and the scale of the estimates (approximately 1.1 standard deviations of the dependent variable in model 1A) requires cautious interpretation;
- the significant, negative coefficient of the variable BANKR_DATA, which reflects the inclusion of consumer bankruptcy information in credit information systems, indicates that in countries where insolvency data are included the NPL level is lower, which is consistent with better borrower selection, a greater ability of financial institutions to identify risk and faster elimination of impaired receivables from the loan portfolio. In this area too the estimate is largest in absolute value for the portfolio of loans to enterprises;
- a lower NPL level is also associated with the variable PRIV_COV, reflecting the degree of coverage of data on borrowers' credit histories in the population through the activities of private credit bureaus (coefficients significant at the 10% level in models 1A and 1B and at the 5% level in model 1C). A higher share of entities covered by databases is consistent with greater transparency of the credit market, more effective scoring mechanisms and a reduction in the occurrence of "anonymous borrowers". The estimate is largest in absolute value for the port-

folio of loans to enterprises. By contrast, no relationship with NPL is observed for the variable PUB_COV (coverage by public registries);

- the variable ESG, unlike most variables describing the scope and depth of the credit information sharing market, has a positive and statistically significant (at the 1% level) coefficient in NPL models in all the segments analyzed. This result should not, however, be interpreted as indicating a negative role of information. One possible interpretation is the so-called credit expansion effect: the development of information systems, including their extension with ESG components, may co-occur with a larger scale of financing and, consequently, with a higher level of non-performing loans. This interpretation is not, however, confirmed in the other models: the ESG variable is associated with a higher ratio of household loans to GDP but with a smaller number of borrowers and credit accounts per 1,000 adults (Appendix 4). Moreover, the variable is based on a single wave of the ACCIS survey (2025), so its coefficient reflects mainly cross-country differences. The coefficient is largest in absolute value in the enterprise segment, which is characterized by greater volatility and higher risk exposure;
- the variable reflecting access to income data (INCOME_DATA) does not show stable statistical significance. This may suggest that income data alone are not a sufficient source of improvement in credit risk assessment and that their informational value is partly explained by other variables;
- the variable LEGAL_RIGHTS, measuring the strength of legal support for borrowers, has a positive and statistically significant (at the 1% level) coefficient in NPL models. This result can be interpreted as a manifestation of the so-called regulatory trade-off effect, according to which greater protection of borrowers fosters the availability of credit but at the same time may weaken credit discipline and increase the propensity to take risk.

Regarding the control variables, the estimation results indicate significant differences in the role of macroeconomic factors across segments of the loan portfolio – for household receivables macroeconomic variables have limited importance, whereas in the enterprise segment economic growth (GDP_GR) shows a significant, negative relationship with the NPL level. Sector-level variables play a significant role in shaping loan portfolio quality. Bank profitability (ROE) shows a stable and statistically significant negative relationship with the level of non-performing loans, which is consistent with the importance of banking sector efficiency for financial stability. In turn, a higher loan-to-deposit ratio (LTD) is associated with a higher NPL level, which is consistent with the credit expansion channel as a source of deterioration in portfolio quality. Capital adequacy (TCR) has a negative coefficient, significant however only in some specifications, which is consistent with its stabilizing role.

The structure of the banking sector is also important for the NPL level of loan portfolios. A higher level of concentration (HHI) is associated with a lower level of non-performing loans.

At the same time, the size of the banking sector (LN_ASSETS) does not show a stable relationship with loan portfolio quality, from which it can be inferred that the scale of activity does not determine the level of risk in the absence of appropriate management mechanisms. The strongest relationships of sector-level variables with NPL are observed in the group of loans to enterprises.

Credit information sharing systems and access to credit

Regarding the relationship between selected characteristics of credit information sharing system models and access to bank credit, two types of models were built. Dynamic models were used for the dependent variables HHL_GDP, NFCL_GDP, BORR_1000 and CACC_1000, as in the case of the credit risk measures (Appendix 4). For the variables treating the cost of credit as a measure of its availability, it was not possible to use dynamic panel models. Based on the results of the Hausman test, static random-effects models were adopted (Appendix 5).

The key result of the study concerning the relationship between the credit information sharing system model and access to credit, obtained with dynamic models for the variables HHL_GDP, NFCL_GDP, BORR_1000 and CACC_1000, is the identification of two divergent patterns of co-occurrence. On the one hand, a broader scope of data, in particular income information and new forms of financing (such as BNPL), is associated with a higher ratio of household loans to GDP (INCOME_DATA: +28.9; BNPL: +10.9; both coefficients significant at the 1% level), which reflects credit volume. On the other hand, higher completeness of the system and the inclusion of insolvency information are associated with a lower number of borrowers and credit accounts per 1,000 adult inhabitants (SEG_COMPL: −72.1 and −141.9; BANKR_DATA: −105.3 and −166.6), which is consistent with tighter borrower selection.

The estimation results also indicate that both patterns coexist, which is consistent with the changing structure of the credit market. One possible interpretation is the so-called substitution effect, consisting in the concentration of credit among a smaller number of better-rated borrowers. This means that the development of credit information systems may be associated not only with market expansion but also with a qualitative change in the market.

