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Overview

The ***Journal of Banking and Financial Economics*** **(JBFE)** is an open access journal. The submission of manuscripts in free of fee payment. This journal follows a double-blind reviewing procedure.

Aims and Scope

JBFE publishes high quality empirical and theoretical papers spanning all the major research fields in banking and financial economics. The aim of the journal is to provide an outlet for the increasing flow of scholarly research concerning banking, financial institutions and the money and capital markets within which they function. The journal also focuses on interrelations of financial variables, such as prices, interest rates and shares and concentrates on influences of real economic variables on financial ones and vice versa. Macro-financial policy issues, including comparative financial systems, the globalization of financial services, and the impact of these phenomena on economic growth and financial stability, are also within the *JBFE*'s scope of interest. The Journal seeks to promote research that enriches the profession's understanding of the above mentioned as well as to promote the formulation of sound public policies.

Main subjects covered include, e.g.: [1] ***Valuation of assets***: Accounting and financial reporting; Asset pricing; Stochastic models for asset and instrument prices; [2] ***Financial markets and instruments:*** Alternative investments; Commodity and energy markets; Derivatives, stocks and bonds markets; Money markets and instruments; Currency markets; [3] ***Financial institutions, services and regulation***: Banking efficiency; Banking regulation; Bank solvency and capital structure; Credit rating and scoring; Regulation of financial markets and institutions; Systemic risk; [4] ***Corporate finance and governance****:* Behavioral finance; Empirical finance; Financial applications of decision theory or game theory; Financial applications of simulation or numerical methods; Financial forecasting; Financial risk management and analysis; Portfolio optimization and trading.

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Proposals of Special Issues should be submitted to at jbfe@wz.uw.edu.pl. All proposals are being reviewed by the Editorial Team on the basis of certain criteria that include e.g.: the novelty, importance and topicality of the theme; whether the papers will form an integrated whole; and the overall 'added value' of a Special Issue.

CONTENTS

Effect of introduction of German and Hungarian bank levies on banks' risk-taking behavior

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ABSTRACT

Policymakers introduce bank levies (BLs) to reduce the probability of crises. In this study, we evaluate the effects of the Hungarian and German BLs implemented in 2010 and 2011, respectively, on the banks' risk-taking behavior. Our analysis compares two completely different BL designs. The German BL is designed to increase as banks' total liabilities increase, while the Hungarian BL is assessed on total assets. The results unambiguously demonstrate that a BL on assets increases banks' credit risk. The results of analyzing the influence that introducing BLs has had on the German banking sector demonstrate that BL on liabilities decreases banks' credit risk. An improved understanding of the impact of regulation on the risky activity of EU banks is very important for a wide range of financial market participants, including borrowers, shareholders regulators and supervisors, especially during turbulent times caused by the COVID-19 pandemic and the Russian war in Ukraine.

JEL Classification: G010, G2, G28

Keywords: bank levy, credit quality, banks, regulations, taxation.

1. INTRODUCTION

The question regarding the additional taxes on banks gained prominence following the financial crisis of 2007–2008. The topic has generated extensive public and political discussion in recent years with many proposals presented, some of which have been implemented in national legislation. In 2010, the International Monetary Fund (IMF, 2010) proposed the Financial Stability Contribution of the financial sector, within which the main component was intended to be a levy to pay for the fiscal cost of any future government support to the sector. IMF stated that this contribution might be paid by all financial institutions and reflect individual institutions' riskiness and contributions to systemic risk.

One of the main purposes of introducing a bank levy (BL) was to limit bank involvement in risky activities and to minimize the likelihood of potential systemic crises, such as those experienced in 2007–2008 (Cannas et al., 2014). Thus, many countries decided to introduce this

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regulatory instrument, even though the taxation schemes they applied differed. For example, the European Union Member States, such as Austria, Belgium, Cyprus, Denmark, Germany, the Netherlands, Latvia, Portugal, Romania, Slovakia, Sweden, and the United Kingdom, decided to introduce a BL on bank liabilities, while Poland and Hungary proposed a BL on bank assets. In turn, France chose to levy bank capital.

The main goal of the study is to examine whether the BLs introduced in Germany and Hungary are fulfilling their roles. In this research, we evaluate the effects of the Hungarian and German BLs implemented in 2010 and 2011, respectively, on the risk-taking behavior of banks. We compare two totally different BL designs. The German BL is designed to increase as a bank's total liabilities increase, with selected positions excluded from total liabilities (Buch, Hilberg, & Tonzer, 2016). Hungary adopted a BL that is conceptually quite different from the German design. In Hungary, the BL was assessed according to the total net assets of inter-bank lending (Devereux, Johannesen, & Vella, 2015).

The analysis covers the panel structure data of 47 Hungarian banks with unconsolidated financial statements and 292 German banks with unconsolidated financial statements from 2005–2015. To evaluate the impact of levies on bank risk-taking behavior, our empirical methodology is a fixed-effects estimation, as suggested by the Hausman test, with standard errors clustered at the institutional level. As measures of bank risk, we use credit quality, measured as the loan loss provision to asset ratio (LLP) and the Z-score as the dependent variable. In a robustness check, we use ROE volatility as the dependent variable. An important research question is whether BLs can reduce bank riskiness. Moreover, which BL design will reduce banks' risk-taking behavior? Does the type of institution also matter?

The estimation results demonstrate that the BL on assets increases banks' risk-taking activities. The BL introduction in Hungary increases the bank's average LLP, especially in smaller commercial banks and other entities. Moreover, research shows that the amount of paid BL also matters. Moreover, BL introduction in Hungary also increases a bank's ROE-volatility ratio. The results suggest that commercial banks with total assets below 50 billion forints are most acutely affected. The estimation results demonstrate that the BL on liabilities decreases banks' risk-taking activities. BL introduction in Germany decreases a bank's LLP, especially in commercial banks with contribution-relevant liabilities lower than EUR 10 billion. However, BL introduction in Germany is found to decrease a bank's ROE volatility ratio in commercial banks.

The main contribution of this study is to answer the question of whether the BL introduced in Europe is fulfilling its expected role. The results of the study indicate that the answer depends on its construction, as the solution introduced in Germany actually reduced the risks taken by banks. However, the Hungarian solution had the opposite effect. Therefore, the results of the research are relevant from the regulators' perspective, especially among those who are currently planning to modify the design of the BL. In particular, the findings are important from the point of view of countries where, as in the Hungarian model, BL depends on the banks' assets. Additionally, we contribute to the very timely but still quite limited literature on BL regulation. Scholars tend to concentrate on particular aspects of BLs instead of the concept itself. More specifically, they look at the effects of introducing BLs in individual countries, often analyzing data with a limited time span. Moreover, the literature shows that little is known about the effect of BLs on institutions' risk-taking behaviors in the cases of two different BL models. Therefore, we argue that this study could significantly contribute to the existing body of knowledge about the BL concept.

The remainder of the paper proceeds as follows: the next section presents the structure of BLs in Europe and reviews the literature in order to develop the hypotheses. The third section presents the study in terms of the sample, and methodology. The fourth section reports the summary statistics, and the fifth section analyses the empirical results. The final section provides conclusions.

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2. LITERATURE REVIEW AND HYPOTHESES DEVELOPMENT

2.1. The structure of BLs in Europe

A BL is a tax on specific elements of bank balance sheets and takes many forms. The most common levy design, adopted by 11 countries (Austria, Belgium, Cyprus, Germany, the Netherlands, Latvia, Portugal, Romania, Slovakia, Sweden, and the UK), taxes some measure of bank liabilities. While the levies are conceptually similar, they vary across several dimensions. First, most of the levies are assessed on total liabilities net of the bank's own funds and customer deposits guaranteed under a deposit insurance scheme. However, two countries (Cyprus and Portugal) include insured deposits in the levy base. Second, the majority of levies treat short-term and long-term liabilities symmetrically, but two countries (the Netherlands and the UK) apply reduced rates to liabilities with maturities exceeding one year. Third, a flat rate is applied in most of the levies, yet four countries (Austria, Germany, the Netherlands, and the UK) have a progressive rate structure, where small banks are taxed at lower rates than large banks or, in some cases, not taxed at all. Finally, unlike other countries, the UK has adopted rules that narrow the taxable base: most notably, they allow for netting gross assets and liabilities against the same counterpart and grant a deduction for highly liquid assets (Devereux et al., 2015).

Four countries (France, Hungary, Slovenia, and Poland) have adopted BLs that are conceptually quite different from the design described above. In France, the taxable base is the minimum amount of capital necessary to comply with regulatory requirements. In Hungary, the BL is calculated on total assets (net of inter-bank lending). In Slovenia, the taxable base is total assets with no deductions; however, the levy is not due if either the level of lending to the non-banking sector or the growth in lending to the non-banking sector exceed a threshold (Devereux et al., 2015). In Poland, the BL is calculated on total assets. The detailed explanation of all European BL construction is presented in an article written by Puławska (2021a).

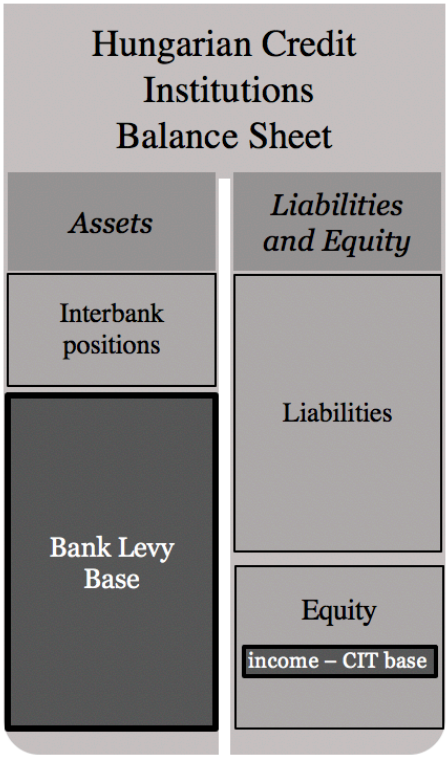
2.1.1. The BL in Hungary

The Hungarian banking sector deserves special consideration, as this country decided to introduce a BL on assets. This form of taxation in Hungary was agreed upon in July 2010. The tax originated not only from a desire to recover some of the budget money allocated to saving the banking sector, but also the need to quickly improve Hungary's economic situation and explore new sources of financing the state budget. The statistics for 2009 confirm significant economic problems in Hungary, such as the GDP recession (OECD, 2016).

Hungary was one of the first countries to implement a BL based on assets of credit institutions. In the article, the general term „bank" is used for all entities subject to Hungarian BL. The approach is in line with, among others, Capelle-Blancard and Havrylchyk (2017).

Unlike other countries, Hungary, and later Poland, decided to tax the asset side of banks' balance sheets. The levy applies to all banks, even those operating at a loss. More importantly, assets – with the exception of interbank positions – are the basis for levy calculation. At the time the tax was introduced, it was presented as a temporary measure, and hence, the tax base was fixed

Figure 1
Hungarian Bank Levy



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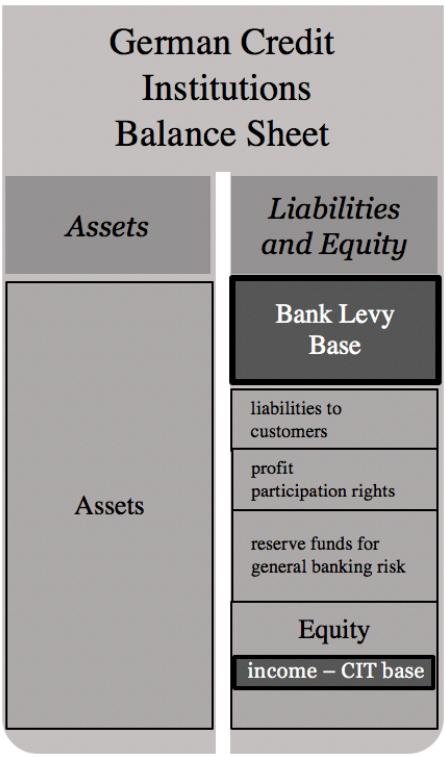
at the amount of assets in 2009. The levy is set at 0.15% of the tax base for small banks (those with assets below 50 billion forints (around EUR 185 million)) and 0.53% of the tax base for larger institutions. This means that the ratio of total tax paid by large banks more than tripled from 0.15% of total assets to 0.53% (Capelle-Blancard & Havrylchyk, 2017). In Figure 1, the Hungarian BL and corporate income tax (CIT) is presented.

2.1.2. The BL in Germany

Germany introduced a progressive BL in 2011 in the wake of the financial crisis; its purpose was to create a restructuring fund with a target value of EUR 70 billion, that is, roughly equal to the public support granted to banks between 2008 and 2013 (EUR 64 billion). The German BL applies to all credit institutions with a German banking license, and it is managed by the Federal Agency for Financial Market Stabilisation (Buch et al., 2016). In the article, the general term "bank" is used for all entities subject to German BL. The approach is in line with, among others, Buch, Hilberg, and Tonzer (2016).

As only systemic banks were rescued there, smaller banks benefit from a tax allowance (Buch et al., 2016), which means that the BL rate for large banks is higher (Buch, Tonzer, & Weigert, 2017). However, Haskamp (2016) observes spill-over effects of the BL from levy-paying banks to banks in the German banking sector that are not obligated to pay the BL. He claims that an increase in the lending rates of the financial institutions paying the BL causes an increase in the lending rates of institutions exempt from the BL.

Figure 2
German Bank Levy



The calculation of the German BL is based on contribution-relevant liabilities from the previous year's balance sheet. The German BL is designed to increase with banks' total liabilities (and, thus, with bank leverage), from which selected positions are deducted. Contribution-relevant liabilities are all liabilities according to the annual statement of the previous financial year ending before March 1 of the contribution year, less (1) liabilities to customers, excluding liabilities issued as bearer securities; (2) profit participation rights with a maturity of more than two years; (3) reserve funds for general banking risk; and (4) equity (Buch et al., 2016).

Therefore, contribution-relevant liabilities in 2011 are based on an bank's 2010 balance sheet. Deposits are exempted, as banks are already paying to cover deposit insurance for them. Contribution-relevant liabilities are taxed at a rate that increases progressively. In the case of liabilities between EUR 300 million and EUR 10 billion, the rate is 0.0002 (EUR 300 million < contribution-relevant liabilities ≤ EUR 10 billion). In the case of contribution-relevant liabilities exceeding EUR 10 billion, the rate increases to 0.0003. In Figure 2, the German BL and corporate income tax (CIT) were presented.

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2.2. Hypotheses development

2.2.1. Does the Hungarian BL increase the risk of future credit losses?

The main aim of the BL, according to IMF (2010), was to pay for the fiscal cost of any future government support to the financial sector and to decrease individual institutions' riskiness. However, researchers and experts have also noticed that BLs might have a negative impact, as they may increase financial transaction costs, reduce the number of transactions, and lower transaction values; this may negatively affect bank liquidity and result in wider interest spreads and higher volatility, as well as higher prices for banking services. On the other hand, researchers have proven that BLs might not decrease the number of bank operations because BL costs might be shifted to customers and/or some financial transactions might be transferred to countries where such taxes do not exist (Albertazzi & Gambacorta, 2010; Huizinga, Voget, & Wagner, 2012).

Previous research on the BL introduced in Hungary signals its negative impact on the stability of the banking sector. For example, Devereux, Johannesen, and Vella (2019) find that the Hungarian BLs induced banks to borrow less but also to hold more risky assets. The reduction in funding risk clearly dominates for banks with high capital ratios but is exactly offset by the increase in portfolio risk for banks with low capital ratios. This suggests that while the levies have reduced the total risk of relatively safe banks, they have done nothing to curb the risk of relatively risky banks, which presumably pose the greatest threat to financial stability. Moreover, Puławska's (2021) and Hryckiewicz and Puławska's (2022) research showed that commercial banks in Hungary prefer to restructure their balance or shift assets among different locations or entities to decrease the BL. Moreover, BL on assets might significantly decrease the value of some interbank loans (Puławska, 2020).

In this study, we argue that Hungarian banks have less flexibility to pass tax costs on to customers, as they are at higher risk of losing their clients and market share (Berger, Miller, Petersen, Rajan, & Stein, 2005). Therefore, higher costs might cause greater willingness to lend to riskier borrowers and consequently might translate into increased credit risk (Blundell--Wignall, Atkinson, & Roulet, 2018)including those associated with collateralised agreements at the heart of complexity and interdependence problems. They point out that in normal times these risk positions mostly cancel out (one's loss being another's gain. Therefore, we formulate the following hypothesis:

H1: *The introduction of a BL in Hungary increases risky activities as banks do not have the flexibility to pass on BL costs. Therefore, willingness to lend to riskier borrowers should increase. More specifically, we argue that LLPs should increase after the introduction of a BL and Z-scores should decrease.*

2.2.2. Does the German BL discourage risky behavior of banks?

The German government introduced a completely different solution compared to the Hungarian one. Buch et al. (2016) were among the first to examine and provide evidence of the German BL's impact on the banking sector. They find that, compared to unaffected banks, banks affected by the BL reduced loan supply. They also conclude that banks tend to increase deposit rates, probably to attract customer deposits, which are deducted from the tax base. In more recent research, Reiter (2018) shows that banks affected by BLs significantly decrease their contribution-relevant liabilities. Banks are replacing contribution-relevant liabilities by non-affected funding (equity and customer deposits), which may help affected banks avoid the BL and decrease risky activities. Kogler's (2019) bank-level evidence also shows that the levy indeed increases the lending and the deposit rate as well as the net interest margin.

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However, by raising the cost of borrowed funds, German levies are designed to increase the banking sector's stability by inducing banks to rely more on their own capital (Haskamp, 2018). At the same time, research shows that a levy on secured liabilities can prevent banks from investing in gambling assets if the levy does not depend on the banks' financial performance (Diemer, 2017). Additionally, Chronopoulos, Sobiech, and Wilson (2019) investigated the impact of the BL on liabilities on bank net worth. They find a significant loss of value for affected banks, following the introduction of the levy. This suggests that the burden of the levy is borne partly by the affected bank's shareholders. Celerier et al. (2020) showed that BLs on liabilities, applied to Belgium banks, lead to a decrease of their leverage, suggesting that these taxes can be a complementary tool to capital requirements.

In line with Devereux et al.'s (2015) argument, the first theoretical prediction may be that a levy on banks' borrowing activities induces them to rely more on equity funding, but also to hold more risky assets. BLs on liabilities target bank balance sheet positions that are considered risky, such as funding sources other than customer deposits and bank equity (Buch et al., 2016). Moreover, many proponents argue that BLs on liabilities serve as a macro-prudential tool to discourage risky activities. Keen (2011) states that BLs might have a more purposive role in the area of corrective taxation. Policymakers assume that BLs on liabilities will prove to be a particularly effective tool for mitigating the risks associated with sudden reversals of foreign capital flows (Jiang, Li, & Shao, 2010). Moreover, levies on liabilities should clearly induce banks to rely more on equity funding (Devereux et al., 2013). As in Germany, the BL is on the volatile short-term funding, while stable funding, such as equity and deposits, is excluded, we formulate the following hypothesis:

H2: *The introduction of a BL in Germany reduces risky activities because banks are discouraged from entering into transactions with higher tax burdens. More specifically, we argue that LLPs should decrease after a BL is introduced and Z-Scores should increase.*

3. RESEARCH DESIGN

3.1. Sample and data collection

In our analysis, we use data from the OrbisFocus database, comprising all banks during 2005–2015, which means that both pre-BL years and post-BL years (when the German and Hungarian BLs are in place) are considered. Such a wide range of data was taken due to the intention to include the period before the global financial crisis of 2007–2008 and accessibility to uniformly reported data.

Consequently, the sample consists of 2,133 observations (47 Hungarian banks with unconsolidated financial statements and 292 German banks with unconsolidated financial statements). Macroeconomic data were sourced from Central Banks' websites.