Another important element of the analysis is the coverage of the population by private credit bureaus (PRIV_COV), which, unlike the variables related to system completeness, has a positive coefficient in the models of the number of borrowers (+0.621) and credit accounts (+0.994) per 1,000 adult inhabitants (both significant at the 5% level), with no significant relationship with the ratio of household loans to GDP (for loans to enterprises the coefficient is significant only at the 10% level). This indicates that broader coverage by private bureaus co-occurs with broader access to the market without increasing its total scale, which may constitute an argument for their role in limiting the phenomenon of "over-crediting". The opposite relationship is observed for coverage by public registries (PUB_COV), which is associated with a lower ratio

of household loans to GDP (−0.061) and with fewer borrowers (−0.721) and credit accounts (−1.092) per 1,000 adults. A detailed presentation is given in Appendix 4.

Based on the estimation results presented in Appendix 5, it can be stated that selected characteristics of credit information sharing systems also affect the level of credit margins and thus the cost of financing. Particularly important is the variable SEG_COMPL, reflecting the completeness of data on all categories of borrowers, whose coefficients are negative and statistically significant (at the 5% or 10% level) for all the types of margins analyzed. This means that in countries where credit information systems cover individuals, SMEs and large enterprises alike, margins (both nominal and real) are lower (by about 0.4-0.5 pp). A possible channel of influence here is the reduction of information asymmetry and the improvement in the quality of credit risk assessment, affecting the costs associated with the impairment of receivables.

A similar relationship is observed for the variable BANKR_DATA (coefficients from −0.38 to −0.49, significant at the 5% or 10% level). The inclusion of consumer bankruptcy information in the data aggregated and processed by credit bureaus is consistent with greater market transparency and more effective risk estimation by banks, which may reduce the need to apply high risk premiums in the price of credit.

The positive and partly statistically significant (only at the 10% level) coefficients for the variables PAYDAY and ESG indicate, by contrast, that extending databases with data on short-term loans and ESG components may be associated with an increase in credit margins, which can be interpreted as an effect of taking additional sources of risk or information costs into account. At the same time, the lack of statistical significance of the variables LEGAL_RIGHTS, CI_DEPTH, PUB_COV and PRIV_COV suggests that the formal quality of the regulatory framework, the detail of credit information and the scale of coverage of credit databases are of limited importance for the formation of credit prices compared with the actual scope and content of the data processed.

Summary

The study examined the relationship between selected characteristics of credit information exchange systems and the materialization of credit risk (NPL), access to credit, and the cost of credit. In the NPL models it was shown that extensive and complete credit information sharing systems are associated with a lower level of non-performing loans. Particularly important are the completeness of the database with regard to information on households, SMEs and large enterprises (SEG_COMPL) and the inclusion of information on consumer bankruptcy (BANKR_DATA), which are associated with a lower NPL in all portfolio segments; the estimates are largest in absolute value for loans to enterprises, where information asymmetry is structurally greatest, although differences between segments were not tested. A difference

can also be observed between models dominated by private databases and those dominated by public credit registries. A higher share of adults covered by private databases is associated with a lower NPL (significance at the 10% level in models 1A and 1B and at the 5% level in model 1C), especially in the enterprise portfolio, whereas no such relationship was found for coverage by public registries.

As regards the cost of credit, it should be emphasized that the completeness of data on borrowers and the inclusion of bankruptcy data are associated with lower credit margins, both nominal and real (by about 0.4–0.5 pp), which is consistent with the interpretation that better information reduces the risk premium built into the price of credit. Extending databases with data on short-term loans and ESG components is, by contrast, associated with higher margins (significance only at the 10% level), which can be interpreted as a reflection of higher information costs or of taking additional types of risk into account. The formal quality of the regulatory framework, the detail of credit information and the scale of coverage of databases do not show a significant relationship with credit prices. This suggests that the actual content and scope of the data processed matter more than the reach of the system alone.

The modeling results thus point to three regularities, corresponding to auxiliary hypotheses H1-H3. The completeness of the credit information system with regard to borrowers and the inclusion of consumer bankruptcy information are associated with both a lower NPL level and lower credit margins. The detail of information (CI_DEPTH) and full reporting (POS_COMPL, NEG_COMPL) do not show such a relationship.

The completeness of the system is associated with narrower access to credit, measured by the number of borrowers and accounts per 1,000 adults, which is consistent with tighter selection; the development of the credit information system is therefore not unambiguously pro-inclusive – it is associated with lower risk and lower costs but at the same time with narrower access, which may concern weaker borrowers in particular. Population coverage by private credit bureaus is associated with a lower NPL and broader access to credit, whereas coverage by public registries is not associated with NPL but is associated with narrower access.

The limitations of the study result from the scope of data availability. The characteristics of the credit information sharing system were entered into the models one at a time because of possible multicollinearity. The variables SEG_COMPL, INCOME_DATA, BANKR_DATA, NEG_COMPL and POS_COMPL are based on two rounds of the ACCIS survey (2020 and 2025), whereas the variables BNPL, PAYDAY and ESG are based on one (2025), which limits their variation over time. The estimates for these variables reflect to a large extent cross-country differences. The research therefore needs to be continued when data from subsequent periods become available.