3.2. Methodology

We use a fixed effects estimator to run the regression. Moreover, the model choice under the current specification was dictated by Hausman's (1978) specification test. The advantage of using the fixed-effect model is to control for bank unobserved individual characteristics. This allows us to capture the heterogeneity between the banks. This means that bank-specific features have been captured by the bank fixed effect (Wooldridge, 2015). We refer to unconsolidated financial statements for all estimations because we argue that the BL effect should be more evident in unconsolidated than consolidated statements, as conglomerate banks might make some

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adjustments and shift activities among their entities to decrease the tax burden (Díaz, Olalla, & Azofra, 2004). Moreover, we are aware of other regulatory changes that occurred during the analyzed period and anomalies in the financial markets (Podgórski, 2018). Therefore, we also modify the standard errors in all regressions to be clustered at the bank level. Following Petersen (2009), we assume that clustered standard errors are unbiased as they account for the residual dependence created by the bank effect. The clustered standard errors correctly account for the dependence in the data common in panel datasets and produce unbiased estimates. Finally, we add a year dummy to control for any other changes in regulations and existence of many other events that are likely to have affected bank risk-taking.

The regression equation consists of bank controls and country controls. The regression is:

$$RISK_{jt} = \beta_0 + \beta_1 BL_t + \beta_2 Size_{jt} + \beta_{3jt} LoanActivityy_{jt} + \beta_4 Efficiency_{jt} + \beta_5 Loss_{jt} + \beta_6 Liquidity_{jt} + \beta_7 Capital\ ratio_{jt} + \beta_8 Inflation_{jt} + {}_{\beta 6} GDPgrowth_{jt} + \varepsilon_j \quad \text{Eq. (1)}$$

β_0 = Intercept term
β_1 = Coefficient for the variable from a given hypothesis
$\beta_2 - \beta_6$ = Coefficients for the control variables
j = Firm's identifier
t = Time as year
ε_{jt} = Error term

To verify the hypotheses, the dependent variable (RISK) is measured as the loan loss provision to total assets ratio (LLP) as a proxy for credit portfolio quality, the Z-score ratio as a proxy for individual risk, and, in robustness tests, ROE volatility as a proxy for risky bank activities. BL is estimated as a dummy variable equal to one for all years BLs existed, and zero otherwise. Additionally, we use BLpaid as a simulated amount of BL payments each year.

Loan loss provisions are an important factor in banking, as they are one of the main accrual expenses for banks. They are set aside by bank managers to face a future deterioration of credit portfolio quality (Curcio & Hasan, 2015). Loan loss provision estimate is a credit risk management tool used by banks to mitigate expected losses on bank loan portfolio (Curcio & Hasan, 2015).

The Z-score is our second risk measure; it provides general information about a bank's financial soundness, and has been used in many previous studies (Hryckiewicz, 2014; Laeven & Levine, 2009; Altunbas, Binici, & Gambacorta, 2018). This ratio is predictive of the bankruptcy risk to which banks are exposed. Its high accuracy has been demonstrated by empirical studies carried out in the Italian banking system (Altman, Danovi, & Falini, 2013) and the French banking system (Cihák & Hesse, 2008).

A Z-score is estimated as a four-year moving average and defined as the ratio of the sum of a bank's average return on assets and capitalization (total equity/total assets) to the standard deviation of return on assets. Intuitively, the measure represents the number of standard deviations below the mean by which profits would have to fall to deplete equity capital (Boyd & De Nicolo, 2005; Hryckiewicz, 2014).[1] A higher Z-score indicates that a financial institution is further from default and, therefore, more stable (Delis & Staikouras, 2011).

[1] The author has used the method proposed also by Yeyati & Micco (2007) and Lepetit & Strobel (2013) to calculate the Z-score. In any of the estimations, the results did not differ in terms of significance. However, following Bongini, Iwanicz-Drozdowska, Smaga, and Witkowski (2018), we agree that there is a lot of weaknesses of aggregated bank-level accounting-based measures as predictors of system-wide bank distress and the use of Z-scores to measure the financial strength of the overall banking system should be reconsidered. Therefore, we concentrate research on LLP.

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Following Devereux et al. (2015), in a robustness check, we use ROE volatility as a proxy for risky bank activities. We measure ROE volatility as the absolute difference between the book value of ROE of the bank itself and the median book value of ROE within the reference group of the bank, with the same size decile and the same equity-asset decile. Increasing ROE volatility increases financial risk (Kwan, 1998). Moreover, higher ROE volatility indicates lower earnings quality (Minami & Wakatsuki, 2014). Following Devereux et al. (2013), we assume that banks that are more willing to take risk should, on average, experience more extreme outcomes. Therefore, assuming that BLs reduce risk, banks exposed to BLs should experience equity returns closer to the reference level of ROE (Devereux et al., 2013). BL is estimated as a dummy variable equal to one for all years when BLs exist and zero otherwise.

In addition, we include a large set of control variables to ensure the BL effect is not influenced by other bank or country characteristics. The construction of all variables is explained in Table 1.

Table 1
Explanation and construction of all variables used

Label	Explanation	Measurement
	Dependent Variables	
Z-score	This ratio predicts the bankruptcy of institutions (Altman et al., 2013).	Z-score is defined as the ratio of the sum of the bank's average capitalization to the standard deviation of return on assets. Z-scores are estimated as four-year moving averages.
LLP	Loan loss provisions are considered as the most important accrual from a bank' balance sheet. At the same time, banks' managers have a significant discretionary power to manipulate loan loss provisions.	The book value of loan loss provisions to total assets as a percentage.
ROE-Volatility (robustness check)	ROE volatility ratio as a proxy of banks' risky activities. The increase in ROE volatility increases the financial risk (Kwan, 1998). Moreover, higher volatility of ROE indicates a lower quality of earnings (Minami & Wakatsuki, 2014). Banks that are more willing to take risk should, on average, experience more extreme outcomes. Assuming that levies reduce risk, banks exposed to the levies should experience equity returns closer to the reference level of ROE volatility (Devereux et al., 2013).	The absolute difference between the book value of return on equity of the bank itself and the median book value of return on equity within the reference group of the bank, with the same size decile and the same equity-asset decile.
	Control variables	
BL	We assign a value of one for all years starting from the introduction year onwards, and a value of zero for all previous years. The inclusion of this variable is especially important, as it allows distinguishing between risk effects stemming from diversification and those of an associated amount of paid levy.	Dummy if company j paid BL in year t, then equals 1; otherwise, zero.
BLpaid	Simulated amount of BL payments during each year.	Natural logarithm of amount calculated according to Puławska (2021a).

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Table 1 – continued

Label	Explanation	Measurement
Loan activity	This ratio measures a bank's activity. This greater relative proportion of loans in the portfolio of the banks is usually coupled with a greater liquidity risk arising from the banks' inability to accommodate decreases in liabilities or to fund increases on the asset side of the balance sheet (Trujillo-Ponce, 2013).	Natural logarithm of total loans to total assets.
Size	Bank size has been shown to be an important determinant of a bank's propensity for risk-taking. We use log transformation to allow for a possible nonlinear relation with risk. Large banks have the ability to diversify risk across product lines and are more skilled in risk management than small entities (Salas & Saurina, 2002). On the other hand, larger banks tend to be more willing to take risk due to the moral hazard problem (De Jonghe, 2010; Uhde & Heimeshoff, 2009).	Natural logarithm of total assets.
Efficiency	Existing research confirms that less efficient banks are more willing to take on additional risk (Louzis, Vouldis, & Metaxas, 2012) to improve their financial performance.	Cost to income ratio.
Loss	We control for the financial performance of the companies using the dummy variable indicating whether the company made a loss in the current year. We argue that declining profitability could tip the incentives of bank managers towards assuming greater risk in an effort to maintain former profit levels (Edwards & Mishkin, 1995).	Dummy if company j has a loss in year t, then equals 1; otherwise, zero.
Liquidity	We use the liquidity ratio defined as the ability of a bank to fund increases in assets and meet obligations as they become due, without incurring unacceptable losses. Research shows that more liquid banks behave less risky (Kashyap, Rajan, & Stein, 2002)	Current assets to total assets.
Capital ratio	Capital ratio measures the bank's financial strength and should have an effect on the risk-taking behavior of the bank (Tran, Lin, & Nguyen, 2016).	Equity to total assets ratio.
Inflation	Inflation creates pressure for banks to modify their behavior in competing for funds and make banks more keenly aware of higher interest rates on money market instruments (Arpa, Giulini, Ittner, & Pauer, 2001).	Value of inflation in a given year.

4. SUMMARY STATISTICS

Table 2 presents summary statistics of the unconsolidated financial statements of Hungarian and German banks for the entire sample period (2005–2015). Table 3 presents summary statistics of the unconsolidated financial statements of Hungarian and German banks before the BL implementation (Hungary in 2005–2009 and Germany in 2005–2010), while Table 4 presents summary statistics on unconsolidated financial statements of Hungarian and German banks after the BL implementation (Hungary in 2010–2015 and Germany in 2011–2015).

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Table 2
Summary statistics on unconsolidated financial statement of Hungarian and German banks for the entire sample period (2005–2015)

	Hungarian banks					German banks				
VARIABLES	**N**	**mean**	**sd**	**min**	**max**	**N**	**mean**	**sd**	**min**	**max**
LLP (%)	157	0.800	2.200	-6.400	20.200	1,725	0.200	0.700	-4.100	8.200
Z-score	243	14.610	9.344	-4.937	49.640	1,725	6.506	9.004	-7.388	49.905
ROE volatility	243	13.982	18.623	0.000	147.176	1,725	0.870	16.62598	-179.883	170.775
Loan activity (%)	234	53.000	25.000	2.200	98.600	1,725	59.500	19.800	0.000	99.800
Total Asset	243	1,926,077	3,978,985	134.000	23,485,343	1,725	26,900,000	291,000,000	449.000	11,800,000,000
Efficiency	243	64.870	20.240	6.641	98.420	1,725	67.239	22.097	0.000	269.700
Loss	243	0.173	0.379	0.000	1.000	1,725	0.046	0.210	0.000	1.000
Liquidity ratio	242	0.357	0.252	0.001	0.939	1,725	0.162	0.155	0.000	0.995
Capital ratio	243	12.073	8.331	-2.964	48.124	1,725	0.072	0.050	0.000	0.644
Inflation (%)	243	2.991	2.398	-0.222	6.066	1,725	1.608	0.746	0.800	3.100
GDPgrowth (%)	243	0.888	2.985	-6.564	4.047	1,725	1.274	3.266	-5.619	4.080
ROA (%)	243	1.260	2.690	-7.666	14.987	1,725	3.753	12.706	-2.000	67.000
ROE (%)	242	9.290	23.540	-133.333	80.928	1,725	4.037	7.457	-93.722	99.000

Table 3
Summary statistics on unconsolidated financial statement of Hungarian and German banks before the implementation of the BL (Hungary in 2005–2009 and Germany in 2005–2010)

	Hungarian banks					German banks				
VARIABLES	**N**	**mean**	**sd**	**min**	**max**	**N**	**mean**	**sd**	**min**	**max**
LLP (%)	28	1.000	3.880	-1.990	20.200	1,024	0.400	0.500	-4.000	8.200
Z-score	49	14.570	8.729	-4.937	40.910	1,024	6.976	9.447	-2.165	49.900
ROE volatility	49	7.667	7.980	0.000	40.215	1,024	1.338	17.02806	-149.856	170.7746
Loan activity (%)	47	52.300	24.700	6.790	95.300	1,024	58.300	19.300	0.000	81.730
Total Asset	49	1,860,797	3,692,996	27,949	17,942,739	1,024	23,840,000	119,200,000	100.000	1,783,000,000
Efficiency	49	63.880	21.030	6.641	94.950	1,024	66.239	19.431	0.000	269.700
Loss	49	0.102	0.306	0.000	1.000	1,024	0.045	0.207	0.000	1.000
Liquidity ratio	49	0.388	0.263	0.003	0.919	1,024	0.167	0.146	0.000	0.969
Capital ratio	49	12.170	8.314	-2.964	39.430	1,024	0.061	0.043	0.000	0.523
Inflation (%)	49	5.157	0.938	4.209	6.066	1,024	1.608	0.746	0.800	3.100
GDPgrowth (%)	49	-2.761	3.764	-6.564	0.889	1,024	1.274	3.266	-5.619	4.080
ROA (%)	49	1.261	2.007	-5.120	5.931	854	5.633	15.518	-2.000	67.000
ROE (%)	48	11.914	12.908	-29.222	40.494	854	4.214	7.218	-93.722	99.000

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Table 4
Summary statistics on unconsolidated financial statements of Hungarian and German banks after BL was implemented (Hungary in 2010–2015 and Germany in 2011–2015)

	Hungarian banks					German banks				
VARIABLES	**N**	**mean**	**sd**	**min**	**max**	**N**	**mean**	**sd**	**min**	**max**
LLP (%)	129	0.746	1.720	-6.370	10.000	701	-0.100	0.700	-4.100	4.200
Z-score	194	14.620	9.514	-0.405	49.640	701	5.009	7.732	-7.388	49.806
ROE volatility	194	15.577	20.158	0.000	147.176	701	0.185	16.008	-179.88	80.058
Paid BL in EUR K	194	979587	2060408	9.650	11,909,878	696	2117.221	15855.830	0.246	271,231
Loan activity (%)	187	53.200	25.200	2.240	98.600	701	56.500	22.200	0.000	98.900
Total Asset	194	1,942,553	4,056,700	0.067	23,491,915	701	31,400,000	437,000,000	362.000	11,800,000,000
Efficiency	194	65.120	20.090	10.800	98.420	701	69.149	25.370	0.100	161.326
Loss	194	0.191	0.394	0.000	1.000	701	0.047	0.212	0.000	1.000
Liquidity ratio	193	0.349	0.249	0.000	0.931	701	0.153	0.167	0.003	0.995
Capital ratio	194	12.049	8.358	0.990	48.124	701	0.085	0.056	0.000	0.643
Inflation (%)	194	2.444	2.346	-0.222	5.668	701	1.112	0.815	0.200	2.100
GDPgrowth (%)	194	1.810	1.848	-1.603	4.047	701	1.839	1.171	0.490	3.660
ROA (%)	194	1.265	2.840	-7.666	14.987	696	1.208	6.673	-0.870	65.000
ROE (%)	194	8.642	25.483	-133.333	80.928	665	3.805	7.421	-17.843	72.000

Tables 3 and 4 allow us to compare the financial performance and risk-taking behavior between two periods: before and after the BL introduction, respectively.

The statistics presented in Tables 3 and 4 suggest that the Z-score ratio increased in the Hungarian banking sector and decreased in German banks after the BLs were introduced. However, the LLP in German banks decreased after the BL introduction, which may mean that banks reduced their high-risk lending practices; we observe a similar trend in Hungary. ROE volatility increased in the Hungarian banking sector and decreased in German banks after the BLs were introduced.

5. RESULTS

5.1. Does the Hungarian BL increase the risk-taking behavior of banks?

Table 5 presents the regression results for the entire sample, that is, including banks operating within the Hungarian financial system, as well as the results for commercial banks only. In this research, 67% of the analyzed Hungarian banks are commercial banks.

The estimation results demonstrate that the BL on assets increases banks' risky activities. According to Table 5, the BL introduction increases the bank's average LLP by 1.318 percentage points, and these results are statistically significant. Therefore, higher costs, low customer mobility, and greater willingness to lend to high-risk borrowers might translate into lower credit quality in Hungarian banks, which confirms the first hypothesis. However, this result is only significant when the entire sample is considered; the results seem to suggest that the total sample of commercial banks is not affected. Commercial banks also differ from other banks in terms of their business objectives, regulation, and ownership structures (Beck, Demirgüç-Kunt, & Pería,

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2011). Commercial banks are, *inter alia*, required to diversify their assets and hold a minimum amount of assets in one particular sector and to hold a minimum level of capital or equity funds that must be contributed and monitored by the owners of a commercial bank (Schneider, 2001). Therefore, BL introduction might not affect commercial banks, as they are highly regulated (Hubbard, 2010).

Table 5
Data presenting estimations based on a fixed effects estimator regarding Hungarian banks.
Symbols *, **, *** represent statistical significance at the level of 10%, 5%, and 1%, respectively.

	All banks		Commercial banks	
VARIABLES	**LLP**	**Z-score**	**LLP**	**Z-score**
BL	1.318***	-0.0918	1.347	-0.275
	(0.435)	(1.338)	(0.818)	(1.758)
Loan activity	-1.372*	-0.190	-1.060	-0.502
	(0.767)	(1.009)	(0.693)	(1.285)
Size	-0.422	-2.186	-0.950	-0.113
	(0.520)	(1.666)	(1.200)	(1.959)
Efficiency	-1.857**	-3.008***	-1.360*	-4.691***
	(0.727)	(1.006)	(0.714)	(1.513)
Loss	1.064**	-3.424***	1.111	-4.639***
	(0.493)	(0.769)	(0.966)	(0.759)
Liquidity	-1.192**	0.445	-1.368***	0.395
	(0.459)	(0.579)	(0.379)	(0.695)
Capital ratio	-1.966*	9.981***	-2.746	11.76***
	(1.144)	(1.632)	(2.562)	(2.220)
Inflation	0.102*	-0.0622	0.0927*	-0.00280
	(0.0515)	(0.135)	(0.0486)	(0.177)
GDPgrowth	-0.0139	0.0614	0.0275	0.123
	(0.0401)	(0.124)	(0.0474)	(0.169)
Constant	16.38	46.68	26.44	10.22
	(13.30)	(32.38)	(29.81)	(37.45)
Observations	157	243	109	165
R-squared	0.397	0.539	0.388	0.505
Institution FE	YES	YES	YES	YES

As mentioned, the Hungarian tax authority decided to vary levy rates depending on bank size. Banks whose total assets exceed 50 billion forints (approximately EUR 160 million) are heavily taxed at the rate of 0.53%, whereas other banks pay only 0.15%. Therefore, we test whether the effect of a BL on risk-taking is stronger in larger banks than in smaller banks. Table 6 presents the results.

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Table 6
Data presenting estimations based on a fixed effects estimator regarding Hungarian commercial banks. Symbols *, **, *** represent statistical significance at the level of 10%, 5%, and 1%, respectively.

	Commercial banks with total assets below 50 billion forints		Commercial banks with total assets equal to and above 50 billion forints	
VARIABLES	**LLP**	**Z-score**	**LLP**	**Z-score**
BL	2.597***	-1.083	1.280	-0.338
	(0.0594)	(0.906)	(0.914)	(2.246)
Loan activity	2.053	-1.064	-0.362	0.387
	(2.445)	(0.817)	(0.782)	(1.051)
Size	3.228***	-4.070	-0.839	0.895
	(0.549)	(2.567)	(1.227)	(2.872)
Efficiency	0.330	-7.506***	-1.798**	-5.193**
	(2.113)	(2.458)	(0.778)	(1.992)
Loss	2.651***	-4.281***	1.804	-5.522***
	(0.245)	(1.163)	(1.196)	(0.899)
Liquidity	4.849***	2.133	-1.347***	0.440
	(1.069)	(2.277)	(0.383)	(0.770)
Capital ratio	0.428	16.72***	-3.155	11.40***
	(1.563)	(2.436)	(2.720)	(2.703)
Inflation	0.385***	-0.526	0.098*	0.059
	(0.0910)	(0.323)	(0.050)	(0.252)
GDPgrowth	-0.007	0.126	0.0167	0.151
	(0.041)	(0.123)	(0.0421)	(0.254)
Constant	-51.62***	80.54	27.56	-6.121
	(9.241)	(48.50)	(31.23)	(54.56)
Observations	23	38	86	127
R-squared	0.837	0.894	0.446	0.430
Institution FE	YES	YES	YES	YES

According to Table 6, in smaller commercial banks, LLPs have doubled after BL introduction. This result can be accounted for by the fact that larger banks, often operating as conglomerates, tend to shift their profits between different entities and locations to reduce their tax burden (Demirgüç-Kunt & Huizinga, 1999), while small commercial banks need to take on higher risk to reduce their tax burden. Furthermore, since banks in Hungary are taxed at different rates depending on size, we argue that smaller banks have less flexibility to pass tax costs to customers, as they are at higher risk than larger entities of losing their clients or market share (Berger et al., 2005).

An interesting question is how risk-taking behavior changes after BL introduction in banks that provide services beyond the scope of ordinary commercial banking, that is, banks other than commercial banks. Table 7 presents the regression results for banks other than commercial banks.

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Table 7
Data presenting estimations based on a fixed effects estimator regarding non-commercial banks in Hungary. Symbols *, **, *** represent statistical significance at the level of 10%, 5%, and 1%, respectively.

	Non-commercial banks	
VARIABLES	**LLP**	**Z-score**
BL	1.152**	0.987
	(0.532)	(1.449)
Loan activity	-3.119	-3.498
	(2.527)	(2.901)
Size	0.213	-6.230**
	(0.525)	(2.177)
Efficiency	-1.982**	-0.923
	(0.719)	(0.878)
Loss	0.885*	-2.102*
	(0.496)	(1.180)
Liquidity	-0.452	0.302
	(0.376)	(0.639)
Capital ratio	-1.231	8.838***
	(1.099)	(2.239)
Inflation	0.121	-0.140
	(0.096)	(0.170)
GDPgrowth	-0.026	-0.149
	(0.0576)	(0.117)
Constant	2.679	11.42**
	(11.55)	(4.201)
Observations	48	78
R-squared	0.578	0.743
Institution FE	YES	YES

According to Table 7, BL introduction is found to increase a bank's LLP by 1.152 percentage points. Therefore, the introduction of a BL in Hungary increases risky activities as banks do not have the flexibility to pass on BL costs. Therefore, willingness to lend to riskier borrowers should increase. It confirms the first hypothesis.

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5.2. Does the amount of paid levy matter? – Hungarian experience

In this section, we perform several tests to see if the amount of paid BLs in Hungary influences banks' risk-taking. Table 8 presents the regression results.

Table 8
Data presenting estimations based on a fixed effects estimator regarding banks in Hungary.
Symbols *, **, *** represent statistical significance at the level of 10%, 5%, and 1%, respectively.

	All banks		Commercial banks	Non-commercial banks
VARIABLES	**LLP**	**Z-score**	**LLP**	**LLP**
BLpaid	0.0671***	0.00335	0.0642	0.0648**
	(0.0215)	(0.0730)	(0.0399)	(0.0268)
Loan activity	-1.282*	-0.189	-1.003	-3.121
	(0.753)	(1.015)	(0.706)	(2.526)
Size	-0.450	-2.174	-0.885	0.122
	(0.514)	(1.703)	(1.174)	(0.549)
Efficiency	-1.848**	-3.008***	-1.381*	-1.952**
	(0.718)	(1.004)	(0.726)	(0.715)
Loss	1.072**	-3.422***	1.142	0.843
	(0.485)	(0.781)	(0.945)	(0.505)
Liquidity	-1.179**	0.447	-1.364***	-0.472
	(0.448)	(0.581)	(0.367)	(0.359)
Capital ratio	-1.939*	9.988***	-2.582	-1.248
	(1.125)	(1.635)	(2.480)	(1.085)
Inflation	0.105**	-0.061	0.104**	0.122
	(0.051)	(0.136)	(0.046)	(0.095)
GDPgrowth	-0.0114	0.0633	0.0362	-0.0349
	(0.042)	(0.126)	(0.0503)	(0.0534)
Constant	16.97	46.46	25.03	4.322
	(13.27)	(33.03)	(29.35)	(12.08)
Observations	157	243	109	48
R-squared	0.393	0.539	0.381	0.588
Institution FE	YES	YES	YES	YES

The estimation results demonstrate that the amount of paid BL on assets influences banks risky activities. According to Table 8, the increase in paid BLs is found to increase bank LLP by 0.0671 percentage points in all banks. This increase is especially seen in non-commercial banks, and the results seem to suggest that commercial banks are not affected.

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5.3. Robustness checks

In this section, we perform several robustness tests to ensure the validity of our results. Table 9 presents the regression results where the LLP and Z-score are replaced by ROE volatility. Therefore, assuming that levies reduce risk-taking behavior, banks exposed to levies should experience equity returns closer to the average level of ROE volatility.

Table 9
Data presenting estimations based on a fixed effects estimator regarding all banks in Hungary.
Symbols *, **, *** represent statistical significance at the level of 10%, 5%, and 1%, respectively.

	ROE-Volatility			
VARIABLES	**All banks**	**Commercial banks**	**Commercial banks with total assets below 50 billion forints**	**Commercial banks with total assets equal to and above 50 billion forints**
BL	**5.255***	**2.645***	**8.575****	**3.509**
	(3.509)	**(2.766)**	**(2.870)**	**(3.403)**
Loan activity	1.314	2.004	-5.982	5.807
	(2.528)	(2.037)	(4.503)	(4.160)
Size	-1.259	5.445	-13.56	6.160
	(6.643)	(5.006)	(8.813)	(8.266)
Efficiency	-1.003	-2.885	-16.69**	0.822
	(5.795)	(6.222)	(5.879)	(7.218)
Loss	21.46***	22.95***	3.741	27.04***
	(5.421)	(8.171)	(2.715)	(9.617)
Liquidity	4.761**	6.048***	-5.539**	7.892***
	(2.089)	(1.699)	(2.488)	(2.304)
Capital ratio	-8.310	0.934	-9.641	-1.748
	(9.744)	(4.515)	(7.381)	(5.781)
Inflation	0.0701	0.503	-1.103	0.749
	(0.628)	(0.716)	(1.021)	(0.779)
GDPgrowth	-0.413	-0.107	-0.689	-0.0129
	(0.363)	(0.329)	(0.496)	(0.335)
Constant	61.41	-78.06	32.29*	-99.89
	(136.8)	(100.5)	(17.96)	(161.8)
Observations	243	165	38	127
R-squared	0.236	0.242	0.493	0.283
Institution FE	YES	YES	YES	YES

According to Table 9, the BL introduction is found to increase a bank's ROE volatility ratio by 5.255 on average in all banks, and these results are statistically significant. The results seem to suggest that commercial banks with total assets below 50 billion forints are most affected, where the ROE volatility ratio increases more than eight times. Our findings support the evidence that BL introduction increases risk-taking by Hungarian banks.

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5.4. Does the German levy discourage banks from engaging in high-risk activities?

In this section, we present the results of analyses of the relationship between the BL and the German financial system. Table 10 presents the regression results for the entire sample, that is, all banks operating in the German banking system, as well as those of commercial banks only. In this research, 40% of the analyzed German banks are commercial banks.

Table 10
Data presenting estimations based on a fixed effects estimator regarding all German banks.
Robust standard errors that control for clustering at the bank-level are reported in brackets.
Symbols *, **, *** represent statistical significance at the level of 10%, 5%, and 1%, respectively.

	All banks		Commercial banks	
VARIABLES	**LLP**	**Z-score**	**LLP**	**Z-score**
BL	-0.648***	0.965	-0.364***	1.166
	(0.0702)	(0.650)	(0.130)	(0.912)
Loan activity	-0.568***	4.948***	0.101	3.098
	(0.110)	(1.429)	(0.0632)	(3.774)
Size	0.0796	1.151**	0.151	6.698***
	(0.0602)	(0.537)	(0.359)	(2.474)
Efficiency	0.0759***	-0.0356	0.0962***	0.0566
	(0.0179)	(0.180)	(0.0212)	(0.201)
Loss	0.219**	-3.794***	0.198	-3.253***
	(0.0859)	(0.633)	(0.160)	(1.200)
Liquidity	-0.0201	0.0981	0.0754	-0.850
	(0.0266)	(0.460)	(0.0697)	(0.698)
Capital ratio	-0.158	-0.0191	-0.183	2.836***
	(0.109)	(0.362)	(0.152)	(0.897)
Inflation	-0.017	-0.143	0.0167	-0.448
	(0.013)	(0.258)	(0.0278)	(0.415)
GDPgrowth	-0.0016	-0.182**	0.019*	-0.238
	(0.003)	(0.082)	(0.011)	(0.249)
Constant	-1.204	-11.73	-2.473	-87.04**
	(0.881)	(8.101)	(5.086)	(35.41)
Observations	1,725	1,725	691	691
R-squared	0.279	0.029	0.201	0.052
Institution FE	YES	YES	YES	YES

The estimation results demonstrate that the BL on liabilities decreases banks' risky activities. According to Table 10, the BL decreases a bank's LLP by 0.648 percentage points in all banks and by 0.364 percentage points in commercial banks. In accordance with Devereux et al.'s (2015) argument, the first theoretical prediction may be that a levy on bank borrowing induces banks to rely more on equity funding. Moreover, Kopecky and VanHoose (2006) find that the imposition of regulatory capital requirements has an initially ambiguous effect on aggregate loan quality,

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although once such requirements are in place, further increases in required capital ratios cause the overall credit quality in the banking system to increase. Therefore, the credit quality in the German banking system increases following the BL introduction.

Germany introduced a progressive BL in the wake of the financial crisis, with the purpose of financing a restructuring fund. As only systemic banks are rescued, a tax allowance was introduced to relieve smaller banks from the tax burden (Buch et al., 2016). Consequently, large commercial banks and head banks of savings banks and credit unions contributed the most (Buch et al., 2017). The German BL calculation is based on contribution-relevant liabilities; the rate is 0.0002 until the following threshold of EUR 10 billion is reached, at which point the rate increases to 0.0003.

In Table 11, we compare the regression results of commercial banks with contribution-relevant liabilities below and equal to EUR 10 billion and those exceeding EUR 10 billion.

Table 11
Data presenting estimations based on a fixed effects estimator regarding German commercial banks. Symbols *, **, *** represent statistical significance at the level of 10%, 5%, and 1%, respectively.

	contribution-relevant liabilities below and equal to EUR 10 billion		**contribution-relevant liabilities above EUR 10 billion**	
VARIABLES	**LLP**	**Z-score**	**LLP**	**Z-score**
BL	-0.367**	0.108	-0.180	-1.704
	(0.143)	(1.647)	(0.114)	(1.809)
Loan activity	0.108*	0.154	0.232	7.958**
	(0.0652)	(0.505)	(0.187)	(3.234)
Size	0.166	6.807***	-0.193	-3.137
	(0.408)	(2.546)	(0.240)	(4.077)
Efficiency	0.104***	0.118	0.00962	-0.639
	(0.0227)	(0.225)	(0.0198)	(0.377)
Loss	0.251	-3.325***	-0.0102	-1.456
	(0.199)	(0.888)	(0.208)	(2.346)
Liquidity	0.0735	-0.965	0.228	3.351
	(0.071)	(0.774)	(0.156)	(3.359)
Capital ratio	-0.225	2.770***	0.0121	2.382***
	(0.189)	(0.934)	(0.103)	(0.743)
Inflation	0.018	-0.345	0.0479	-0.365
	(0.031)	(0.428)	(0.0545)	(0.652)
GDPgrowth	0.020*	-0.231	-0.004	0.142
	(0.012)	(0.259)	(0.009)	(0.118)
Constant	-2.745	-86.12**	4.304	85.48
	(5.626)	(34.98)	(4.522)	(77.39)
Observations	638	638	53	53
R-squared	0.217	0.050	0.120	0.309
Institution FE	YES	YES	YES	YES

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According to Table 11, LLPs decrease almost by 0.4 percentage points in commercial banks with contribution-relevant liabilities lower than EUR 10 billion. This might mean, following the BL introduction, that banks decide to invest funds in more stable assets. Moreover, smaller banks tend to operate according to a more traditional business model, with a greater focus on lending activities (Köhler, 2012), and usually derive a greater share of their income from more stable provisions (Stiroh, 2004). Therefore, small banks have been shown to hold less risky assets (Schneider, 2001) and replace relevant liabilities with non-affected funding (e.g., equity) (Reiter, 2018).

As with the Hungarian sample, we evaluate the risk-taking behavior of entities other than commercial banks, following the BL introduction. Table 12 presents the regression results.

Table 12
Data presenting estimations based on a fixed effects estimator regarding German non-commercial banks. Symbols *, **, *** represent statistical significance at the level of 10%, 5%, and 1%, respectively.

	Banks other than commercial banks	
VARIABLES	**LLP**	**Z-score**
BL	-0.564***	0.747
	(0.0797)	(0.815)
Loan activity	-0.0859	0.282
	(0.0802)	(0.429)
Size	-0.294**	2.325
	(0.137)	(1.467)
Efficiency	0.0434	-0.301
	(0.0453)	(0.598)
Loss	0.141	-3.085***
	(0.111)	(0.759)
Liquidity	-0.0590	0.0102
	(0.0528)	(0.725)
Capital ratio	-1.031***	5.437***
	(0.257)	(1.940)
Inflation	-0.012	-0.836**
	(0.013)	(0.327)
GDPgrowth	-0.0028	-0.109
	(0.0031)	(0.088)
Constant	1.370	-7.925
	(1.757)	(19.21)
Observations	1,034	1,034
R-squared	0.401	0.035
Institution FE	YES	YES

According to Table 12, the BL decreases the LLP by 0.564 percentage points. These correlations can be interpreted in the same way as the results of the smaller commercial banks presented in Table 11.

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5.5. Does the amount of paid levy matter? – German experience

In this section, we perform several tests to see if the amount of paid BL in Germany influences risk-taking measures. Germany introduced a progressive BL in 2011. Larger banks, banks with a market-based funding strategy, and banks involved in derivatives trading faced a higher marginal levy. "Contribution-relevant liabilities" are total liabilities minus equity, customer deposits, profit participation rights, and reserve funds for general banking risk. Banks are exempted from the levy if their contribution-relevant liabilities are smaller than or equal to EUR 300 million. Table 13 presents the regression results.

Table 13
Data presenting estimations based on a fixed effects estimator regarding all German banks.
Symbols *, **, *** represent statistical significance at the level of 10%, 5%, and 1%, respectively.

	All banks		Commercial bank	Non-commercial banks
VARIABLES	**LPP**	**Z-score**	**LLP**	**LLP**
BLpaid	0.001	-0.234**	-0.010	-0.018**
	(0.006)	(0.103)	(0.013)	(0.008)
Loan activity	-0.0770	-0.928**	-0.011	-0.040
	(0.050)	(0.404)	(0.073)	(0.077)
size	-0.054	0.383	-0.044	-0.724***
	(0.117)	(0.488)	(0.385)	(0.175)
Efficiency	0.087***	-0.052	0.097***	0.040
	(0.017)	(0.186)	(0.021)	(0.044)
Loss	0.253***	-3.972***	0.137	0.137
	(0.086)	(0.668)	(0.172)	(0.118)
Liquidity	0.0203	-0.139	0.099	-0.070
	(0.031)	(0.477)	(0.072)	(0.068)
Capital ratio	-0.340*	-0.596	-0.252	-1.762***
	(0.185)	(0.437)	(0.184)	(0.322)
Inflation	-0.017	0.0350	0.004	-0.041***
	(0.017)	(0.260)	(0.032)	(0.014)
GDPgrowth	-0.018***	-0.168**	0.013	-0.011***
	(0.003)	(0.080)	(0.009)	(0.003)
Constant	-0.224	-0.452	-0.0346	5.594**
	(1.738)	(7.152)	(5.449)	(2.193)
Observations	1,725	1,725	691	1,034
R-squared	0.119	0.022	0.164	0.311
Institution FE	YES	YES	YES	YES

The estimation results demonstrate that an increase of the amount of paid BL on liabilities influences banks' risky activities. According to Table 13, we find that the LLP decreases in non-commercial banks as the paid BLs increase. On the other hand, the increase in paid BLs is found to decrease a bank's Z-score ratio 0.234 times in all banks and it is significant. It shows that with an increase of the amount of paid BL, the Z-score decreases; therefore, the risk of default increases.

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5.6. Robustness checks

In this section, we perform several robustness tests to ensure the validity of our results. We present the regression results in which we replace the LLP and Z-score by ROE volatility. Therefore, assuming that levies reduce risky activities, banks exposed to levies should experience equity returns closer to the reference level of volatility. Table 14 presents the regression results.

Table 14
Data presenting estimations based on a fixed effects estimator regarding all German banks.
Symbols *, **, *** represent statistical significance at the level of 10%, 5%, and 1%, respectively.

	ROE-Volatility			
VARIABLES	**All banks**	**Commercial banks**	**contribution-relevant liabilities below and equal to EUR 10 billion**	**contribution-relevant liabilities above EUR 10 billion**
BL	-0.957	-6.773**	-7.000**	-8.365
	(0.841)	(2.725)	(2.888)	(6.682)
Loan activity	0.0933	-0.237	-0.435	-13.09
	(0.523)	(1.006)	(1.231)	(10.63)
size	-0.334	-9.957	-12.86*	-11.90
	(0.995)	(6.287)	(7.492)	(11.05)
Efficiency	0.127	-0.128	-0.274	1.076
	(0.238)	(0.211)	(0.226)	(0.811)
Loss	1.233	3.695	1.375	8.425
	(2.715)	(2.772)	(1.999)	(6.819)
Liquidity	-0.985	-2.594	-2.568	1.732
	(0.832)	(1.832)	(1.873)	(18.35)
Capital ratio	0.384	-4.777	-6.890	2.341
	(0.924)	(3.542)	(4.405)	(2.550)
Inflation	1.086*	2.121**	1.999*	4.148
	(0.561)	(1.055)	(1.102)	(3.650)
GDPgrowth	-0.0619	-0.0584	-0.0131	-0.567
	(0.152)	(0.298)	(0.318)	(1.096)
Constant	3.102	13.02	16.39*	22.48
	(13.69)	(8.118)	(9.395)	(21.44)
Observations	1,725	691	638	53
R-squared	0.060	0.062	0.069	0.154
Institution FE	YES	YES	YES	YES

The estimation results demonstrate that the BL on liabilities decreases banks' risky activities. According to Table 14, the BL introduction is found to decrease a bank's ROE volatility ratio 6.773 times in commercial banks, and these results are statistically significant. The results seem to suggest that commercial banks with contribution-relevant liabilities below and equal to EUR 10 billion are most affected; the BL introduction is found to decrease a bank's ROE volatility ratio seven times in these banks. Our findings support the evidence that BL introduction decreases risk-taking by German banks.

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6. CONCLUSIONS

Various taxes have been imposed within the banking sector in Europe, one of which is a tax depending on the balance sheet position, i.e., a BL. In this study, we analyzed the impact of BLs on the German and Hungarian banking sectors, and our regression estimations show that the effect of BLs depends on their construction. More specifically, the results demonstrate that the BL on assets introduced in Hungary has increased the LLP. This effect is the most significant for small commercial banks. This could be because larger banks, often operating as conglomerates, tend to shift their profits between different entities and locations to reduce their tax burden (Demirgüç-Kunt & Huizinga, 1999), while small commercial banks take on higher risk to potentially reduce their tax burden.

Within the German banking sector, the estimation results are also consistent with expectations and the extant literature. The LLPs of German banks decrease following the BL introduction. According to our results, banks with lower tax rates have a more significant decrease in the LLP than other banks. Moreover, our research shows that, for commercial banks and those subject to a lower BL, this effect was more evident. A levy is intended to curb banks' risk-taking behavior, and this goal has been achieved in the German banking sector. In Hungary, the effect is entirely the opposite. Accordingly, our research suggests that the asset-based levy should be reformed in order to avoid banks' insolvency. These results are also relevant to regulators in other countries where levies are based on assets, such as Poland.

The comparison of only two BL models should be considered as the main limitation of this research. The German and Hungarian models actually represent opposite models, but for an accurate overview of the impact of BLs, future research might consider a third type of bank tax, which is the model introduced in France.

Therefore, it is suggested that further studies both extend the types of BL models analyzed and consider the changes that regulators have implemented since the BLs were introduced. Previous studies as well as this research indicate that not all BL models fulfill their role. This has been observed by both researchers and regulators who have made changes to BL-related regulations. Have did these changes improve the effectiveness of this regulatory instrument?

Due to the current energy crisis, some countries are introducing, and some intend to introduce, additional taxes on banks. For example, the Spanish government plans to impose a 4.8 percent tax on banks' income from interest and commissions for two years, arguing that rising interest rates earn "extraordinary" profits for the banking and energy sectors in which inflation may further increase profits. On September 23, 2022, the European Central Bank (ECB) received a request from the Banco de España, on behalf of the Spanish Parliament, for an opinion on a draft law. Such a law addressed the imposition of temporary levies on operators in the energy sector, credit institutions, and financial credit establishments, to counter the cost-of-living crisis. However, the ECB warned that Spain's so-called "windfall" tax could negatively impact the profitability of lenders, as the basis on which the temporary levy would be established does not take into consideration the full business cycle and does not include, *inter alia*, operational expenses and the cost of credit risk. As a result, the amount of the temporary levy might not be commensurate with the profitability of a credit institution. Thus, as a result of the general application of the temporary levy, credit institutions that do not necessarily benefit from current market conditions could become less able to absorb the potential downside risks of an economic downturn. The ECB also suggested that Spain's proposal could distort market competition both within Spain and across the banking union (ECB, 2022). However, countries including Italy, Hungary, and the Czech Republic have also already announced plans of imposing extra taxes on banks to reduce the impact of energy prices (ECB, 2022).