Appendix 1

Characteristics of the set of variables used in the study of the impact of the credit information sharing system model on credit risk in banks and on the availability of bank credit

Variable	Definition	Area of analysis	Data source
Dependent variables – materialization of credit risk (model group 1)			
NPL_TOT	Value of the NPL ratio of the total loan portfolio in the banking sector of a given country in a given year	Loan portfolio quality and its changes – scale of credit risk materialization in the banking sector	ECB Consolidated Banking Data
NPL_HH	Value of the NPL ratio of the household loan portfolio in the banking sector of a given country in a given year		
NPL_NFC	Value of the NPL ratio of the non-financial corporate loan portfolio in the banking sector of a given country in a given year		
Dependent variables – access to bank credit (model group 2)			
HHL_GDP	Household loans / GDP of the country	Level of financial sector involvement in lending to the economy	EUROSTAT https://ec.europa.eu/eurostat/databrowser/view/tipspd25/default/table
NFCL_GDP	Loans to enterprises / GDP of the country		
BORR_1000	Number of borrowers per 1,000 adults in a given country	Scale of credit involvement	
CACC_1000	Number of credit accounts per 1,000 adults in a given country		

Variable	Definition	Area of analysis	Data source
Dependent variables – price of credit as a component of availability (model group 3)			
MRG_MORT_NOM	Margin (nominal interest rate basis) on housing loans (new business, AAR)	Bank interest margin defined as the difference between the average interest rate on loans in a given exposure category and the yield on risk-free assets (instruments offered by the central bank in a given country as a liquidity-absorbing tool)	Own calculations based on data from the ECB database and the databases of individual central banks
MRG_CONS_NOM	Margin (nominal interest rate basis) on consumer loans (new business, AAR)		
MRG_MORT_REAL	Margin (real interest rate basis) on housing loans (new business, AAR)		
MRG_CONS_REAL	Margin (real interest rate basis) on consumer loans (new business, APRC)		
Explanatory variables – macroeconomic characteristics			
HICP	HICP index – harmonized measure of inflation in the EU	Inflation rate	Eurostat
GDP_GR	Change in the real value of the country's GDP	Level of economic growth	
PUBDEBT_GDP	General government debt / GDP of the country	Scale of public debt	
Explanatory variables – sector-level characteristics			
HHI	Herfindahl-Hirschman index	Level of market competition in the banking sector of a given country	ECB Structural Financial Indicators https://data.ecb.europa.eu/methodology/structural-financial-indicators

Variable	Definition	Area of analysis	Data source
Explanatory variables – sector-level characteristics			
LN_ASSETS	Natural logarithm of total sector assets	Size of the banking sector	ECB Consolidated Banking Data https://data.ecb.europa.eu/data/data-categories
TCR	Total equity / RWA	Financial stability of banking sectors	
LTD	Total loans to the non-financial sector / total deposits from the non-financial sector	Balance of funding of the non-financial sector	
ROE	Net result / average equity of the banking sector	Profitability/efficiency of the banking sector	
Variables of interest – characteristics of the credit information sharing system model			
SEG_COMPL	Binary variable reflecting the borrower-coverage criterion; 1 – where complete data are processed, covering individuals, small and medium-sized enterprises and large enterprises; 0 – where the data do not cover the enterprise segment	Completeness of data collected and processed by credit bureaus – borrower-coverage criterion	Own analyses based on ACCIS (2025), ACCIS Membership Survey 2025 and ACCIS (2020), ACCIS Membership Survey
INCOME_DATA	Binary variable reflecting the processing by credit bureaus of data on borrowers' incomes – 1 where the data are collected and processed; 0 – where this component is not included in the information processed	Scope of processing of economic data on borrowers who are natural persons	
BANKR_DATA	Binary variable reflecting the processing of data by credit bureaus on the occurrence of consumer bankruptcy; 1 – where data in this area are analyzed; 0 – otherwise	Inclusion of consumer bankruptcy in the data collected and processed on borrowers	

Variable	Definition	Area of analysis	Data source
Variables of interest – characteristics of the credit information sharing system model			
BNPL	Binary variable reflecting the processing of data by credit bureaus on BNPL loans; 1 – where data in this area are analyzed; 0 – otherwise	Inclusion of information on BNPL receivables in the information processed	ACCIS (2025), ACCIS Membership Survey 2025
PAYDAY	Binary variable reflecting the processing of data by credit bureaus on short-term payday loans; 1 – where data in this area are analyzed; 0 – otherwise	Inclusion of information on receivables from short-term loans in the information processed	
NEG_COMPL	Binary variable reflecting the criterion of the scope of processing of negative information: 1 – where the bureau processes information in at least 4 of 6 areas: a) default status (delay of more than 90 days); b) arrears (30–90 days past due); c) list of rejected cheques; d) number of unpaid/ overdue installments; e) impairment write-downs on receivables; f) original amount of the loan agreement (initial exposure amount); 0 – otherwise	Completeness of negative information processed by credit bureaus in a given country	Own analyses based on ACCIS (2025), ACCIS Membership Survey 2025 and ACCIS (2020), ACCIS Membership Survey
POS_COMPL	Binary variable reflecting the criterion of the scope of processing of positive information: 1 – where the bureau processes information in at least 4 of 6 areas: a) amount outstanding; b) payment terms; c) type of interest rate; d) level of interest rate; e) payments made on time; f) credit period; 0 – otherwise	Completeness of positive information processed by credit bureaus in a given country	
ESG	Binary variable concerning the support by credit bureaus for the process of building information databases for estimating ESG risk in the credit process; 1 – bureaus in each country are building a database supporting the process; 0 – no such activities are undertaken	Involvement of credit bureaus in the process of building databases of information on borrowers' ESG standards	ACCIS (2025), ACCIS Membership Survey 2025

Variable	Definition	Area of analysis	Data source
Variables of interest – characteristics of the credit information sharing system model			
LEGAL_RIGHTS	Index of the strength of legal support for borrowers; scale 0–12	Aggregate parameter – measures whether the regulations on collateral and bankruptcy contain elements that facilitate lending	World Bank Group
CI_DEPTH	Depth of credit information index; scale 0–8	Aggregate parameter – measures the scope, range and accessibility of credit information provided by entities offering credit reporting services, such as credit bureaus or credit registries.	
PUB_COV	Number of individuals or business entities included in the databases of public credit registries for which current credit history data are available, including both positive and negative information. The value of the indicator is expressed as a percentage of the adult population.	Scope of coverage of credit information by private and public credit bureaus	
PRIV_COV	Number of individuals or business entities included in the databases of private credit bureaus for which current credit history data are available, including both positive and negative information. The value of the indicator is expressed as a percentage of the adult population.		

Source: Own elaboration

Appendix 2

Descriptive statistics of the variables used in models 1–3

Variable	Mean	Median	Standard deviation	Minimum	Maximum
SEG_COMPL	0.400	0.000	0.491	0.000	1.000
INCOME_DATA	0.250	0.000	0.434	0.000	1.000
BANKR_DATA	0.650	1.000	0.478	0.000	1.000
BNPL	0.550	1.000	0.499	0.000	1.000
PAYDAY	0.600	1.000	0.491	0.000	1.000
NEG_COMPL	0.400	0.000	0.491	0.000	1.000
POS_COMPL	0.250	0.000	0.434	0.000	1.000
ESG	0.424	0.000	0.495	0.000	1.000
LEGAL_RIGHTS	5.497	6.000	2.331	2.000	9.000
CI_DEPTH	6.063	7.000	1.785	0.000	8.000
PUB_COV	20.252	1.900	31.561	0.000	100.000
PRIV_COV	53.067	65.700	39.825	0.000	100.000
NPL_HH	6.279	3.328	9.486	0.633	55.014
NPL_NFC	11.759	6.674	12.740	0.388	67.367
NPL_TOT	5.653	2.962	7.824	0.565	46.776
MRG_MORT_NOM	2.107	2.258	1.227	−2.786	6.541
MRG_CONS_NOM	6.620	6.018	3.717	−3.688	20.064
MRG_MORT_REAL	2.420	2.613	1.264	−2.436	7.288
MRG_CONS_REAL	7.918	7.190	4.934	−3.688	33.218
NFCL_GDP	76.462	63.500	45.592	26.300	248.500
HHL_GDP	51.077	49.100	26.434	12.500	130.700
BORR_1000	412.768	437.175	117.619	204.320	669.260
CACC_1000	652.834	636.515	224.640	309.190	1217.310
HICP	2.690	1.600	3.668	−2.500	20.700
GDP_GR	2.609	2.500	3.753	−10.940	24.620
PUBDEBT_GDP	69.228	61.150	38.863	8.500	209.400
HHI	0.137	0.114	0.075	0.010	0.356
LN_ASSETS	19.687	19.787	1.701	16.911	23.005
TCR	20.033	19.672	3.799	12.045	35.611
LTD	91.386	83.846	34.097	44.117	248.936
ROE	7.381	8.181	5.977	−24.217	21.801

Source: own elaboration based on the dataset.

Appendix 3

Estimation results of model 1A – credit information sharing systems and credit risk of total loan portfolios (NPL_TOT)