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However, upon analysis of the results of this study, which directly show that an inadequate tax model can have a negative impact on the banking sector, we agree with the ECB's view that:

> *"Imposing any ad hoc taxes or levies on credit institutions for general budgetary purposes should be preceded by a thorough analysis of potential negative consequences for the banking sector to ensure that such taxes do not pose risks to financial stability, banking sector resilience and to the provision of credit, which could eventually adversely affect real economic growth*" (ECB, 2022, p. 4).

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The modeling of earnings per share of Polish companies for the post-financial crisis period using random walk and ARIMA models

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ABSTRACT

The proper forecasting of listed companies' earnings is crucial for their appropriate pricing. This paper compares forecast errors of different univariate time-series models applied for the earnings per share (EPS) data for Polish companies from the period between the last financial crisis of 2008–2009 and the pandemic shock of 2020. The best model is the seasonal random walk (SRW) model across all quarters, which describes quite well the behavior of the Polish market compared to other analyzed models. Contrary to the findings regarding the US market, this time-series behavior is well described by the naive seasonal random walk model, whereas in the US the most adequate models are of a more sophisticated ARIMA type. Therefore, the paper demonstrates that conclusions drawn for the US might not hold for emerging economies because of the much simpler behavior of these markets that results in the absence of autoregressive and moving average parts.

JEL Classification: C01, C02, C12, C14, C58, G17

Keywords: earnings per share, time series, random walk, ARIMA, financial forecasting, Warsaw Stock Exchange.

1. INTRODUCTION

It is important to understand which underlying univariate time-series processes may generate earnings per share of listed companies from a practical investment point of view and pure academic perspective. The purpose of the paper is to examine which of the statistical time-series models of random walk and ARIMA types well approximates the behavior of earnings per share for the Polish market. The issue had been investigated in the literature since the late 1960s, mostly for US companies. Various models were examined including the naïve random walk class of models as well as autoregressive integrated moving average type models (Ball & Watts, 1972; Watts, 1975; Griffin, 1977; Foster, 1977; Brown & Rozeff, 1977, 1979b). The results of these studies were mixed and led to ambiguous conclusions. In some works, it was argued that the naive model provided the best results and more advanced mechanical models were not able to

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beat the naive ones, whereas in others different conclusions were drawn. However, for quarterly data, a consensus among researchers arose that ARIMA-type models performed the best (Lorek, 1979; Bathke & Lorek, 1984). Market and academic interest in the subject lasted until the late 1980s when the widespread consensus that forecasts provided by financial analysts were better than those made by time-series models was formed (Brown et al., 1987). This opinion prevailed till the most recent years when the superiority of analysts over time series was questioned again (Pagach & Warr, 2020).

Because the literature almost exclusively focuses on the US, it is interesting to see how it looks in the other markets. Only a few papers were dedicated to this issue. The author could find only papers focused on companies from Taiwan and the Baltic states (Bao, 1996; Grigaliūnienė, 2013). Unfortunately, the samples of companies used in these papers were of very limited size. From this perspective, it is valuable to examine this problem in the context of the Polish market, which is the deepest among emerging Central European capital markets. This market is not as developed as the US market and has a much shorter history and different institutional framework. Moreover, the good quality of earnings forecasting in these markets is of much higher importance than in the US market because only a small fraction of companies is covered by financial analysts.

It is worth mentioning that all the existing research is limited to the period ending before 2009, i.e. the year prior to the last financial crisis. No paper covers yet the most recent period of stability, i.e. the period between the financial crisis shock and the pandemic shock. From this perspective, this paper is the first to analyze this period. The sample of 267 listed companies and quarterly data for the period from 2010 to 2019 are used for the analysis. The data from Q1 2010 to Q4 2018 are used for the estimation of the time-series model and the period Q1 2019 – Q4 2019 for testing. The robustness check is made to confirm the obtained results using the expanding window approach for the years 2018 and 2017 as hold-out validation samples.

Eight different univariate time-series models are estimated and assessed. The first four models are the naïve time-series models like the random walk model, the random walk with drift model, the seasonal random walk model, and the seasonal random walk with drift model. The next four models are the models of autoregressive integrated moving average type. They are the Griffin-Watts model, the Foster model, the Brown-Rozeff model, and the firm-specific ARIMA model.

Instead of relying on the mean absolute percentage error (MAPE) metric widely used in the previous research, the mean arctangent absolute percentage error (MAAPE) is calculated (Kim & Kim, 2016). The latter overcomes the primary difficulty with the standard MAPE error metric that is related to the explosion of this measure when its denominator is very small, i.e. when actual earnings are close to zero. It is found that the distribution of arctangent absolute percentage forecast errors is similar in all analyzed quarters, which leads to a conclusion that surprisingly the forecast errors do not increase with forecast horizons. The best model, with the lowest rank, is the seasonal random walk (SRW) model across all quarters, which is superior to other models and particularly more advanced ARIMA-type models. This empirical regularity contradicts the results obtained for the US market and studies limited to pre-2008 time periods. The SRW model relatively well captures the behavior of the Polish companies, compared to other models. It turns out that the medians of errors of eight analyzed models differ statistically significantly in almost all quarters.

The superiority of the seasonal random walk model (SRW) implies that the underlying EPS generating process exhibits neither autoregressive nor moving average parts and there is no drift component. The horizontal performance of the stock market index WIG during the analyzed period implies the absence of a trend. In the context of emerging markets, the absence of the moving average part is consistent with the fact that a lower fraction of companies publish the forecasts of their earnings compared to developed markets, and hence not for so many companies past forecast errors result in the correction of the performance of future earnings. The non-existence of the autoregressive part may be related to the dominance of the seasonal component relative to past

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EPS behavior, which might imply that Polish and more generally emerging market companies are more seasonal than those operating in developed markets.

This paper contributes to the literature in four different ways. First, the time-series models are estimated using the most recent data coming from a period of relative earning stability, i.e. ranging from the last financial crisis of 2008–2009 to the pandemic shock of 2020. No academic paper has so far focused on that recent period. Second, the study covers the behavior of emerging market companies, not frequently documented in the literature, like in the papers by Bao (1996) and Grigaliūnienė (2013). Contrary to the US findings, the earnings per share behavior are well described by the seasonal random walk model, whereas in the US the most adequate models are of the more sophisticated ARIMA type. It may result from a different level of advancement as well as an institutional framework of the US market compared to emerging economies. This shows that conclusions drawn for the US might not automatically hold for emerging economies. Also, this result is more important for emerging markets, given that only a small fraction of companies are covered by financial analysts in these markets, contrary to the situation in the US. Third, the research uses a large sample compared to studies mentioned above regarding emerging markets. Consequently, the findings in this paper are supposed to be more statistically meaningful. Fourth, instead of the mean absolute percentage error (MAPE), which is the most popular metric to measure time-series forecast errors, a modification of this measure is used to overcome the standard difficulty of exploding the MAPE metric when earnings are close to or equal to zero. This is done by using the mean arctangent absolute percentage error (MAAPE). Despite the disadvantage described above, the MAPE metric is widely used in literature, e.g. in publications written by Johnson and Schmitt (1974), Lorek (1979), Bathke and Lorek (1984), Collins et al. (1984), Brown et al. (1987), Bao (1996), Lorek and Willinger (2007) and Grigaliūnienė (2013). The paper concludes that for the Polish market the most appropriate model describing earnings per share behavior is the naïve seasonal random walk model. It is consistent with the dominance of a seasonal component over EPS behavior and the fact that only a small fraction of companies publish the forecasts of their earnings.

2. LITERATURE REVIEW

There are four areas of research dedicated to modeling earnings per share using univariate time-series models. The first distinction refers to which earnings are forecasted – annual earnings or quarterly earnings. The research started with annual earnings modeling because this approach required much fewer data points, which was a necessity arising from the computational power at that time. The second cut is based on the statistical techniques used. Three groups of models are applied in the literature starting from naive models relying on random walk processes through the class of autoregressive integrated moving average models, exponential smoothing models, and others.

The literature referring to modeling of companies' earnings using a statistical approach started from the paper by Cragg and Malkiel (1968) in which the authors found that security analysts' predictions performed not much better than those based on past growth rates. Later research was either focused on listed companies' earnings or companies' EPS. Hence, the term earnings is hereafter used interchangeably either for net earnings or for EPS. Beaver (1970) concluded that the underlying process that generates annual earnings was likely to be a mixture of a random walk and a mean-reverting process. Ball and Watts (1972) argued that the measured annual accounting income followed either a submartingale or some very similar process. The famous research by Elton and Gruber (1972) examined the accuracy of forecasts produced by nine mechanical models. It occurred that the additive exponential smoothing with no trend in trend dominated other models. They also found that the differences in forecasts accuracy of mechanical

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models and security analysts' forecasts were not statistically significant. In the work by Johnson and Schmitt (1974), also various mechanical models were tested including naive random walk, moving average model, linear projection model, single double and triple exponential smoothing models, and the accuracy of their forecasts was calculated. The naive model provided the best results and more advanced mechanical models were not able to beat the naive one. Brooks and Buckmaster (1976) applied single, double, and triple exponential smoothing models for different strata of earnings time series, and Albrecht et al. (1977) analyzed various models across three industries (chemical, food, and steel). It is worth emphasizing that only the behavior of annual earnings has been investigated so far.

Watts (1975) focused on modeling quarterly earnings as one of the first. He introduced widely recognized autoregressive integrated moving average (ARIMA) type of models using a method developed some time ago by Box and Jenkins. Later, his findings were extended by Griffin (1977), who accomplished the first parsimonious ARIMA model of quarterly earnings. The model relied on the observation that quarterly earnings could not be adequately described as a random walk or a martingale (sub martingale) and the successive changes in quarterly earnings were not independent. The author concludes that quarterly earnings could be parsimoniously described as a multiplicative combination of two processes: one that reflected adjacent quarters and the other that reflected the seasonal component. The first of the premier models was named the Griffin-Watts (GW) model and was based on the seasonal autoregressive integrated moving average, i.e. SARIMA $(0,1,1)\times(0,1,0)$, framework. The second premier model comes from Foster (1977). He evaluated the predictive ability of six forecasting models: simple and seasonal random walk with or without drift, his model (F) as well as individually estimated Box-Jenkins model (Box and Jenkins, 1976). This firm-specific model is denoted as BJ. After concluding that quarterly earnings did not follow the submartingale process that appeared to adequately describe annual earnings, he found that the model developed by him (F) outperformed other ones. His model referred to the $(1,0,0)\times(0,1,0)$ SARIMA framework. Salamon and Smith (1977) found that there was diversity in time series characteristics of the EPS sequence of individual firms. Finally, the third parsimonious model of the $(1,0,0)\times(0,1,1)$ SARIMA type was published by Brown and Rozeff (1977). Brown and Rozeff (1978) claimed in another paper that their model (BR) and BJ models performed equally well and were superior to other models for short forecast horizons. For longer forecast horizons, accuracy of the BR model deteriorated, but it outperformed BJ models. Brown and Rozeff (1979b) found also in another research that financial analysts' behavior was at a one-quarter-ahead horizon similar to the three primary (BW, F, BR) models. However, the answer to the question of which parsimonious models performed the best was ambiguous. Lorek (1979) indicated that the GW model was the dominant model and three parsimonious models (GW, F, BR) and firm-specific (BJ) models performed better than simplistic random walk models. Hopwood and McKeown (1981) wrote that a transfer function model proposed by them performed the best and BR was the second best. The incorporation of Box-Cox power transformation, which converts non-normal distribution into a normal shape, according to Hopwood et al. (1981), improved on average forecasts made by BW, F, BR, and BJ models. In the work by Bathke and Lorek (1984), it turned out that the BR model dominated the other models across error metrics and quarters. Kao et al. (1996), based on the Dickey-Fuller test, found that net income and EPS series contained a unit root and hence were nonstationary. This was consistent with the hypothesis that income series generally contained both permanent and transitory components. The result showed that the most of quarterly income series contained a substantial moving average part even after seasonality was accounted for.

Some researchers focused on the relation between firm characteristics and forecast accuracy. Bathke et al. (1989) tested the prediction power for large, medium-, and lower-sized firms. Bathke et al. (2004) found also that, while the seasonal random walk (SWR) model did not appear to be descriptively valid for the entire sample of firms, it may, nevertheless, be more appropriate

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for some firms relative to others. Lorek and Willinger (2007) concluded that the choice of an appropriate model was dependent on the business context.

It is noticed that during two decades spanning approximately from 1968 to the late 1980s, many researchers examined whether analysts' forecasts were superior to time-series forecasts. Elton and Gruber found that the differences in forecasts accuracy between forecasts made by mechanical models (especially by those made by the exponential smoothing additive model) and security analysts' forecasts were not statistically significant. Collins and William (1980) wrote that financial analysts provided forecasts more accurately than the statistical models because financial analysts could respond to situations such as strikes or sudden swings in earnings. Conroy and Harris (1987) concluded that, on average, the primary forecasting advantages of analysts over time-series methods appeared to occur over short forecast horizons. The above studies were however based on annual data. Using quarterly time series of earnings, Brown and Rozeff (1979a) argued that at longer horizons the analyst behavior corresponded to autoregressive time-series models rather than moving average models. Hopwood et al. (1981) pointed out that forecasts of quarterly earnings made by time-series models were outperformed by financial analysts. This literature culminated in 1987 with a conclusion in the paper of Brown et al. (1987) that analyst forecasts were superior to time-series forecasts because analysts had an information advantage and a timing advantage. It took two decades to conclude it. Subsequently, there was a sharp decline in research on the properties of times series EPS forecasts. The research by Damodaran (1989) stressed, however, the importance of time-series models to forecast earnings when analyst forecasts were not available. Walther (1997) found that market participants were placing more weight on analyst forecasts relative to time-series models as institutional ownership and analyst coverage increased, which was the proxy for investor sophistication. Bradshaw et al. (2012) point out that the fraction of listed companies in the US uncovered by analysts diminished from 55% in 1980 to around 20% in 2007. It was one of the major reasons for less interest in statically based forecasting of earnings. Recently, Pagach and Warr (2020) re-examined the hypothesis of analysts' forecasts superiority vs. time-series forecasts made by BR and seasonal random walk models by using quarterly data. The general results were consistent with the analysts' dominance; however, more contextual interpretation was suggested. Specifically, they found that for a relatively large number of cases (approximately 40%) ARIMA time-series forecasts of quarterly EPS were equal to or more accurate than consensus analysts' forecasts. Moreover, the percentage of time series superiority increased for longer forecast horizons as the firm size decreased and for high-technology firms. It occurred also that ARIMA models dominated the SRW model.

Mostly, the research was focused on the US-listed companies due to the long earnings history as well as the extensive analyst coverage compared to other markets. Few exceptions to this rule were papers by Bao et al. (1996) and Grigaliūnienė (2013).

In the first of the above papers, the authors referred to the annual earnings of Taiwanese listed companies. The forecast accuracy of a pure mean-reverting process with and without growth component that was a deterministic function of time, random walk, and random walk with drift processes was considered. It appeared that the model that fitted time-series data the most was the random walk model. The second paper suggested that in Baltic countries quarterly earnings followed a simple and seasonal random walk process compared to the three premier models (BW, F, BR). Unfortunately, the samples of companies used in that research are quite small – they consisted only of 48 companies and 8 companies respectively. They were not large enough to draw statistical conclusions.

It is also worth stressing that all the existing research was limited to the period ending before 2009, which is the year of structural change marked by the last financial crisis, and no paper yet covers the most recent period of stability, i.e. the period between the financial crisis shock and the pandemic shock.

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One of the first literature reviews dedicated to modeling earnings using some time-series techniques was provided by Watts and Leftwich (1977). It was followed by Bao et al.'s (1983) work and a very in-depth description of existing research by Bradshaw et al. (2012). One of the lastly published reviews of evolving accomplishments in that field was the paper by Grigaliūnienė (2013).

The literature review and observation indicate that only very few research papers were devoted to the modeling of earnings per share in emerging markets. Moreover, in those papers, the samples of companies used were not of a substantial size. Also, the periods covered in those publications are generally quite old. Hence, my research goal will be to analyze one of the important emerging markets using the most recently available data and having a sizable sample of companies. Apart from that, in almost all existing literature, the mean absolute percentage metric is used to access the accuracy of forecasts. However, this measure has a serious disadvantage to deal with situations when earnings are close to or equal to zero. A modification of this metric will be proposed to address this issue.

3. METHODOLOGY AND DATA

3.1. Methodology

Naïve models

Five naïve time-series models and four seasonal autoregressive integrated moving average (SARIMA) type models are analyzed in the paper. Denoted as Q_t is the realization of *EPS* at the end of quarter t. The naïve models include:

1. The random walk model (RW) can be described as:

$$Q_t = Q_{t-1} + \varepsilon_t, \text{ where } \varepsilon_t \text{ are IID}^1 \text{ and } \varepsilon_t \sim N(0, \sigma^2)$$

Hence $E_{t-1}(Q_t) = Q_{t-1}$, so the model does not need any estimation of parameters to make the forecasts. To estimate the variance of the disturbance term: $\varepsilon_t = Q_t - Q_{t-1}$, the following calculations have to be made: $\hat{\sigma}^2 = \sum_{t=1}^{T} \frac{(\varepsilon_t - \bar{\varepsilon}_t)^2}{T-1}$, where $\bar{\varepsilon}_t = \sum_{t=1}^{T} \frac{\varepsilon_t}{T}$.

2. The random walk model with drift (RWD) can be described as:

$$Q_t = \delta + Q_{t-1} + \varepsilon_{t-1}, \text{ where } \varepsilon_t \text{ are IID and } \varepsilon_t \sim N(0, \sigma^2)$$

Thus $E_{t-1}(Q_t) = \delta + Q_{t-1}$. To make the forecast, we have to estimate the drift parameter as $\hat{\delta} = \bar{\varepsilon}_t$, whereas $\hat{\sigma}^2$ is estimated as above.

3. The seasonal random walk model (SRW) can be described as:

$$Q_t = Q_{t-4} + \varepsilon_t, \text{ where } \varepsilon_t \text{ are IID and } \varepsilon_t \sim N(0, \sigma^2)$$

$E_{t-1}(Q_t) = Q_{t-4}$, so the model does not need any estimation of parameters to make the forecasts. To estimate the variance of the disturbance term: $\varepsilon_t = Q_t - Q_{t-4}$, the calculations similar to those described in point 1 have to be made: $\hat{\sigma}^2 = \sum_{t=1}^{T} \frac{(\varepsilon_t - \bar{\varepsilon}_t)^2}{T-1}$, where $\bar{\varepsilon}_t = \sum_{t=1}^{T} \frac{\varepsilon_t}{T}$.

[1] IID – independent, identically distributed.

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4. The seasonal random walk model with drift (SRWD) can be described as:

$$Q_t = \delta + Q_{t-4} + \varepsilon_t, \text{ where } \varepsilon_t \text{ are IID and } \varepsilon_t \sim N(0, \sigma^2)$$

Similarly to the random walk with drift model $E_{t-1}(Q_t) = \delta + Q_{t-4}$. To make the forecast, we have to estimate the drift parameter as $\hat{\delta} = \bar{\varepsilon}_t$, whereas $\hat{\sigma}^2$ is estimated as mentioned in point 4.