VARIABLE	NPL_TOT											
	SEG_ COMPL	**INCOME_ DATA**	**BANKR_ DATA**	**BNPL**	**PAYDAY**	**NEG_ COMPL**	**POS_ COMPL**	**ESG**	**LEGAL_ RIGHTS**	**CI_ DEPTH**	**PUB_ COV**	**PRIV_ COV**
NPL_TOT (−1)	0.842*** (0.067)	0.856*** (0.064)	0.831*** (0.069)	0.876*** (0.059)	0.869*** (0.061)	0.853*** (0.062)	0.858*** (0.064)	0.847*** (0.066)	0.742*** (0.078)	0.748*** (0.076)	0.751*** (0.074)	0.733*** (0.081)
VAR. OF INTEREST	**−8.912** (4.221)	**3.105** (2.887)	**−10.443** (4.997)	**2.781** (1.608)	**1.944** (2.083)	**4.882** (4.201)	**4.603** (4.314)	**5.431*** (2.066)	**0.401*** (0.121)	**−0.082** (0.192)	**−0.007** (0.008)	**−0.015** (0.008)
HICP	−0.012 (0.118)	−0.014 (0.117)	−0.011 (0.119)	−0.015 (0.116)	−0.013 (0.117)	−0.012 (0.118)	−0.012 (0.118)	−0.016 (0.119)	0.072 (0.152)	0.068 (0.154)	0.052 (0.148)	0.059 (0.153)
GDP_GR	−0.082 (0.142)	−0.085 (0.141)	−0.081 (0.143)	−0.089 (0.140)	−0.086 (0.141)	−0.083 (0.142)	−0.084 (0.142)	−0.091 (0.144)	0.071* (0.043)	0.074* (0.044)	0.066* (0.041)	0.069* (0.043)
PUBDEBT_ GDP	0.021 (0.061)	0.020 (0.061)	0.022 (0.062)	0.019 (0.060)	0.020 (0.060)	0.021 (0.061)	0.021 (0.061)	0.018 (0.062)	0.061 (0.050)	0.063 (0.051)	0.044 (0.052)	0.060 (0.051)
HHI	−9.884 (14.003)	−10.228 (13.821)	−9.332 (14.221)	−10.664 (13.572)	−10.441 (13.601)	−10.112 (13.667)	−10.183 (13.719)	−9.451 (14.055)	−32.772*** (9.412)	−34.115*** (9.633)	−33.201*** (9.512)	−35.004*** (9.083)
LN_ASSETS	0.612 (1.311)	0.629 (1.298)	0.588 (1.324)	0.664 (1.271)	0.645 (1.284)	0.621 (1.290)	0.633 (1.296)	0.682 (1.318)	−0.301 (1.166)	−0.333 (1.186)	−0.072 (1.151)	−0.095 (1.139)
TCR	−0.031 (0.059)	−0.033 (0.058)	−0.030 (0.060)	−0.034 (0.057)	−0.032 (0.058)	−0.031 (0.059)	−0.032 (0.059)	−0.036 (0.060)	−0.071* (0.041)	−0.068* (0.042)	−0.081** (0.038)	−0.076* (0.041)

VARIABLE	NPL_TOT											
	SEG_ COMPL	INCOME_ DATA	BANKR_ DATA	BNPL	PAYDAY	NEG_ COMPL	POS_ COMPL	ESG	LEGAL_ RIGHTS	CI_ DEPTH	PUB_ COV	PRIV_ COV
LTD	0.038*	0.037*	0.039*	0.036*	0.037*	0.038*	0.037*	0.035*	0.021***	0.021***	0.022***	0.020***
	(0.023)	(0.022)	(0.023)	(0.022)	(0.022)	(0.022)	(0.023)	(0.023)	(0.008)	(0.008)	(0.007)	(0.008)
ROE	−0.141***	−0.144***	−0.138***	−0.147***	−0.145***	−0.142***	−0.143***	−0.149***	−0.201***	−0.194***	−0.189***	−0.183***
	(0.051)	(0.050)	(0.052)	(0.049)	(0.050)	(0.050)	(0.051)	(0.052)	(0.023)	(0.024)	(0.023)	(0.024)
AR(1)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.001***	0.001***	0.001***	0.001***
AR(2)	0.312	0.287	0.338	0.251	0.266	0.294	0.281	0.303	0.412	0.395	0.377	0.421
Hansen test	0.31	0.28	0.34	0.26	0.27	0.29	0.30	0.33	0.48	0.45	0.41	0.44
Nb. of instruments	24	24	24	24	24	24	24	24	24	24	24	24

Standard errors in parentheses; *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Estimation results of model 1B – credit information sharing systems and credit risk of household loan portfolios (NPL_HH)

VARIABLE	NPL_HH											
	SEG_ COMPL	**INCOME_ DATA**	**BANKR_ DATA**	**BNPL**	**PAYDAY**	**NEG_ COMPL**	**POS_ COMPL**	**ESG**	**LEGAL_ RIGHTS**	**CI_DEPTH**	**PUB_COV**	**PRIV_COV**
NPL_HH (−1)	0.861*** (0.063)	0.872*** (0.060)	0.852*** (0.067)	0.889*** (0.057)	0.883*** (0.059)	0.866*** (0.060)	0.871*** (0.061)	0.859*** (0.064)	0.751*** (0.075)	0.758*** (0.073)	0.762*** (0.072)	0.744*** (0.078)
VAR. OF INTEREST	**−7.214** (3.512)	**2.884** (2.563)	**−9.338** (4.114)	**2.431** (1.442)	**1.602** (1.876)	**4.211** (4.982)	**4.095** (4.071)	**4.872*** (1.854)	**0.338*** (0.098)	**−0.074** (0.151)	**−0.006** (0.007)	**−0.013** (0.007)
HICP	−0.018 (0.102)	−0.019 (0.101)	−0.017 (0.103)	−0.020 (0.100)	−0.019 (0.101)	−0.018 (0.102)	−0.018 (0.102)	−0.021 (0.103)	0.066 (0.134)	0.062 (0.136)	0.048 (0.131)	0.055 (0.135)
GDP_GR	−0.096 (0.124)	−0.098 (0.123)	−0.095 (0.125)	−0.101 (0.122)	−0.099 (0.123)	−0.097 (0.124)	−0.097 (0.124)	−0.104 (0.126)	0.062* (0.038)	0.065* (0.039)	0.058* (0.036)	0.061* (0.038)
PUBDEBT_ GDP	0.018 (0.054)	0.018 (0.054)	0.019 (0.055)	0.017 (0.053)	0.018 (0.053)	0.018 (0.054)	0.018 (0.054)	0.016 (0.055)	0.054 (0.044)	0.056 (0.045)	0.039 (0.046)	0.053 (0.045)
HHI	−8.442 (12.231)	−8.763 (12.040)	−7.991 (12.406)	−9.215 (11.862)	−9.028 (11.910)	−8.726 (11.973)	−8.791 (12.021)	−8.103 (12.298)	−28.114*** (8.203)	−29.332*** (8.401)	−28.605*** (8.315)	−30.018*** (7.964)
LN_ ASSETS	0.511 (1.084)	0.526 (1.072)	0.489 (1.098)	0.556 (1.051)	0.539 (1.061)	0.518 (1.067)	0.529 (1.073)	0.575 (1.091)	−0.244 (0.987)	−0.268 (1.003)	−0.061 (0.972)	−0.079 (0.963)
TCR	−0.028 (0.048)	−0.029 (0.047)	−0.027 (0.049)	−0.030 (0.047)	−0.028 (0.047)	−0.028 (0.048)	−0.028 (0.048)	−0.031 (0.049)	−0.059* (0.034)	−0.057* (0.035)	−0.069** (0.032)	−0.064* (0.034)

VARIABLE	NPL_HH											
	SEG_ COMPL	INCOME_ DATA	BANKR_ DATA	BNPL	PAYDAY	NEG_ COMPL	POS_ COMPL	ESG	LEGAL_ RIGHTS	CI_DEPTH	PUB_COV	PRIV_COV
LTD	0.031*	0.030*	0.032*	0.029*	0.030*	0.031*	0.030*	0.028*	0.018***	0.018***	0.019***	0.017***
	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.018)	(0.019)	(0.006)	(0.006)	(0.006)	(0.006)
ROE	−0.118***	−0.121***	−0.115***	−0.123***	−0.121***	−0.119***	−0.120***	−0.126***	−0.178***	−0.171***	−0.167***	−0.161***
	(0.044)	(0.043)	(0.045)	(0.042)	(0.043)	(0.043)	(0.044)	(0.045)	(0.020)	(0.021)	(0.020)	(0.021)
AR(1)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.001***	0.001***	0.001***	0.001***
AR(2)	0.295	0.268	0.321	0.244	0.257	0.281	0.269	0.296	0.401	0.382	0.366	0.408
Hansen test	0.34	0.31	0.36	0.29	0.30	0.32	0.33	0.35	0.49	0.46	0.42	0.45
Nb. of instruments	24	24	24	24	24	24	24	24	24	24	24	24

Standard errors in parentheses; *** $p < 0.01$; ** $p < 0.05$; * $p < 0.1$.

Estimation results of model 1C – credit information sharing systems and credit risk of non-financial corporate loan portfolios (NPL_NFC)

VARIABLE	NPL_NFC											
	SEG_ COMPL	**INCOME_ DATA**	**BANKR_ DATA**	**BNPL**	**PAYDAY**	**NEG_ COMPL**	**POS_ COMPL**	**ESG**	**LEGAL_ RIGHTS**	**CI_DEPTH**	**PUB_COV**	**PRIV_COV**
NPL_NFC (−1)	0.823*** (0.071)	0.836*** (0.069)	0.812*** (0.074)	0.852*** (0.064)	0.847*** (0.066)	0.831*** (0.068)	0.835*** (0.069)	0.826*** (0.072)	0.702*** (0.086)	0.709*** (0.083)	0.715*** (0.081)	0.694*** (0.089)
VAR. OF INTEREST	**−9.874** (4.103)	**4.621** (3.743)	**−11.552** (4.889)	**3.984** (1.612)	**2.871** (2.743)	**5.911** (5.023)	**5.288** (5.117)	**6.204*** (1.954)	**0.466*** (0.134)	**−0.095** (0.178)	**−0.011** (0.009)	**−0.018** (0.008)
HICP	−0.009 (0.129)	−0.011 (0.128)	−0.008 (0.130)	−0.012 (0.127)	−0.010 (0.128)	−0.009 (0.129)	−0.009 (0.129)	−0.013 (0.130)	0.081 (0.167)	0.076 (0.170)	0.058 (0.163)	0.066 (0.168)
GDP_GR	−0.143** (0.071)	−0.147** (0.070)	−0.141** (0.072)	−0.152** (0.069)	−0.148** (0.070)	−0.145** (0.071)	−0.146** (0.071)	−0.155** (0.073)	−0.089* (0.052)	−0.093* (0.053)	−0.084* (0.050)	−0.088* (0.052)
PUBDEBT_ GDP	0.033 (0.059)	0.032 (0.058)	0.034 (0.060)	0.031 (0.057)	0.032 (0.057)	0.033 (0.058)	0.033 (0.058)	0.029 (0.060)	0.072 (0.048)	0.075 (0.049)	0.052 (0.050)	0.071 (0.049)
HHI	−18.223 (15.892)	−18.917 (15.604)	−17.441 (16.103)	−19.884 (15.321)	−19.332 (15.435)	−18.765 (15.508)	−18.912 (15.551)	−17.998 (15.947)	−38.774*** (10.041)	−40.112*** (10.355)	−39.228*** (10.214)	−41.667*** (9.721)
LN_ ASSETS	1.204 (1.331)	1.236 (1.309)	1.156 (1.351)	1.287 (1.276)	1.258 (1.292)	1.221 (1.301)	1.239 (1.308)	1.298 (1.344)	0.112 (1.178)	0.074 (1.196)	0.488 (1.152)	0.462 (1.136)
TCR	−0.052 (0.051)	−0.054 (0.050)	−0.050 (0.052)	−0.056 (0.049)	−0.053 (0.050)	−0.052 (0.051)	−0.053 (0.051)	−0.057 (0.052)	−0.098** (0.041)	−0.094** (0.042)	−0.109*** (0.038)	−0.102** (0.041)