SARIMA models

Seasonal autoregressive integrated moving average (SARIMA) models are a class of autoregressive integrated moving average models (ARIMA) with a seasonal component. The next four presented models are of the seasonal autoregressive integrated moving average (SARIMA) type and they generally can be expressed in the following way:

$$\varphi(B)(1-B)^d\Phi(B^S)(1-B)^D Q_t = \theta(B)\Theta(B^S)\varepsilon_t + \theta_0$$

where B and B^S are backshift and seasonal backshift operators, i.e. $BQ_t = Q_{t-1}$ and $B^S Q_t = Q_{t-4}$. The error terms ε_t are generally assumed to be independent, identically distributed variables sampled from a normal distribution with zero mean, i.e. $N(0, \sigma^2)$. $\varphi(B)$ and $\Phi(B^S)$ are polynomials referring to the autoregressive part, respectively: $\varphi(B) = 1 - \varphi_1 B - \ldots - \varphi_p B^p$ and $\Phi(B^S) = 1 - \varphi_1(B^S) - \ldots - \varphi_P(B^S)^P$. $\theta(B)$ and $\Theta(B^S)$ are polynomials describing moving average parts, so $\theta(B) = 1 - \theta_1 B - \ldots - \theta_q B^q$, where θ_0 is a constant term and $\Theta(B^S) = 1 - \Theta_1(B^S) - \ldots - \Theta_Q(B^S)^Q$. D and d parameters are the degrees of freedom of ordinary and seasonal parts required to eliminate the so-called "unit root" problem, i.e. to achieve stationarity of the Q_t series. Thus, any model can be described of order $(p, d, q)\times(P, D, Q)$, where parameters p, P describe the autoregressive, seasonal autoregressive part, parameters q, Q describe the moving average, seasonal moving average part, and parameters d, D describe the order of differencing, seasonal differencing. Parameters of the SARIMA model are estimated using the maximum likelihood estimation (MLE) method. The MLE estimates for SARIMA parameters are consistent, normally distributed, and asymptotically efficient (Asteriou & Hall, 2011).

The considered SARIMA models are described as follows:

5. The Griffin-Watts (GW) model is the SARIMA model of order $(0, 1, 1)\times(0, 1, 1)$ without constant term and can be described as:

$$Q_t = Q_{t-1} + (Q_{t-4} - Q_{t-5}) + \varepsilon_t - \theta_1\varepsilon_{t-1} - \Theta_1\varepsilon_{t-4} - \theta_1\Theta_1\varepsilon_{t-5}$$

so the forecast is:

$$E_{t-1}(Q_t) = Q_{t-1} + (Q_{t-4} - Q_{t-5}) - \theta_1\varepsilon_{t-1} - \Theta_1\varepsilon_{t-4} - \theta_1\Theta_1\varepsilon_{t-5}.$$

6. The Foster (F) model is the SARIMA model of order $(1, 0, 0)\times(0, 1, 0)$ with constant term and can be written in the following way:

$$Q_t = Q_{t-4} + \varphi_1(Q_{t-1} - Q_{t-5}) + \varepsilon_t + \theta_0$$

and the forecast is given as:

$$E_{t-1}(Q_t) = Q_{t-4} + \varphi_1(Q_{t-1} - Q_{t-5}) + \theta_0.$$

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7. The Brown-Rozeff (BR) model is the SARIMA model of order $(1, 0, 0)\times(0, 1, 1)$ without constant term and is formulated as follows:

$$Q_t = Q_{t-4} + \varphi_1(Q_{t-1} - Q_{t-5}) + \varepsilon_t - \theta_1\varepsilon_{t-1} - \Theta_1\varepsilon_{t-4}$$

which implies the following forecast:

$$E_{t-1}(Q_t) = Q_{t-4} + \varphi_1(Q_{t-1} - Q_{t-5}) - \Theta_1\varepsilon_{t-4}.$$

8. The firm-specific (BJ) model in which parameters $(p, d, q)\times(P, D, Q)$, as well as the constant term θ_0, are chosen individually for every company. To determine the orders of differencing d and D, the KPSS test described below is performed. The choice of the most appropriate model type is determined by the lowest Akaike's information criterion (AIC)[2] (Asteriou & Hall, 2011). The individual SARIMA models are selected using the stepwise procedure described by Hyndman and Khandakar (2008).

Forecasts accuracy given by the above models is measured in two ways, using mean percentage absolute error and average rank of error.

Stationarity test

To apply the above models, a time series needs to be stationary. The Kwiatkowski-Phillips-Schmidt-Shin (KPSS) nonparametric test of stationarity is used (Kwiatkowski et al., 1992) to establish the difference of that time series over 4 quarters concerning the training period.

$$H_0 : \textit{time series is stationary}$$

Mean arctangent absolute percentage error (MAAPE).

Let's call by $A_1^i,\ldots,A_4^i$ the actual EPS realized in the *1-st*,..., *4-th* quarter respectively of 2019 for the *i-th* firm. $F_1^i,\ldots,F_4^i$ are forecasts of this variable in the above periods. An absolute percentage error (APE) of the forecasts for an *i-th* individual company in the *j-th* quarter of 2019 is defined as:

$$APE_j^i = \left|\frac{A_j^i - F_j^i}{A_j^i}\right|.$$

Based on this error metric, the so-called mean absolute percentage error (MAPE) is defined, which is widely used in the existing research. This is the most popular measure of a time-series forecast; however, APE has a significant disadvantage: it produces infinite or undefined values when the actual values are zero or close to zero, which is a common occurrence in the forecasting of earnings. If the actual values are very small (usually less than one), APE yields extremely large percentage errors (outliers), while zero actual values result in infinite APEs. To overcome this difficulty, Kim and Kim (2016) introduced a modified APE measure called arctangent absolute percentage error, which is a novel approach in the literature:

$$AAPE_j^i = arctan\left(\left|\frac{A_j^i - F_j^i}{A_j^i}\right|\right),$$

because *arctan* is a function transforming $[-\infty, +\infty]$ interval into $[-\pi/2, \pi/2]$ interval.

[2] Bayesian information criterion (BIC) has been used alternatively for model selection. This criterion prevents overfitting, which may arise in the case of AIC. The conclusions remain valid regardless of the information criterion being used.

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Hence, the mean arctangent absolute percentage error (MAAPE) for the *i-th* company across all 4 quarters can be written as:

$$MAAPE^i = \frac{1}{4}\sum_{j=1}^{4} AAPE_j^i = \frac{1}{4}\sum_{j=1}^{4} arctan\left(\left|\frac{A_j^i - F_j^i}{A_j^i}\right|\right).$$

And the mean arctangent absolute percentage error (MAAPE) for the *j-th* quarter across all *I* companies in the sample can be expressed as:

$$MAAPE_j = \frac{1}{I}\sum_{i=1}^{I} AAPE_j^i = \frac{1}{I}\sum_{i=1}^{I} arctan\left(\left|\frac{A_j^i - F_j^i}{A_j^i}\right|\right).$$

Thus, the mean arctangent absolute percentage error (MAAPE) across all 4 quarters and across all *I* companies in the sample is given by the formula:

$$MAAPE = \frac{1}{I}\sum_{i=1}^{I} MAAPE^i = \frac{1}{4}\sum_{j=1}^{4} MAAPE_j = \frac{1}{4I}\sum_{i=1}^{I} arctan\left(\left|\frac{A_j^i - F_j^i}{A_j^i}\right|\right).$$

For the described models, forecasts are made and for the *m-th* model, $MAAPE(m)_1$,…, $MAAPE(m)_4$ as well as $MAAPE(m)$ are calculated.

The average rank of error

For every firm and quarter combination, absolute percentage errors of the above-mentioned models are ranked. The model with the lowest error is given a rank of 1 and the model with the highest error is given a rank of 8. Then, the average rank of each model across all firms for 1-st quarter-ahead,…, 4-th quarter-ahead forecasts is calculated together with the average rank across 4 quarters and across all companies. Denoted by $AAPE(m)_j^i$, the arctangent absolute percentage error of the forecast for an i-th individual company in the *j-th* quarter of 2019 given by the *m-th* model and $R(m)_j^i$ is the rank of that forecast, where $m = 1,\ldots, 8$. Hence, the average rank of the *m-th* model and the *i-th* company across all 4 quarters can be written as:

$$\bar{R}(m)^i = \frac{1}{4}\sum_{j=1}^{4} R(m)_j^i.$$

The average rank of the *m-th* model and the *j-th* quarter across all *I* companies in the sample can be expressed as:

$$\bar{R}(m)_j = \frac{1}{I}\sum_{i=1}^{I} R(m)_j^i.$$

The average rank of the *m-th* model across all *I* companies in the sample and all across 4 quarters can be expressed as:

$$\bar{R}(m) = \frac{1}{I}\sum_{i=1}^{I} \bar{R}(m)^i = \frac{1}{4}\sum_{j=1}^{4} \bar{R}(m)_j = \frac{1}{4I}\sum_{i=1}^{I} R(m)_j^i.$$

For the described models, forecasts are made and for the *m-th* model, $\bar{R}(m)_1,\ldots,\bar{R}(m)_4$ as well as $\bar{R}(m)$ are calculated.

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The Kruskal-Wallis test

Then, the Kruskal-Wallis one-way H-test (Corder & Foreman, 2009) is made. This is a nonparametric test that avoids difficulties concerning the potential normality of errors. The null hypothesis is that the median AAPEs of all models are equal, i.e the average ranks of 8 models are the same. This is calculated for respective quarters as well as for all forecast quarters and Kruskal-Wallis H statistics with their respective p-values are calculated.

$$H_0 : \textit{medians of AAPEs of all } 8 \textit{ models are the same}$$

The null hypothesis is rejected when the p-value of Kruskal-Wallis H statistics is greater than the assumed significance level[3].

The Wilcoxon test

As the last one, the paired comparison of forecast errors is performed using the nonparametric two-sided Wilcoxon test (Wilcoxon, 1945) to assess the equality of median absolute percentage errors of various models. For each quarter 1,…,4 and all quarters, separate tables are calculated in which above the diagonal p-values of Wilcoxon statistic are presented for all model pairs.

$$H_0 : \textit{medians of AAPEs of a pair of models are the same}$$

The null hypothesis that medians of absolute percentage errors are the same is rejected when the respective p-value is lower than the assumed significance level. It is important that the test is quite 'robust' and does not require any specific assumptions about a probability distribution apart from symmetricity of the difference in scores and independence of observations.

3.2. Data

The Polish stock market is the deepest among counties that joined the European Union after 2004. At the end of 2021, the capitalization of the Warsaw Stock Exchange was USD 197 bn with 774 listed companies and was the largest in the region. Polish stocks are also not so widely covered by financial analysts as the US market or even Western European companies. In Poland, for only a small fraction of companies, EPS forecasts for the next year are released, so time-series models providing a credible forecast would be of paramount importance. At the end of the analyzed period, i.e. 2019, only around 20% out of 711 listed companies were covered by financial analysts. I focus on earnings per share (EPS) data series, since this measure is merger and split resistant. The data source is EquityRT[4], which is a financial analysis platform. The behavior of earnings per share (EPS) of firms listed on the Warsaw Stock Exchange is analyzed spanning from Q1 2010 to Q4 2019, i.e. between two structural shifts of the processes driving earnings. The first event is the financial crisis of 2008 and the subsequent decline in GDP growth of the Polish economy in 2009. The second one is the beginning of the COVID-19 pandemic followed by the lockdown of the economy and a sharp fall in GDP growth in Q1 2020. The data for the period Q1 2010 – Q4 2018 (36 quarters) are used for the estimation of various models, whereas the data from Q1 2019 to Q4 2019 are used as a hold-out validation sample for testing forecast accuracy of 1 quarter-ahead, 2 quarters-ahead, 3 quarters-ahead, and 4 quarters-ahead forecasts. Hence, the companies for which EPS are forecasted require sufficiently long time series (40 observations for training and testing) of earnings and thus are subject to survivorship bias. This bias is however characteristic of the choice of companies to use any more advanced time-series model that requires a series of

[3] It is assumed at 0.05 level.

[4] EquityRT is a product of Turkish company RASYONET.

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data that is long enough. To assert comparability of results, it is required – even for naïve models – to have the same data sample as for more advanced ones. Hence, firms in the sample are likely to be larger and older than the average. Moreover, I decided to eliminate only stocks with splits/reverse splits because such operations influence EPS behavior substantially. There were only cases of splits/reverse splits for 12 companies in the analyzed period.

To validate that results are not specific for 2019 year, other years are chosen as hold-out samples. The models are estimated using the expanding window approach, i.e. the sample Q1 2010 – Q4 2017 is used for their estimation and Q1 2018 – Q4 2018 for their testing. Then, the same procedure is applied taking the year 2017 to validate the results.

After imposing a full time window 2010–2019 coverage and excluding splits, there are 267 such companies on the market. In various studies mentioned in the previous section, firms which were subject to government rate regulation, like utilities and financial sectors, were eliminated from consideration. Because I cannot find a clear reason why the time-series methodology cannot be applied in these cases, I do not exclude them from the sample. Moreover, in many cases, it is hard to determine to what extent the government regulations are shaping the revenue and what portion of revenues can be attributed to market behavior.

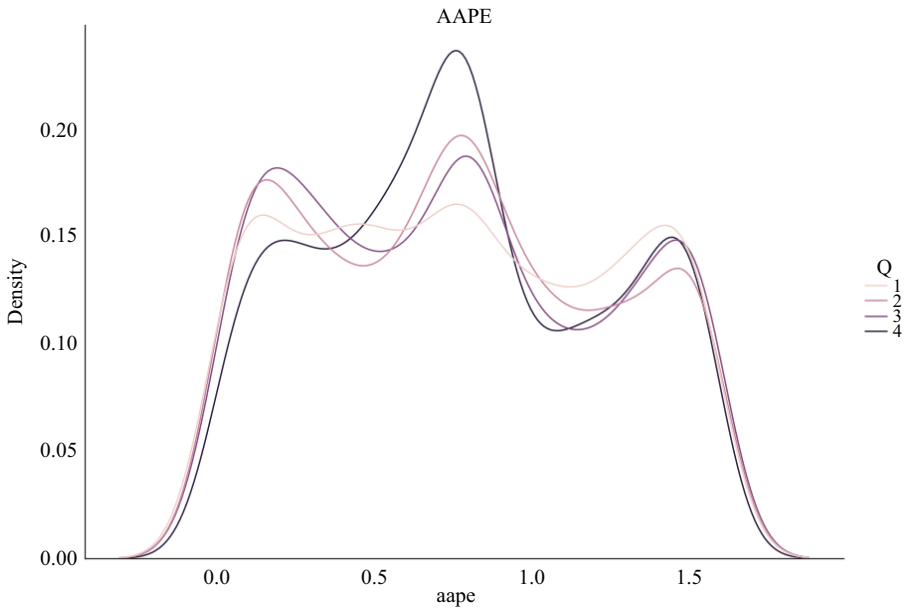
4. RESULTS

4.1. Empirical findings

The time series were analyzed on a level scale. At the beginning of this study, the Kwiatkowski-Phillips-Schmidt-Shin (KPSS) stationarity test is applied to the difference over 4 quarters for the analyzed time series to verify if SARIMA type models can be applied. In all cases, the null hypothesis of stationarity cannot be rejected.

Figure 1 suggests that kernel density estimators of arctangent absolute percentage forecast errors are pretty similar in all analyzed quarters. Surprisingly, it implies that forecast errors do not increase with forecast horizons. It is confirmed by the behavior of MAAPE for studied models in Table 1.

Fig. 1.
The kernel density estimators of arctangent absolute percentage errors for forecast quarters



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The model that performs the best and has the lowest rank in respective quarters as well as for all quarters is the seasonal random walk (SRW) model, which is presented in Table 1. The model which in turn performs the worst and has the highest ranks is the seasonal random walk with drift (SRWD) model. Almost the same holds for mean arctangent absolute percentage errors (MAAPEs) except for the 2nd and 4th quarters. In the 2nd and 4th quarters, the models with the lowest mean error are the company specific SARIMA (BJ) models. However, average prediction errors of these models do not differ substantially from the seasonal random walk model (i.e., by only 0.01) in those quarters. The model which in turn performs the worst and has the highest MAAPE is the random walk with drift (RWD) model. It happens in all quarters but not in the 4th quarter as well as jointly for all quarters. In the 4th quarter, the model with the highest rank is the Griffin-Watts (GW) model. The conclusion is that for the Polish market and the forecast period Q1–Q4 2019, the naïve seasonal random walk (SRW) model performs better than more advanced SARIMA type models. This is consistent with the findings of Bao (1996) for Taiwan and Grigaliūnienė (2013) for the Baltic countries that the most appropriate for these markets were naïve models.

Table 1 presents the results of nonparametric Kruskal-Wallis H statistics and its p-value, which does not require a normality assumption. The null hypothesis is that medians of arctangent absolute percentage errors (AAPEs) of all 8 models are the same. The test is made for all quarters respectively and for the entire period. The test shows that the null hypothesis can be rejected in all cases except the 4th quarter. It might derive from the fact that dispersion of ranks between the best and the worst model is much greater for these quarters than for the 4th quarter. In this quarter, the hypothesis that all models generate a similar median of errors statistically cannot be rejected.

In the next step, it is checked if the errors of the best model are statistically significantly different from the results of other models. To do so, the Wilcoxon test nonparametric is calculated for all model pairs. The null hypothesis states that medians of arctangent absolute percentage errors (AAPEs) of a selected pair of models are the same. Tables from 2 to 5 present p-values of the test for all combinations of model pairs in respective quarters. In Table 6, the results for all joint quarters are analogously displayed. The test confirms that the seasonal random walk (SRW) model produces a median of errors statistically significantly lower than other models in the 1st quarter. The only exception to this rule might be the firm-specific SARIMA (BJ) model. It is worth noting that the p-value for the combination of SRW and BJ models is 0.0487, which is only slightly below the assumed significance level of 0.05. Hence, the null hypothesis cannot be rejected at the 0.01 significance level. So, it can be said that BJ forecast errors given by these two models are not so statistically different. In the 2nd quarter, the median of errors of the SRW model are not statistically different from those of the BR (Brown-Rozeff) and BJ models. In the 3rd quarter, only the median of errors of the BR model does not statistically differ from the best SRW model. In the 4th quarter, we can't reject the null hypothesis that the median errors are different for the SRW and BJ models at 0.05 level of significance and for the SRW and BR models at 0.01 significance level. With respect to all quarters, only the SRW and BJ models generate statistically not different medians of errors. It emerges from the above analysis that mainly medians of errors of the firm-specific (BJ) model are statistically the same as the best seasonal random walk (SRW) model in most periods.

It is worth emphasizing that the seasonal random walk model (SRW) is a special case of the Foster (F), Brown-Rozeff (BR), and firm-specific models that assume quarterly seasonality and set all parameters equal to zero. The fact that mean arctangent absolute percentage errors of the SRW model are substantially lower than those of the above-mentioned ARIMA models might emerge from how the models are estimated. Minimization of the maximum likelihood function, which is a standard technique for the model estimation, is not fully consistent with the minimization of any type of absolute percentage error including mean arctangent absolute percentage error.

The superiority of the seasonal random walk model (SRW) implies that the underlying EPS generating process exhibits neither autoregressive nor moving average parts and there is no drift. It means that any older or shorter history than exactly one-year history has no substantial

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influence. The horizontal performance of the stock market index WIG during the analyzed period implies the absence of a trend. The absence of the moving average part means non-existence of an error correction mechanism by which past errors influence the behavior of future earnings. Past errors are deviations of actual EPS numbers from the data forecasted by the model. In the context of emerging markets, it is consistent with the fact that a small fraction of companies publish forecasts of their earnings compared to developed markets. Hence, for not so many companies from these markets, past forecast errors result in the correction of the performance of future earnings. Non-existence of the autoregressive part may in turn be related to the dominance of the seasonal component relative to past EPS behavior, which might imply that Polish and, more generally, emerging market companies are more seasonal than those operating on developed markets. This hypothesis could be examined in further research.

4.2. Robustness check

Table 7 confirms that the seasonal random walk model is characterized by the lowest rank, i.e. gives the best results not only in 2019, but also in 2018 and 2017. Also high values of Kruskal-Wallis H statistics reject the null hypothesis that the model errors are not statistically different in those years. Additionally, the Wilcoxon test is made for all model pairs with the seasonal random walk model and p-values across different years are presented in Table 8. In 2017, they all are lower than the assumed significance level, so the errors of all models are statistically different from the errors of the seasonal random walk model. In 2018, similarly to 2019, only the results of the firm-specific model (BJ) are statistical not different from those of the seasonal random walk model. Hence, it emerges from the above that the superiority of the seasonal random walk model seems to be invariant in time.