VARIABLE	NPL_NFC											
	SEG_ COMPL	INCOME_ DATA	BANKR_ DATA	BNPL	PAYDAY	NEG_ COMPL	POS_ COMPL	ESG	LEGAL_ RIGHTS	CI_DEPTH	PUB_COV	PRIV_COV
LTD	0.049**	0.048**	0.050**	0.047**	0.048**	0.049**	0.048**	0.046**	0.029***	0.029***	0.030***	0.028***
	(0.022)	(0.021)	(0.022)	(0.021)	(0.021)	(0.021)	(0.022)	(0.022)	(0.008)	(0.008)	(0.008)	(0.008)
ROE	−0.163***	−0.167***	−0.159***	−0.170***	−0.167***	−0.164***	−0.166***	−0.172***	−0.221***	−0.214***	−0.209***	−0.203***
	(0.048)	(0.047)	(0.049)	(0.046)	(0.047)	(0.047)	(0.048)	(0.049)	(0.024)	(0.025)	(0.024)	(0.025)
AR(1)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.001***	0.001***	0.001***	0.001***
AR(2)	0.271	0.244	0.298	0.229	0.241	0.263	0.252	0.276	0.389	0.371	0.355	0.397
Hansen test	0.29	0.27	0.32	0.25	0.26	0.28	0.30	0.31	0.46	0.43	0.40	0.42
Nb. of instruments	24	24	24	24	24	24	24	24	24	24	24	24

Standard errors in parentheses; *** p < 0.01; ** p < 0.05; * p < 0.1.

Appendix 4

Selected estimation parameters of the model of determinants of credit availability – variables of interest describing the credit information sharing system model (dynamic models)

VARIABLE	SEG_ COMPL	INCOME_ DATA	BANKR_ DATA	BNPL	PAYDAY	NEG_ COMPL	POS_ COMPL	ESG	LEGAL_ RIGHTS	CI_ DEPTH	PUB_ COV	PRIV_ COV
						HHL_GDP						
HHL_GDP(−1)	0.781*** (0.082)	0.802*** (0.079)	0.769*** (0.085)	0.816*** (0.072)	0.798*** (0.077)	0.792*** (0.078)	0.801*** (0.076)	0.795*** (0.076)	0.764*** (0.088)	0.771*** (0.086)	0.768*** (0.084)	0.742*** (0.089)
VAR. OF INTEREST	**−31.52*** (9.88)**	**28.94*** (8.72)**	**−36.11*** (11.43)**	**10.87*** (3.91)**	**19.03*** (5.02)**	**8.72** (4.21)**	**14.96*** (5.47)**	**12.64*** (4.18)**	**0.91** (0.45)**	**1.08* (0.63)**	**−0.061** (0.028)**	**0.031 (0.021)**
AR(1)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.001***	0.001***	0.001***	0.001***
AR(2)	0.312	0.301	0.338	0.289	0.294	0.307	0.298	0.303	0.412	0.398	0.377	0.421
Hansen (p)	0.34	0.36	0.33	0.35	0.34	0.32	0.34	0.35	0.48	0.45	0.41	0.44
Nb. of instruments	24	24	24	24	24	24	24	24	24	24	24	24
						NFCL_GDP						
NFCL_GDP(−1)	0.753*** (0.091)	0.771*** (0.087)	0.741*** (0.095)	0.788*** (0.080)	0.765*** (0.084)	0.759*** (0.086)	0.767*** (0.083)	0.768*** (0.084)	0.731*** (0.096)	0.739*** (0.093)	0.735*** (0.091)	0.722*** (0.097)
VAR. OF INTEREST	**−18.44** (7.89)**	**24.62*** (8.33)**	**−15.06 (10.92)**	**3.91 (4.77)**	**11.28* (6.31)**	**−0.94 (5.44)**	**2.87 (6.81)**	**6.12 (5.11)**	**0.83 (0.98)**	**−0.05 (1.08)**	**−0.042 (0.039)**	**0.048* (0.026)**

VARIABLE	SEG_ COMPL	INCOME_ DATA	BANKR_ DATA	BNPL	PAYDAY	NEG_ COMPL	POS_ COMPL	ESG	LEGAL_ RIGHTS	CI_ DEPTH	PUB_ COV	PRIV_ COV
NFCL_GDP												
AR(1)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.001***	0.001***	0.001***	0.001***
AR(2)	0.284	0.276	0.312	0.268	0.271	0.289	0.280	0.286	0.401	0.387	0.366	0.408
Hansen (p)	0.31	0.33	0.30	0.32	0.31	0.29	0.31	0.32	0.47	0.44	0.40	0.42
Nb. of instruments	24	24	24	24	24	24	24	24	24	24	24	24
BORR_1000												
BORR_1000(−1)	0.911*** (0.044)	0.924*** (0.041)	0.905*** (0.046)	0.933*** (0.038)	0.919*** (0.041)	0.914*** (0.043)	0.918*** (0.042)	0.918*** (0.042)	0.892*** (0.052)	0.896*** (0.050)	0.893*** (0.049)	0.887*** (0.051)
VAR. OF INTEREST	**−72.11** (32.88)**	**−138.57*** (41.06)**	**−105.33*** (35.90)**	**−162.4*** (29.55)**	**−135.1*** (38.77)**	**−168.92*** (27.44)**	**−98.44*** (26.88)**	**−129.88*** (27.41)**	**−15.41*** (5.03)**	**−23.77** (11.62)**	**−0.721*** (0.281)**	**0.621** (0.298)**
AR(1)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.001***	0.001***	0.001***	0.001***
AR(2)	0.298	0.287	0.321	0.276	0.279	0.292	0.284	0.289	0.409	0.392	0.371	0.413
Hansen (p)	0.35	0.38	0.33	0.36	0.34	0.32	0.34	0.35	0.49	0.46	0.42	0.45
Nb. of instruments	24	24	24	24	24	24	24	24	24	24	24	24

VARIABLE	SEG_ COMPL	INCOME_ DATA	BANKR_ DATA	BNPL	PAYDAY	NEG_ COMPL	POS_ COMPL	ESG	LEGAL_ RIGHTS	CI_ DEPTH	PUB_ COV	PRIV_ COV
						CACC_1000						
CACC_1000(−1)	0.903*** (0.052)	0.916*** (0.049)	0.899*** (0.055)	0.924*** (0.045)	0.911*** (0.048)	0.907*** (0.051)	0.909*** (0.050)	0.910*** (0.048)	0.884*** (0.058)	0.889*** (0.057)	0.886*** (0.055)	0.881*** (0.058)
VAR. OF INTEREST	**−141.88*** (48.77)**	**−82.31 (74.22)**	**−166.55** (67.38)**	**−178.9*** (43.11)**	**−150.77** (59.02)**	**−202.81*** (45.66)**	**−113.55** (48.01)**	**−221.77*** (56.02)**	**−24.11*** (5.19)**	**−23.88** (10.92)**	**−1.092*** (0.388)**	**0.994** (0.472)**
AR(1)	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.000***	0.001***	0.001***	0.001***	0.001***
AR(2)	0.271	0.265	0.298	0.254	0.258	0.276	0.267	0.271	0.389	0.374	0.355	0.397
Hansen (p)	0.33	0.36	0.31	0.34	0.32	0.30	0.32	0.33	0.46	0.43	0.40	0.42
Nb. of instruments	24	24	24	24	24	24	24	24	24	24	24	24

Standard errors in parentheses; *** p < 0.01; ** p < 0.05; * p < 0.1.

Appendix 5

Selected estimation parameters of the model of determinants of the nominal and real cost of bank credit – variables of interest describing the credit information sharing system model (static models)

VARIABLE	SEG_ COMPL	INCOME_ DATA	BANKR_ DATA	BNPL	PAYDAY	NEG_ COMPL	POS_ COMPL	ESG	LEGAL_ RIGHTS	CI_ DEPTH	PUB_ COV	PRIV_ COV
MRG_MORT_NOM	−0.42**	0.31*	−0.38*	0.15	0.22*	0.05	0.11	0.19*	−0.03	−0.02	−0.01	0.01
	(0.18)	(0.17)	(0.21)	(0.11)	(0.13)	(0.12)	(0.14)	(0.11)	(0.04)	(0.03)	(0.01)	(0.01)
MRG_CONS_NOM	−0.36*	0.28	−0.41*	0.18	0.25*	0.09	0.16	0.21*	−0.04	−0.03	−0.01	0.02
	(0.20)	(0.19)	(0.22)	(0.13)	(0.14)	(0.13)	(0.15)	(0.12)	(0.04)	(0.03)	(0.01)	(0.01)
MRG_MORT_REAL	−0.51**	0.27	−0.44*	0.12	0.20	0.03	0.09	0.18	−0.02	−0.03	−0.01	0.01
	(0.21)	(0.19)	(0.23)	(0.12)	(0.15)	(0.14)	(0.15)	(0.12)	(0.04)	(0.03)	(0.01)	(0.01)
MRG_CONS_REAL	−0.47**	0.26	−0.49**	0.16	0.23	0.08	0.14	0.20	−0.03	−0.02	−0.01	0.02
	(0.22)	(0.20)	(0.24)	(0.13)	(0.15)	(0.14)	(0.16)	(0.13)	(0.04)	(0.03)	(0.01)	(0.01)

Standard errors in parentheses; *** p<0.01; ** p<0.05; * p<0.1.

References

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