5. CONCLUSIONS

The paper describes the forecasting characteristics of eight univariate time-series models applied for quarterly earnings per share of 267 Polish companies in the period 2010–2019. It turns out that counter-intuitively forecast errors do not increase with forecast horizons. The best model, with the lowest rank, is the seasonal random walk (SRW) model across all quarters, which describes quite well the behavior of the Polish market compared to other models. This is consistent with the findings of Bao (1996) for Taiwan and Grigaliūnienė (2013) for the Baltic countries that the most appropriate for these markets were naïve models. The medians of errors of the analyzed models differ statistically significantly in almost all quarters. Medians of errors of the firm-specific (BJ) model are statistically not different from the best seasonal random walk (SRW) model for most analyzed periods. The superiority of the seasonal random walk model seems to be invariant in time.

This finding is consistent with the absence of drift and autoregressive and moving average parts. It might be related to the performance of the stock market index during the analyzed period, the fact that a lower fraction of emerging market companies publish forecasts of their earnings compared to developed markets, and the dominance of the seasonal component compared to past EPS behavior. The above hypothesis can be verified in further research.

Concerning a future research agenda, it would be interesting to verify if another class of time-series models relying on exponential smoothing provides more precise forecasts than naïve random walk models. The relation between forecast efforts and firm size should also be examined. The business context described by the sector in which a company operates may also play an important role in assessing which model most accurately forecasts earnings per share. Additionally, a seasonal pattern described by the SRW model might imply an investment strategy based on this pattern. In further research, such a strategy could be tested in terms of its capability to beat the market. These findings might contradict the weak form of efficient market hypothesis (EMH).

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Table 1
Summary statistics on forecast errors and Kruskal-Wallis test for 2019 quarters

model	Quarters								All Quarters	
	Q1 MAAPE	Q1 Average Rank	Q2 MAAPE	Q2 Average Rank	Q3 MAAPE	Q3 Average Rank	Q4 MAAPE	Q4 Average Rank	MAAPE	Average Rank
RW	0.89	5.21	0.80	4.68	0.83	5.01	0.74	3.97	0.81	4.72
RWD	0.92	5.81	0.84	5.26	0.88	5.59	0.79	4.96	0.85	5.40
SRW	0.66	3.69	0.70	3.98	0.65	3.74	0.74	3.97	0.69	3.85
SRWD	0.70	4.03	0.73	4.35	0.73	4.25	0.80	4.67	0.74	4.33
GW	0.78	4.51	0.80	4.81	0.77	4.52	0.82	4.84	0.79	4.67
F	0.77	4.38	0.75	4.49	0.75	4.35	0.80	4.75	0.77	4.49
BR	0.75	4.16	0.74	4.24	0.71	4.14	0.80	4.62	0.75	4.29
BJ	0.71	4.20	0.69	4.19	0.74	4.40	0.73	4.23	0.72	4.25
H statistics		63.92		19.79		38.18		10.79		36.56
p-value		0.00		0.01		0.00		0.15		0.00

Table 2
P-values of paired Wilcoxon test of forecast errors in Q1 2019

model	RWD	SRW	SRWD	GW	F	BR	BJ
RW	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
RWD		0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
SRW			0.0218	0.0001	0.0000	0.0005	0.0487
SRWD				0.0052	0.0129	0.0887	0.5389
GW					0.4606	0.0609	0.0240
F						0.7939	0.1090
BR							0.1573

Table 3
P-values of paired Wilcoxon test of forecast errors in Q2 2019

model	RWD	SRW	SRWD	GW	F	BR	BJ
RW	0.0000	0.0004	0.0210	0.3844	0.0412	0.0066	0.0004
RWD		0.0000	0.0003	0.0541	0.0012	0.0001	0.0000
SRW			0.0036	0.0002	0.0001	0.5705	0.9455
SRWD				0.0215	0.2108	0.9248	0.2197
GW					0.0763	0.0010	0.0007
F						0.4492	0.0856
BR							0.4630

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Table 4
P-values of paired Wilcoxon test of forecast errors in Q3 2019

model	RWD	SRW	SRWD	GW	F	BR	BJ
RW	0.0000	0.0000	0.0001	0.0028	0.0001	0.0000	0.0003
RWD		0.0000	0.0000	0.0001	0.0000	0.0000	0.0000
SRW			0.0001	0.0020	0.0000	0.1113	0.0005
SRWD				0.1770	0.2032	0.2569	0.5654
GW					0.1947	0.0441	0.6852
F						0.1285	0.9419
BR							0.2883

Table 5
P-values of paired Wilcoxon test of forecast errors in Q4 2019

model	RWD	SRW	SRWD	GW	F	BR	BJ
RW	0.0000	0.0000	0.0000	0.0011	0.0000	0.0213	0.7377
RWD		0.0000	0.4202	0.1339	0.8936	0.4939	0.0785
SRW			0.0000	0.0011	0.0000	0.0213	0.7377
SRWD				0.1578	0.6280	0.8037	0.0281
GW					0.2343	0.0502	0.0045
F						0.8973	0.0196
BR							0.0547

Table 6
P-values of paired Wilcoxon test of forecast errors for all quarters 2019

model	RWD	SRW	SRWD	GW	F	BR	BJ
RW	0.0000	0.0000	0.0000	0.0163	0.0003	0.0000	0.0000
RWD		0.0000	0.0000	0.0002	0.0000	0.0000	0.0000
SRW			0.0001	0.0000	0.0000	0.0042	0.0930
SRWD				0.0066	0.0183	0.7726	0.2826
GW					0.0984	0.0008	0.0007
F						0.0282	0.0131
BR							0.3392

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Table 7
Summary statistics on forecast terrors and Kruskal-Wallis for all quarters 2017–2019

model	2017		2018		2019	
	MAAPE	Average Rank	MAAPE	Average Rank	MAAPE	Average Rank
RW	0.83	4.78	0.86	4.97	0.81	4.72
RWD	0.85	5.42	0.88	5.60	0.85	5.40
SRW	0.69	3.86	0.71	3.81	0.69	3.85
SRWD	0.72	4.29	0.76	4.27	0.74	4.33
GW	0.79	4.75	0.80	4.62	0.79	4.67
F	0.75	4.45	0.78	4.41	0.77	4.49
BR	0.74	4.24	0.75	4.19	0.75	4.29
BJ	0.72	4.21	0.73	4.14	0.72	4.25
H statistics		32.07		40.28		36.56
p-value		0.00		0.00		0.00

Table 8
P-values of paired Wilcoxon test of forecast errors for all quarters 2017–2019 and SRW model

year	model	RWD	SRWD	GW	F	BR	BJ
2017	SRW	0.0000	0.0013	0.0000	0.0000	0.0007	0.0233
2018	SRW	0.0000	0.0000	0.0000	0.0000	0.0488	0.1686
2019	SRW	0.0000	0.0001	0.0000	0.0000	0.0042	0.0930

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FinTech regulation and the development of the FinTech sector in the European Union

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ABSTRACT

The aim of the article is to identify the relationship between the level of regulation of various segments of the FinTech industry and the level of development of this sector. To address this research problem, the paper analyses the scope of regulation in 14 segments of the FinTech sector, and based on that, develops the FinTech Regulation Index for the individual European Union countries. Then, the paper uses this index to examine if there is a relationship between the level of regulation and the level of FinTech development in the various European Union countries. The econometric analysis confirmed the initial hypothesis that there is a significant relationship between the level of FinTech sector regulation and the level of its development.

JEL Classification: G2, G23

Keywords: FinTech, FinTech Regulation Index, digital innovations.

1. INTRODUCTION

Already a few years ago, the European Union noticed significant changes in the financial sector due to the digitalisation of financial services. Supervisors and regulators have been facing the challenge of regulating the FinTech sector and the various segments of finance supported by new technologies (Lehmann, 2020). Additionally, new market players and the possibility of operating in a single financial market in the EU present significant challenges in applying the same rules to the same activities. However, when analysing changes that have taken place in the environment of financial institutions, it can be observed that technology is developing exponentially, whereas the same cannot be said about the legislative process. The dynamics of technological change overtakes the regulatory process despite the fact that it is very advanced in the financial system. The uneven development of these two areas can lead to a risk of hampering

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innovation. Moreover, innovations in the FinTech sector pave their way through the maze of regulations and unregulated areas (Kasiewicz & Kurkliński, 2018).

Undoubtedly, new technologies in the banking market have enabled the dynamic development and growth of interest in digital finance, which responds to the needs and preferences of financial market participants. Digital finance encompasses a wide range of products, applications, processes and business models that changed the way financial services are delivered to customers, and the FinTech sector exerts a significant impact on the development of the financial market. There is a need for significant changes in the regulation of the FinTech sector and the effectiveness of regulatory implementation. This is also an important issue for market regulators (Restoy, 2021). Most often, FinTech market regulation is dedicated to the payments segment (Khiaonarong & Goh, 2020), but this paper presents a broader approach that addresses a regulatory impact in the various segments of FinTech activities.

The paper presents the authors' attempt to identify the relationship between the regulation level of various segments of the FinTech industry and the development level of this sector in the European Union countries. The authors' analysis on the level of regulation of the FinTech sectors was based on data obtained from the World Bank database. It covers the level of regulation in more than 200 countries around the world until mid-2021. Additionally, the level of fintechisation was determined based on the Findexable database, which contains information about more than 11,000 FinTech companies.

2. LITERATURE REVIEW

Numerous banking regulations, poor confidence in financial institutions as well as conservatism of traditional banks have enabled the emergence and rapid development of new players in the financial market. Those entities propose a personalised offer in order to meet the needs of the modern customer of financial products and services. Solutions based on new technologies most often focus on providing services using the internet and mobile devices.

Recently, the concept of financial technology (FinTech) has attracted extensive attention from international organisations and regulators, in particular, as regards the ways to achieve a "win-win" situation between financial institutions' FinTech innovation and effective regulation (Yueling et al., 2021). In legal and regulatory debates on issues related to regulatory regimes, the FinTech sector is increasingly mentioned in terms of the need for regulatory changes that could replace the traditional approaches to systemic risk and financial stability regulatory models (Saule, 2020). Effective financial regulation is clearly crucial to innovation and the future success of the financial services industry and, specifically, the FinTech sector (Treleaven, 2015). However, regulating the FinTech sector presents significant challenges. The rapidly evolving technological landscape poses challenges for financial regulators, which are already facing the need to address a broader set of regulatory objectives and policy priorities (Bromberg et al., 2017). Digital innovations are created very quickly, along with emerging activities of new players in the financial market. This leads to the situation when regulators need to change their approach to regulating the financial sector towards a new model of regulation that takes into account digital finance (Douglas et al., 2017).

The European Commission noticed a significant impact of the FinTech sector on traditional finance. For this reason, it adopted in March 2018 an action plan for the FinTech sector to support a more competitive and innovative European financial sector (European Commission, 2020). Initiatives taken by European authorities aim to enable the rapid initiation of innovative digital financial solutions across EU countries. Digital innovation also generates various risks. Therefore, the main objective of creating a safe, single, innovative and digital banking market in the EU is to ensure consumer protection and enhance financial stability. Digital innovation brings significant

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benefits, both to consumers and businesses, as well as to financial institutions, by enabling greater access to financial services. It also fosters the elimination of national barriers and leads to dynamic growth in the European single market, especially in the e-banking, money transfer, social lending and personal finance sectors.

The Digital Finance Strategy is a new digital roadmap based on a new plan of cooperation with FinTech towards a more competitive innovative European financial sector (European Commission, 2018). In recent years, the financial sector has become the largest user of digital technologies, but it is also a major source of digital innovation.

FinTech entities very often provide their services in one or more financial sectors. Therefore, they should not be fully regulated like credit institutions. Nevertheless, it is worth bearing in mind that these new actors create new services and processes that may not have been subject to supervision and regulation so far. A lack of control of such entities may not only lead to inadequate consumer protection in the financial market but also threaten the stability of the financial sector (Chen et al., 2019)[1]. In this context, it is worth considering measures aimed at bringing new innovative business models, especially FinTech companies, under regulation and supervision.

The EU encompasses many economies and may therefore have different regulatory approaches to innovative solutions. National supervisors should cooperate with each other so that the approach to regulation is uniform in each EU country. The European Commission is therefore seeking to set a clear and consistent direction for authorisation requirements for FinTech companies. This direction will encourage the setting of common FinTech standards and solutions. The preferred approach is to develop global operating standards. One of the first challenges for the financial sector in this respect was the implementation of the Payment Services Directive 2 (PSD 2 Directive). It was based on global collaboration between banks and FinTech companies. As part of it, banks had to create and open appropriate communication channels to enable FinTech companies to provide their services based on access to payment accounts held by banks. To assist national supervisors, an innovation-friendly environment is being created in cooperation with national coordinators/innovators. Such environments are innovation hubs and regulatory sandboxes (EBA, 2017)[2]. Therefore, creating the conditions for innovative business models in the EU using innovation coordinators is necessary.

The rapid growth of the FinTech market has created numerous challenges for market regulators and supervisors. The FinTech sector has the potential to significantly impact the stability of the financial system and its safety, especially in the context of cyber-attacks. Following the 2007–2009 financial crisis, numerous legislation acts had an impact on the perception of banking sector stability. However, the widely highlighted lack of regulation of FinTech activities could lead to significant stability problems of the financial sector as a whole. The European Commission and supervisory authorities recognise the rapidly growing FinTech sector and attempt to identify possible risks emerging from it.

The direction of change that eliminates the risks associated with financial innovation is one that ensures consumer protection and attention to financial stability. The quality of law or even the lack of it in terms of consumer protection, such as in crowdfunding and community lending, should also be improved. There is also a need for legislative acts to ensure that financial stability is strengthened alongside the development of financial innovation. The European Parliament has therefore called on regulators and supervisors to continuously monitor the impact of digitalisation on the competitive situation in all key segments of the financial sector.

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[1] Research shows that some start-ups can negatively impact financial sustainability, see more: Chen et al. (2019).

[2] "*Innovation hub*" refers to an institutional arrangement in which regulated and unregulated entities (e.g. unlicensed companies) establish a relationship with a competent authority to share information, views, etc. and to obtain clarification on the compliance of business models with the legal framework or regulatory or licensing requirements (i.e. individual guidance for companies on the interpretation of applicable regulations). "*Regulatory sandboxes*" provide financial institutions and non-financial companies with a controlled space where they can test innovative FinTech solutions with the support of an authority for a limited period of time, and thus validate and test their business models in a secure environment.

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Technological innovation in financial services is evolving rapidly and there are and will continue to be opportunities and threats to financial stability that regulators and supervisors should pay close attention to. Risk analysis is particularly important because many financial innovations have yet to be tested in a full financial cycle, and decisions taken at this early stage can be the basis for maintaining stability in the whole financial sector. Currently, any assessment of the impact of the FinTech sector on financial stability is difficult due to the very limited availability of official data, which is very often only held by the private sector. The lack of access to data and the lack of regulation of the FinTech sector, which has been very often mentioned in many opinions of researchers and practitioners, implied a request by G20 countries to the Financial Stability Board (FSB) to formulate a report on regulatory and supervisory issues in the development of the FinTech sector and its impact on financial stability. The FSB has identified three key areas in international cooperation: operational risk management, cyber threat analysis, macroeconomic risk monitoring. The FSB emphasises the role of international cooperation in the regulation and supervision of the FinTech sector, which will reduce the risk of regulatory fragmentation or divergence (Kobza, 2019). Both the European Parliament and the European Council called on the European Commission to prepare a legal framework. The framework:

a) will be more oriented towards the development of the FinTech sector;
b) will be open to digitalisation;
c) and will create an environment where innovative FinTech services and solutions can be rapidly deployed across the EU member states.

The aim of this framework is to achieve the economies of scale of the single market without undermining financial stability or weakening consumer and investor protection (European Commission, 2018). The European Commission's plan provides an overview of initiatives and an action plan for the development of the FinTech sector in the EU countries. The European Commission has also proposed a plan to support the introduction of financial innovation into the financial sector in order to make the financial sector safer and more resilient and to create the conditions for the spread of innovative business models across the EU.

The increasing area of FinTech companies' activity leads to the establishment of research teams operating alongside institutions that form a financial safety net at the national and international levels. The European Banking Authority (EBA) has identified the following challenges facing the financial market as a result of the emergence of technological innovation (EBA, 2018b):

- consumer protection,
- prudential risk analysis,
- impact of the FinTech sector on the business models of financial institutions,
- creation of regulatory sandboxes,
- impact of technological innovation on the resolution of credit institutions.

The EBA is particularly focused on consumer protection in the financial market. Digitalisation of financial services leads to the exposure of financial institutions and their customers to cyber-attacks. As a result, financial institutions incur an increasing cost to protect their consumers against the risks associated with the growth of the internet. The scale of the financial institutions' operations enables them to work continuously on their security system and to cover costs related to this work. FinTech companies very often do not possess significant capital and have not significant capital expenditures related to security systems and consumer protection. As a result, FinTech companies may have a considerable problem with proper consumer protection. It is therefore a very important task to identify and mitigate prudential risks.

The lack of regulation of the FinTech sector specifically encourages entities concerned to create a regulated space for the development of financial innovation. FinTech companies are relatively young entities that are very often unregulated. Therefore, it is difficult to obtain financial data on their activities. As a result of the aggressive expansion of FinTech companies in the financial market, the amount of analysis of this market in the literature increases. However, due to the lack

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of statistical data, their analysis is a challenge (Yinqiao et al., 2017). The reason for this is that it is a very innovative, young sector which is difficult to quantify. Solving supervisory problems which are difficult or practically impossible to quantify with the application of quantitative methods can be considered not only a fundamental regulatory mistake but also an idea that creates barriers for traditional banks and prevents them from doing their business (Koleśnik, 2017). Therefore, the shape of regulation (in particular, its stringency) is very important, which, together with ICT innovations, will determine the future development of the banking sector – see Table 1 (O'Brien & Keith, 2009). The market regulator/supervisor can directly verify either the idea could exist in the market within the regulatory framework already implemented or the solution will require regulatory adaptation (Marchewka-Bartkowiak, 2018).

Table 1.
Scenarios for the banking future depending on the stringency of supervisory regulation and ICT innovation

Specification		Stringency of supervisory regulation	
		High	**Low**
ICT innovation	**rapid**	new technologies widely used by supervisors in both regulatory and day-to-day operations	elimination of technological and regulatory barriers, which leads to the appearance of a global market based on self-regulation and good practice
	slow	strong emphasis on safety rather than development of new technologies or products	steady emergence of transnational markets based on self-regulation and good practice

Source: Koleśnik (2017).

A number of studies indicate that, depending on the actors that implement new technologies in the financial world, they comply with or significantly violate rules/regulations (Dermot, 2021). An important challenge for the financial market is the fact that there is no single approach to methods of regulation of the FinTech sector. Everything depends on the approach of the national regulator (Yesha, 2020).

3. METHODOLOGY, DATA AND RESULTS

Due to the rapid growth of FinTech companies and their wide range of activities, national financial market regulators/supervisors approach the regulation of the various FinTech segments in different ways. In line with the World Bank's methodology and based on the Global Fintech-enabling regulations database, the FinTech sector was divided into 14 tiers. This division is in line with the division of the FinTech sector proposed, among others, by Ehrentraud et al. (2020):

- Anti-money laundering – regulations and rules related to anti-money-laundering/combating the financing of terrorism,
- CBDC – includes those that are actively working on understanding the feasibility of the economics and technology surrounding Central Bank Digital Currencies,
- CDD – Community-Driven Development (CDD) programmes operate under the principles of transparency, participation, local empowerment, demand responsiveness, greater downward accountability, and enhanced local capacity,
- Cryptocurrency – very few have issued regulations on cryptocurrencies; there are, however, guidelines on their use as outlined below,

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- Cybersecurity – regulations and rules as related to cybersecurity,
- Equity crowdfunding – regulations or guidelines in this regard,
- P2P,
- Data protection – includes laws and regulations relevant to the security and transmission of data,
- Digital banking – the treatment of digital-only banks as part of the regular bank licence or as a separate entity in the banking system,
- Digital ID – includes those that currently have digital ID systems and regulations surrounding them,
- Electronic money – highlights the ability to conduct electronic transactions including the ability to use debt-like instruments, i.e. so called e-money,
- Electronic payments/transactions,
- Innovation facilitators – typically, innovation facilitators are one of three types: innovation hub, regulatory sandbox and regulatory accelerator,
- Open banking – regulation that allows a bank to share customer data with customers' consent and in their interest.

In view of more and more emerging technological innovations in the banking sector, one can also observe an increasing number of entities applying for a licence granted by the national authorities responsible for licensing entities in the financial market. Therefore, an important challenge is the licensing of new entrants by national authorities but also the sealing of regulations already in place. In order to ensure the full transparency of the research conducted, the authors based their study on the level of regulation examined by the World Bank. The information collected focuses primarily on legislation and regulations implemented, but also includes related guidelines where relevant. These are laid out in a searchable, easy-to-use format. The database covers country treatments of two foundational regulations such as anti-money laundering and countering financial terrorism and the rules to combat cybercrime as well as regulations specific to FinTech business models such as digital banking and cryptoassets and marketplace lending (World Bank, 2022).

The analysis of the level of regulation in selected financial market segments varies according to the level of development of the regions under analysis. It is also worth noting that several segments around the world are significantly regulated and some are not sufficiently regulated by national supervisory authorities. Significantly regulated FinTech sectors are:

- Digital banking – 197 countries have regulated this sector, 1 country has not,
- Anti-money laundering – 194 countries have regulated this sector, 4 countries have not,
- E-money – 178 countries have regulated this sector, 20 countries have not,
- Cybersecurity – 173 countries have regulated this sector, 25 countries have not.

There are also areas of FinTech that are materially unregulated as regards the conduct of business. These are primarily sectors related to the cryptocurrency market (only 25 countries have regulations in this area, 173 do not have them) and the sector of digital currency of central banks – CBDC (54 countries have regulations in this area, while 144 do not have them). It is also worth noting that financial market regulators are sceptical about supporting innovation implementation processes in a regulated environment – through, among other things, an innovation hub and a regulatory sandbox (75 countries have regulations, while 123 do not have them).

Creating a regulated environment for digital innovations in the financial market is particularly important. Unlike traditional financial innovation implementation centres, which provide legal advice on demand, the regulatory sandbox approach usually involves a prior application process with the regulator/market supervisor. A company – usually a FinTech company applying to participate in a regulatory sandbox – must meet numerous criteria set by the sandbox developer. The undoubted advantage of the regulatory sandbox is that both regulated entities (financial institutions) and unregulated entities (e.g. start-ups) can participate in it. Additionally, a regulatory

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sandbox can address supervisors' challenges to improve consumer protection in the financial market. Benefits of participating in a regulatory sandbox are:

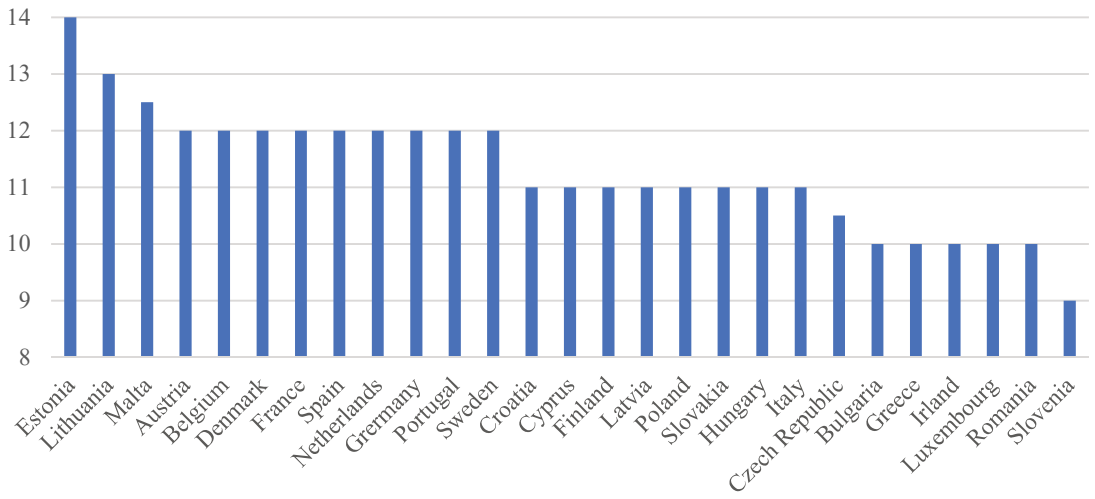
- shortening the process of introducing innovations into the market,
- enabling FinTech companies (mainly start-ups) to access funding more easily,
- allowing more services to be tested,
- enabling cooperation between the supervisor and a FinTech company on the application of consumer protection safeguards to the financial service offered.

Despite the many differences between the regulatory sandboxes in use, the EBA's report indicates that they also have many features in common, among others (EBA, 2018a):

- they are aimed at the entire FinTech sector,
- they are open to both large, regulated institutions and unregulated start-ups,
- they have virtually the same goals.

Based on data from the above mentioned database, the paper proposes an Index of FinTech Regulation based on three scores: a regulated segment is attributed 1 point, unregulated but not banned one – 0.5 points, not regulated – 0 points. Based on this index, it is possible to identify countries that have a very restrictive and intensive regulation of their FinTech sectors (e.g. Estonia, Lithuania, Malta) and countries that are less determined in regulating their FinTech sectors (e.g. Slovenia). Figure 1 presents the results of the above-mentioned index for each EU country. Analysing various FinTech segments, the most heavily regulated FinTech areas are: anti-money laundering, CDD, cybersecurity, data protection, digital banking, electronic payments/transactions and open banking, while the least regulated are cryptocurrencies and CBDC.

Figure 1.
FinTech Regulation Index in the EU countries in 2021 (in points)



Source: Own presentation based on the World Bank database – Global Fintech-enabling regulations database.

EU countries also show variation in the level of regulation of the FinTech sectors. Countries such as Slovenia, Romania, Luxembourg, Ireland, Greece or Bulgaria can be considered moderately focused on FinTech regulation, while Estonia, Lithuania and Malta belong to leaders in terms of FinTech market regulation. Within the EU's single financial market, different levels of the sector regulation can significantly affect safety of the market. A remarkable level of FinTech market regulation in Baltic countries (Estonia and Lithuania) can be linked to the large number of players operating in these markets. In Lithuania, the rapid increase in the number of FinTech companies was a result of Brexit, after which FinTech companies from the UK wishing to continue operating in the EU single market had to apply for a licence in one of the EU member states. Lithuanian regulations are characterised by both fast procedure for obtaining a licence and preferential tax arrangements.

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4. THE IMPACT OF REGULATIONS ON THE FINTECH SECTOR DEVELOPMENT

Indicative capture of the FinTech sector is a significant challenge, primarily due to the continuous nature of change in this sector as well as the relatively short lifespan of financial market players. Therefore, the literature review noted several indices used to classify the sector. One of the most common FinTechisation indices is a group of indicators covering the entire FinTech system proposed by global company Findexable. It is a digital platform that allows investors to get an up-to-date assessment of the level of the FinTech sector development in a single country as well as in major financial centres of the world. A competitive advantage of this database is manifested, among other things, in the real and up-to-date analysis of the changing components of the FinTech sector. The main objective of the Global Fintech Index database (GFI) is to increase the capacity and transparency in the global financial system focused on the implementation of financial innovation. Within that index, several factors have been identified that indicate its main features:

- neutrality – a strictly proprietary algorithm generates a real-time ranking which is not subject to change by an expert group,
- reality – the report is generated in real time, allowing an up-to-date assessment of the financial market situation and the level of innovation development of this sector,
- scale of activity – the index covers the entire developed financial market (global), which enables a comparative analysis between countries and cities,
- wide range of data provided by authorities analysing the role and scale of innovation implementation in the financial system.

FinTech companies have an extensive impact on the global financial system and the global economy. They help to access financial services in emerging markets and facilitate the transfer of money and international exchange. FinTechs are perceived as the 'heart' of digital technology in the financial world. They enable better communication between countries and regions and reduce the dependence on traditional financial institutions. Therefore, it is important to analyse and classify countries in terms of their FinTech sector development. Accordingly, different FinTech indices have been proposed in the financial world, such as the Global Fintech Index proposed by Findexable, a global data and analytics company. The index ranks the FinTech ecosystem across more than 200 cities and 60 countries, examining the activities of more than 7,000 FinTech companies. Figure 2 presents this index for the EU countries. Based on this index, Sweden, the Netherlands, Germany and Lithuania can be identified as the leaders in implementing innovations. On the other hand, there are countries that are the least successful in implementing innovations, such as Croatia, Greece and Slovakia.

The next step was to compute the correlation between the FinTech Development Index (Figure 2) and the FinTech Regulation Index (Figure 1). The results are presented in Model 1, which demonstrates a significant relationship between the analysed variables.

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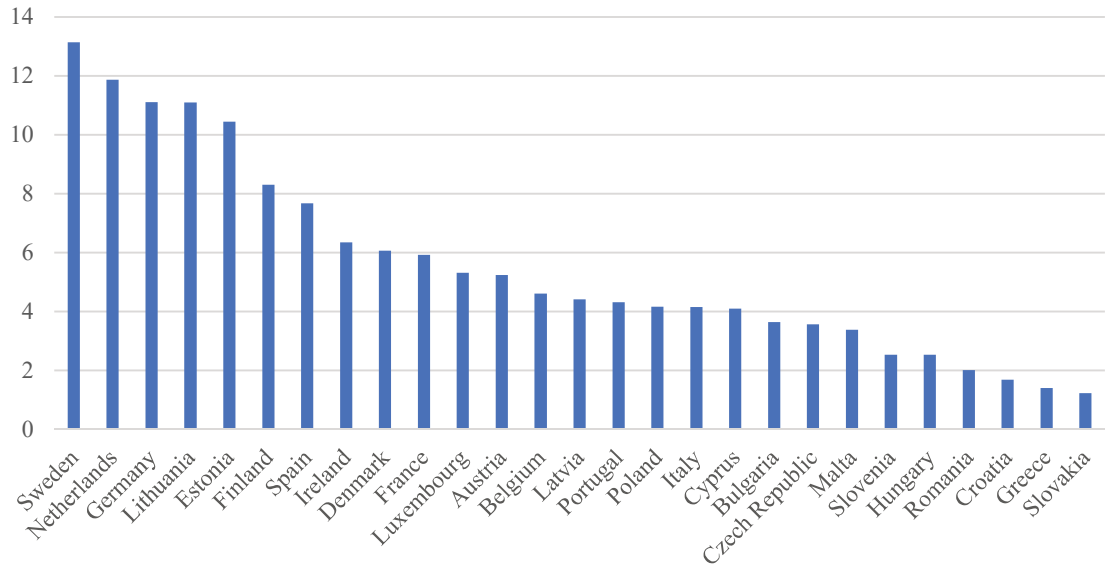
Figure 2.
FinTech Development Index in the EU countries in 2021 (in points)



Source: Own presentation based on Findexable: The Global Fintech Index database.

Model 1
Least squares approximation, observations used: 1–26
Dependent variable (Y): FinTech Development Index

	Factor	*Standard error*	*t-Student*	*p-value*	
const	−15.5119	5.72810	−2.708	0.0123	**
Regulation index	1.86881	0.504218	3.706	0.0011	***

Arithmetic mean of dependent variable	5.620000	Standard deviation of dependent variable	3.451299
Residual sum of squares	189.3863	Standard error	2.809109
Coefficient of determination (R-square)	0.364020	Adjusted R-square	0.337521
F(1, 24)	13.73705	P-value for F-test	0.001103
Logarithm of reliability	−62.70640	Akaike information criterion	129.4128
Bayesian information criterion	131.9290	Hannan-Quinn information criterion	130.1374

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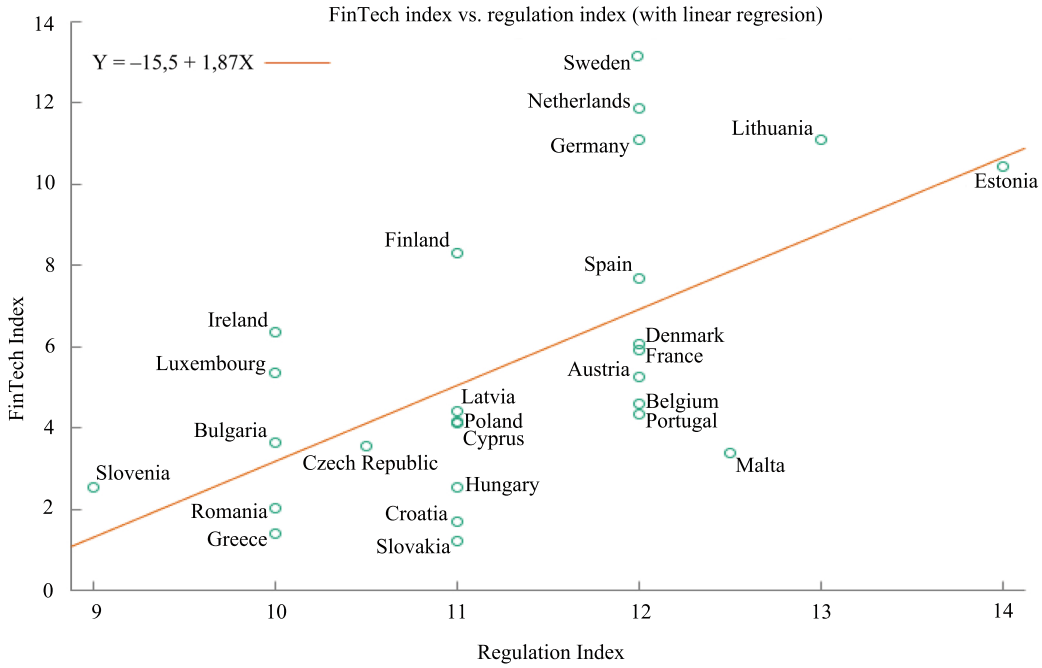
The results of the analysis are also presented in Figure 3, which allows for a number of observations:

- the Baltic countries have the most developed, but also most regulated, FinTech sectors (apart from Latvia, which has a number of reputational problems in the financial industry),
- the Netherlands and Germany have highly developed FinTech sectors with relatively strong regulations,
- there is a group of countries with relatively strong regulations but low development of the FinTech sector, which illustrates the need for future research on factors stimulating financial innovations,
- however, the least regulated countries have on average the lowest level of development of their FinTech sector.

Figure 3.
Correlation between the FinTech Development Index and the FinTech Regulation Index in 2021



Note: FinTech Index refers to the FinTech Development Index; Regulation Index means the FinTech Regulation Index.

Source: Own calculation.

5. CONCLUSION

The European Commission and regulators, noting the rapidly growing FinTech sector, try to identify possible resultant risks in this sector in terms of digital inclusion (EBA, 2019; Vives, 2017; FSB, 2017). Therefore, they recommend the implementation of good practices that contain, among others, more effective consumer protection as well as the creation of a regulated environment conducive to the implementation of technology-based solutions such as regulatory sandboxes and innovation hubs (EBA, 2018b). New players in the financial market cannot be characterised by a high level of public trust in their solutions, which can lead to deterioration of digital inclusion and a decrease in the level of financial market safety. Therefore, regulatory sandboxes can be perceived as an innovative ex-ante regulatory impact assessment tool (Marchewka-Bartkowiak, 2019). Nonetheless, new regulatory initiatives for the FinTech sector are particularly important, although the rapidly growing financial sector compounds the difficulty with creating new legislation.

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Given the significant challenge in implementing financial sector regulation, the EBA has proposed that existing laws/directives on regulatory requirements should also include guidelines and recommendations for the financial sector that could provide a basis for changes in subsequent implemented regulatory requirements. Therefore, the regulation index contains not only „hard regulations" such as the PSD 2 Directive but also „soft regulations" which are based on guidelines and recommendations issued by regulatory authorities. National regulators, noting the dynamic digitalisation process in society and the difficulty with clear identification and classification of digital innovations in the banking sector, target their regulatory activities at the areas of modern technology, innovation and cybersecurity. An example might be the Polish Financial Supervision Authority, which decided to publish in 2019 the Digital Supervision Agenda, which contains a roadmap for its digital innovation activities and initiatives. The document presents four thematic areas and directions of the FSA's activities in terms of new technological and business phenomena in the financial market and the need for digital transformation (KNF, 2019). These areas include:

- new developments in the financial market,
- supporting FinTech,
- cybersecurity,
- electronic government.

Regulating the FinTech sector is a significant challenge. Constant changes in its business models and significant innovativeness hinder the implementation of effective legal regulations. National regulatory authorities implement financial regulations related to the dynamic development of new technologies to a varying degree and extent. When analysing the level of FinTech regulation in EU countries, segments like payments and open banking can be assessed as significantly regulated ones. On the other hand, the direction and scale of regulation in other segments of digital finance – e.g. cryptocurrencies and CBDCs – have not yet been clearly defined by EU countries. This indicates the need for significant changes in the approach of national regulators to the dynamics of implementing regulatory changes and the necessity to accelerate work in this area.

The paper proposed and analysed the FinTech Regulation Index for the EU countries, based on the World Bank data. The index allowed for researching the relationship between the regulatory attitude and the development of the FinTech sector in the EU countries. The empirical analysis allowed for detecting a significant correlation between these variables, which may contribute to the discussion on the impact of the level of regulation on the development of digital innovation and, more broadly, on financial market stability and growth. Moreover, an additional problem has been identified. The objective of the EU regulators to set the same rules for the same activity in the EU single market may not be implementable due to different approaches of national regulators to their FinTech sectors.

The significant relationship between the FinTech Development Index and the FinTech Regulation Index illustrates the important role of supervisors and regulators in ensuring safety of the rapidly growing FinTech sector. The research shows a special role of Baltic states (Estonia and Lithuania) in the digitalisation of the banking sector. The increasing number of players and innovative solutions being implemented in these countries and the level of financial market regulation may set the future direction of change for other countries. It should be noted that the context of the single financial market within the EU plays an important role in the development of this market. Therefore, the FinTech Regulation Index proposed by the authors allows for analysing the level of regulatory advancement in a country and indicates its relationship with the level of FinTech sector development. The FinTech Regulation Index and the FinTech Development Index are significantly correlated. This indicates a very high level of regulation due to the rapid development of the FinTech sector in the EU countries. Nevertheless, it is also possible to identify countries that have a high level of FinTech regulation and a relatively low FinTech Development Index (Malta, Belgium and Portugal) and countries that have a low level of FinTech regulation and a relatively high FinTech Development Index (Finland, Ireland, Luxembourg).

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ANNEX

	Anti-money laundering	CBDC	CDD	Cryptocurrency	Cybersecurity	Equity crowdfunding	P2P	Data protection	Digital banking	Digital ID	Electronic money	Electronic payments/ transactions	Innovation facilitators	Open banking
Austria	1	0	1	0	1	1	1	1	1	1	1	1	1	1
Belgium	1	0	1	0	1	1	1	1	1	1	1	1	1	1
Bulgaria	1	0	1	0	1	0.5	0.5	1	1	1	0	1	1	1
Croatia	1	0	1	1	1	0.5	0.5	1	1	1	1	1	0	1
Cyprus	1	0	1	0	1	0.5	0.5	1	1	1	1	1	1	1
Czech Republic	1	0	1	0	1	1	0.5	1	1	1	1	1	0	1
Denmark	1	1	1	0	1	1	1	1	1	0	1	1	1	1
Estonia	1	1	1	1	1	1	1	1	1	1	1	1	1	1
Finland	1	0	1	0	1	1	1	1	1	1	0	1	1	1
France	1	1	1	0	1	1	1	1	1	1	0	1	1	1
Greece	1	0	1	0	1	1	0	1	1	1	0	1	1	1
Spain	1	1	1	0	1	1	1	1	1	1	0	1	1	1
Netherlands	1	1	1	0	1	1	1	1	1	1	0	1	1	1
Irland	1	0	1	0	1	0.5	0.5	1	1	0	1	1	1	1
Lithuania	1	1	1	0	1	1	1	1	1	1	1	1	1	1
Latvia	1	0	1	0	1	0.5	0.5	1	1	1	1	1	1	1
Luxemburg	1	0	1	0	1	0.5	0.5	1	1	1	0	1	1	1
Malta	1	0	1	1	1	1	0.5	1	1	1	1	1	1	1
Germany	1	1	1	0	1	1	1	1	1	1	0	1	1	1
Poland	1	0	1	0	1	0.5	0.5	1	1	1	1	1	1	1
Portugal	1	0	1	0	1	1	1	1	1	1	1	1	1	1
Romania	1	0	1	0	1	0.5	0.5	1	1	1	0	1	1	1
Slovak Republic	1	0	1	0	1	1	1	1	1	1	1	1	0	1
Slovenia	1	0	1	0	1	0	0	1	1	1	1	1	0	1
Sweden	1	1	1	0	1	0	1	1	1	1	1	1	1	1
Hungary	1	0	1	0	1	1	1	1	1	1	0	1	1	1
Italy	1	1	1	0	1	1	0	1	1	1	0	1	1	1
Total	27	9	27	3	27	21	19	27	27	25	16	27	23	27
					legislation	1								
					unregulated but not prohibited	0.5								
					no legislation identified	0								

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Efficiency of the banking sector in Poland compared to other countries in the region

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ABSTRACT

The banking system is one of the most important components of the financial systems on which modern economies are largely based. The occurrence of instability in this area may lead to serious economic problems. Therefore, the interest of researchers in this area has been focused mainly on assessing the effectiveness and efficiency of the banking sector, which will allow for identifying possible areas for improvement.

In this paper, we discuss the use of efficiency as one of the basic measures used to assess the functioning of the banking sector. The aim of this study is to examine the efficiency of the banking sector in Poland, and then to compare the obtained results with selected countries of the region in 2014–2018. The paper presents theoretical considerations in the field of the financial system, the banking system and the efficiency of entities.

In the empirical part of the paper, we conducted our own research on the efficiency of the banking sector in Poland using the DEA (Data Envelopment Analysis) method. The results were compared with those obtained in selected countries in the region. The selected countries of the region are: Bulgaria, the Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Romania and Slovakia.

JEL Classification: C14; G21

Keywords: banking sector, efficiency, financial system, DEA method

1. INTRODUCTION

The banking system is an important component of the financial system, which is the basis for the functioning of modern economies. The key purpose of its existence is to ensure that individual entities, i.e. businesses and individuals, can invest their cash. On the other hand, it makes it

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possible to obtain financing for business development or consumption. It thus allows the transfer of funds from entities with a surplus to those in deficit. The banking system is also an important part of the payment infrastructure, enabling payments and settlements to be made between the entities concerned. Due to its important role in the economy, issues related to ensuring its proper functioning are therefore of great importance. The occurrence of instability in this area may lead to the inhibition of the development of enterprises and individual entities and, consequently, to serious economic problems. In order to counteract such a situation, the interest of researchers focuses on assessing the effectiveness and efficiency of the banking sector. Such an assessment allows for the timely identification of areas that need to be improved.

Our aim is to examine the efficiency of the banking sector in Poland and then compare the results obtained with selected countries in the region in 2014–2018 using the non-parametric DEA (Data Envelopment Analysis) method. The selected countries of the region are: Bulgaria, the Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Romania and Slovakia. The subject matter undertaken is important because of the extremely important role of the banking sector for the health of the economy as a whole, as described above. The study also provides important added value, as it allows us to compare the efficiency of the banking sectors in countries with a relatively short recent banking history (post-transition) and to identify those that have developed better over the years.

The study was carried out on the basis of the non-parametric DEA method, which makes it possible to analyse the efficiency of entities by referring to the relationship of multiple inputs and outputs without knowing the precise relationship between them.

This paper consists of five chapters. The second chapter presents the essence of the financial system and its models. Two basic models of the financial system found in the literature (Anglo-Saxon and continental) are also characterised. The essence of the functioning of the banking system is presented, indicating that its main purpose is to transfer money from surplus to deficit entities. This is followed by a discussion of the risks involved in banking activities, i.e. credit, operational, market and liquidity risks. The third chapter presents the theoretical foundations of banking sector efficiency. A definition of efficiency of entities' operations is provided and the concept of effectiveness is discussed. The basic methods of measuring efficiency are indicated, i.e. ratio analysis, parametric and non-parametric models, including the DEA method. The following section reviews the literature on efficiency measurement in relation to the banking sector. The fourth chapter is the authors' empirical study. The research sample is described, with the rationale behind the assumed inputs and effects included in the model, as well as the choice of period and countries analysed. The non-parametric DEA method used in the study is also presented in more detail. The characteristics of the economies and the banking sector and the results of the study are presented. Chapter five provides a summary.

2. FINANCIAL SYSTEM

2.1. Concept and functions

The starting point for considering the banking sector is to understand the fundamentals of the financial system. It is difficult to imagine the functioning of modern economies without an efficient financial system, which is a key element of them. It enables the financial and investment needs of individual system participants to be met and allows financial transactions to take place between them. By its action, it stimulates the economy and boosts its growth. The financial system is made up of both a market sphere and a public sphere, which complement each other. The inefficiency of financial markets in certain areas is offset by the activity of public finance. Depending on the financial system model adopted in a given economy, its structure may look different. According

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to the classical division, the system may be dominated by banking entities (continental model) or capital market entities (Anglo-Saxon model). The infrastructure that ensures the technical side of the financial system is also an important element of the system. It is formed by both the IT infrastructure and relevant regulations.

There is no uniform approach to defining the concept of the financial system in the literature. Pietrzak et al. (2008) define it as a part of the financial sphere or, more broadly, of the economic system, constituting a mechanism through which services are provided that allow the circulation of purchasing power in the economy. According to this approach, the financial system enables the creation and flow of money between entities of the real sphere (pp. 15–16). Thus, its main task is to supply the economy with money by carrying out various types of financial operations between households and businesses. In a broader sense, the notion of the financial system is defined by Owsiak (2015) as a set of logically related organisational forms, legal acts, financial institutions and other elements enabling entities to establish financial relations in both the real and the financial sector. In his view, the financial system is a legally regulated platform used to manage the finances of economic entities. It is a form of intermediation between entities that have surplus capital and those that need funds to finance their activities. It enables households and businesses to make profits by investing their accumulated savings in the financial markets and allocating them to support the activities and development of other actors by providing them with financing in the form of loans and credits. A similar view is taken by the International Monetary Fund (IMF), which points out that the financial system consists of institutional units and markets that interact to mobilise resources for investment and provide facilities, including payment systems, to finance commercial activities (IMF, 2016).

Pietrzak et al. (2008) distinguish three key functions of the financial system:

- monetary,
- capital-redistributive,
- control (pp. 18–19).

The monetary function is one of the basic functions performed by the financial system. It refers to the provision of money to entities in the real sphere as a means of economic exchange and its free movement in the form of carrying out various types of financial operations.

An equally important function is the capital-redistributive function. It primarily includes the ability to invest the savings of households and businesses to make a profit and transfer them to those who make the demand for capital needed for investment.

The control function, on the other hand, refers to the monitoring of invested or borrowed capital in the past in financial terms as well as corporate management (Pietrzak et al., 2008). A different approach to defining the function of the financial system was taken by Merton and Bodie (1998). According to them, the role of the financial system is:

- to provide payment clearing and settlement methods to facilitate trade,
- to provide a mechanism for pooling resources and distributing shares in different companies,
- to provide ways to transfer economic resources over time, across borders and between industries,
- to provide ways to manage risks,
- to provide ways of imparting price information to help coordinate decentralised decision-making in different sectors of the economy,
- to provide ways to address incentives created when information asymmetries exist (p. 5).

2.2. Financial system models

In modern economies, there is no accepted uniform approach to shaping the financial system. The structure of the financial system, i.e. the size and diversity of markets and the entities operating in them, may look different in different countries. This is due to the presence of various

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country-specific conditions, i.e. the economic, institutional or regulatory environment, among others. These factors can directly determine the design of the financial system and influence its functioning. As a result, two models of the financial system are most commonly distinguished in the literature:

- **Anglo-Saxon system**,
- **German-Japanese (continental) system**.

Anglo-Saxon model

According to Iwanicz-Drozdowska et al. (2017), in the Anglo-Saxon model of the financial system, financial markets play a key role (p. 23). Entities operating in this market raise the capital necessary for growth (including the issue of securities, particularly shares or bonds). The form of corporate financing is one of the main features distinguishing between the Anglo-Saxon and German-Japanese financial systems. Financial markets can also be used for profit-oriented investment transactions, i.e. the purchase of securities, as well as to provide day-to-day liquidity or to hedge against currency or interest rate risks. The predominant market within this model is the capital market where transactions between different entities are most often concluded via a stock exchange.

Grosfeld (1994), in her publication on this subject, points out that characteristic of the Anglo-Saxon model of the financial system is also wide access to information on the financial instruments and entities concerned. Both the stock exchange and individual participants publish information on the daily quotation of securities or their financial situation (p. 6). This allows for greater transparency and ease of execution of transactions. As a result, individual market participants can make more optimal investment choices and thus achieve greater financial returns.

Operating on a stock exchange is somewhat limited due to the high barrier to entry. Numerous financial, legal and formal requirements have to be met and the necessary permits must be obtained. As a result, the market structure is dominated mainly by large, specialised entities that are able to bear the costs associated with a debut and further operation on the market. According to Grosfeld, an important factor differentiating the models in question is also the greater dispersion of ownership. In the Anglo-Saxon system, through the issue of securities, the shareholders of a given company are many. They are able to influence the strategy and investment decisions taken by the enterprise to a lesser extent than if a greater part of the enterprise is held by one major entity. On the other hand, possible financial problems of a given enterprise will not have such a severe impact on an individual investor with a small share of profits compared to investors with a much larger shareholding.

The financial system model based on financial markets is mainly characteristic of Anglo-Saxon countries. The key representatives of this model are the United Kingdom and the United States. Allen and Gale (2000), in their publication, point out that the main reason for the strong entrenchment of the markets-based financial system in the UK is due to the historical background related in particular to the period of the Industrial Revolution. During this time, there was a huge demand for the capital required to develop businesses and key industries. Due to easy access to the capital market and favourable investment conditions there, i.e. the ability to obtain high and long-term funding, it gained considerable strength compared to funding through banking products, which were less financially viable (pp. 31–32). In the United States, this model gained importance mainly due to the US Securities and Exchange Commission (SEC) enacting stricter regulations in the area of investment banking after the outbreak of the Great Depression in 1929. The US model has gained importance mainly due to the adoption of stricter regulations for the banking sector than for the capital market after the Great Depression of 1929, as well as the introduction of new financial instruments such as options and futures (pp. 33–34).

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The share of stock market capitalisation in the United States and the United Kingdom as a percentage of GDP in 2017 is presented below. The analysis shows that that share in the US in the period under review was approximately 164.9%, while in the UK it stood at about 116.9%, confirming the dominant role of the stock market and the capital market in countries based on the Anglo-Saxon model.

Table 1
Share of stock market capitalisation in selected countries as a percentage of GDP in 2017

	United States	United Kingdom
Share of stock market capitalisation as % of GDP	164.845	116.881

Source: CEIC (2019), CEIC (2020).

Japanese-German model (continental)

The second model of the financial system most often described in the literature is the Japanese-German or otherwise continental model. Its characteristic feature is the high concentration of banking entities in the structure of the system, which significantly dominate the other entities, including the stock exchange (Maciejczyk-Bujnowicz, 2015, pp. 60–61). They perform both a clearing function by intermediating in various types of financial transactions concluded in the market as well as deposit and credit activities. Banks enable households and businesses to invest their surplus capital in the form of bank deposits, which ensure that they earn a return on their invested funds. Investing in the Japanese-German model carries a lower risk compared to the Anglo-Saxon model. Investors are not exposed to fluctuations in market parameters, including but not limited to volatility in securities prices caused by speculative transactions. Therefore, to a greater extent, the bank-based market is perceived as stable and safe. Under this model, the main source for companies to raise the capital needed to develop their business is bank loans and advances. From deposited funds, banks' lending activities are financed. In contrast to the Anglo-Saxon model, obtaining financing by a company does not require the issue of securities. Consequently, they do not lose potential profits from their ownership rights in return for recapitalisation. At the same time, they maintain control of the business, which can be at risk in the case of equity issues, where investors, depending on the size of their stake, can influence decisions taken by the company. In this model, there are also fewer barriers to accessing the dominant market than in the Anglo-Saxon model. The products offered by banks are more accessible to both households and companies. They can invest and raise capital with relative ease, which in the capital market is subject to greater requirements and restrictions. This is particularly evident in the case of households, for which it is essentially impossible to obtain financing from the capital market. As a result, the model in question is dominated mainly by commercial, universal, non-specialised banks geared towards acquiring a broad customer portfolio (Maciejczyk-Bujnowicz, 2015). This is one of important factors that account for the strength of this model.

The bank-based model of the financial system has mainly developed in some European countries, in particular Germany and Japan. Since the beginning of the German financial system, credit and lending institutions have played a dominant role. According to Detzer et al. (2013), the largest players in the market there were mainly joint-stock or private banks, which were created and managed by private investors. Over time, other banking entities, i.e. State Savings Banks and Co-operative Banks, which were state-owned, also gained importance (p. 19). Allen and Gale (2000) point out that one of the reasons for the high concentration of the banking sector in Germany may have been a large share of banks in the ownership of companies. Consequently, they were able to have a greater influence on investment decisions made by companies. Thus,

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companies were more willing to finance their activities through banking products (p. 37). Japan is also an example of a continental financial system. According to Allen and Gale (2000), the banking system in Japan mainly gained importance after the Second World War, when there was large demand for capital among companies, which was met in particular through bank loans and credits. However, a significant role for the state in the banking system was apparent. It set the course for the development of individual sectors of the economy and thus decided for development of which companies to provide financing and in what amount. As in the German banking system, banks in Japan also held shares in the profits of companies, which also determined their development in comparison with other financial institutions operating in the market (pp. 40–41).

The following shows the share of bank assets in Japan and Germany as a percentage of GDP in 2017. The analysis shows that these countries are characterised by a high degree of banking sector concentration in the structure of the financial system. The share of bank assets as a percentage of GDP in 2017 in Japan was around 157.5%, while in Germany it was around 91%.

Table 2
Share of bank assets in selected countries as a percentage of GDP in 2017

	Japan	Germany
Share of banks' assets as % of GDP	157.51	91.07

Source: The Global Economy (2019).

To conclude the discussion of the existence of different models of the financial system, it should be considered whether those distinguished are valid in modern economies. Banks are currently operating in a global environment in which an advanced digital transformation is underway. As a result, it can be expected that new different models have developed. Perhaps this is the case if other criteria for division are adopted. There is no doubt that countries may have a mixed system, i.e. the banking system and the capital market are partially equally important for institutional participants or even individuals.

In the Anglo-Saxon system, the capital market is the main source of financing enterprises or meeting the financial needs of individuals, and in the continental system, these main sources are banks. Taking into account that the two distinguished models of the financial system are the result of historical conditions (habits of society that have not changed fundamentally); the models defined in this way are up-to-date and continue to be useful for describing reality.

Of course, the effects of implementing advanced digital transformation may lead to changes in such a way that there will be no link in the direct relationship between the customer and the financial institution. Then only the regulator will be aware of how the service provider is classified (bank or other financial institution), and the customer will not be interested in this.

2.3. The modern banking system

The banking system is a structure in which banks play a dominant role. Depending on their type, they perform different functions in the economy. Central banks mainly supervise and stabilise the macroeconomic situation in individual markets, in particular by maintaining an overall price equilibrium. Commercial banks, on the other hand, focus on maximising their own profit. They are mainly oriented towards granting loans and credits, investing surplus cash and carrying out payment transactions between the various entities of the banking system. The activities of banks, like all businesses, are exposed to various risks that may affect the efficiency of their operations. Therefore, it is important to take measures to mitigate these risks and their negative effects on

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banks. Legal regulations, which precisely define the principles of their functioning in the banking system and economy, may be helpful in this respect.

In the collective work edited by Jaworski and Zawadzka (2002), the banking system is defined as both banking institutions and the norms conditioning their interrelationships and relations with the environment (p. 38). Thus, according to the cited approach, the banking system is a plane on which mainly banks and other institutions conducting activities characteristic of banks operate. Its proper functioning requires the existence of strict legal norms that regulate the interrelationships between banking institutions, as well as households and enterprises, thus preventing various types of financial abuse and limiting the occurrence of negative market fluctuations that threaten the stability of the banking system as well as the entire economy. Four basic functions performed by the banking system have been distinguished, which include:

- raising and investing money,
- making cash transfers,
- providing pricing information,
- creating the conditions for the transformation of investment resources (Crane et al., 1995).

The key players in the banking system are commercial banks of which there are many types. Which types of them will develop in a given economy mainly depends on macroeconomic, legal and political conditions. One of the dominant types of commercial banks are universal banks. Their characteristic feature is the versatility and multifunctionality of their operations. According to Jaworski and Zawadzka, universal banks offer both the possibility of depositing funds and granting financing in the form of credits and loans, as well as providing additional services of a banking nature, i.e. concluding transactions typical of the capital market (p. 29). The largest universal banks in the world and in Europe by asset size in 2018 are presented below.

Table 3
A breakdown of the world's 10 largest universal banks by asset size in 2018

No.	Name	Country of origin	Value of assets (billions of USD)
1	Industrial & Commercial Bank of China Ltd	China	4 027.44
2	China Construction Bank Corp.	China	3 376.52
3	Agricultural Bank of China Ltd.	China	3 287.36
4	Bank of China Ltd.	China	3 092.21
5	Mitsubishi UFJ Financial Group Inc.	Japan	2 812.88
6	BNP Paribas SA	France	2 336.66
7	Credit Agricole Group	France	2 123.61
8	Japan Post Bank Co. Ltd.	Japan	1 911.48
9	Sumitomo Mitsui Financial Group Inc.	Japan	1 848.20
10	Mizuho Financial Group Inc.	Japan	1 837.80

Source: S&P Global (2019).

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Table 4
List of Europe's top 5 universal banks by asset size in 2018

No.	Name	Country of origin	Value of assets (billions of USD)
1	BNP Paribas SA	France	2 336.66
2	Credit Agricole Group	France	2 123.61
3	Banco Santander SA	Spain	1 670.79
4	Deutsche Bank AG	Germany	1 543.55
5	Societe Generale SA	France	1 485.31

Source: S&P Global (2019).

Investment banks are another important type of commercial banks. Unlike the universal banks described above, they are characterised by a greater degree of segmentation of banking services. Their activities are mainly based on performing financial operations of an investment nature, including in particular the sale and purchase of securities and derivatives on behalf of clients (Jaworski & Zawadzka, 2002). Investment banks mainly target large companies and financial institutions that are looking for attractive forms of investment and raising capital for the development of their business. By definition, they have more capital at their disposal compared to other banks, and securities-based transactions allow them to achieve higher returns than from standard banking products, i.e. deposits and loans. At the same time, their activities are subject to considerable risk due to the relatively high volatility of financial instrument prices and high susceptibility to speculation.

The table below shows the world's largest investment banks by asset size in 2018.

Table 5
A breakdown of the world's top 5 investment banks by asset size in 2018

No.	Name	Country of origin	Value of assets (billions of USD)
1	JPMorgan Chase & Co.	United States	2 622.53
2	HSBC Holdings PLC	United Kingdom	2 558.12
3	Bank of America Corp.	United States	2 354.51
4	Citigroup Inc	United States	1 917.38
5	Wells Frago & Co.	United States	1 895.88

Source: S&P Global (2019).

2.4. Banking risks

In the context of analysing the efficiency of the banking sector, it is also reasonable to discuss issues related to the risks to which banking entities are exposed. The activities of banks, like all other enterprises operating in the markets, are susceptible to various factors. These can have both a positive and negative impact on their financial standing. These include the macroeconomic environment, institutional environment or the internal structure and organisation of banks. Since banks are seen as public trust entities which the functioning of many market players relies heavily on, it is therefore important to maintain their stability, which then translates into the stability of the entire financial system. It is therefore of paramount importance to identify all the risks to which banking entities are exposed and to monitor them afterwards in order to respond quickly and efficiently to possible risks and to limit their negative effects. The Basel Committee on Banking

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Supervision in the New Capital Accord identifies three basic types of risks relating to banking activities:

- credit risk,
- operational risk,
- market risk (BIS, 2006).

Following the global financial crisis of 2007, liquidity risk and the methods used to measure and monitor it also gained importance, as described, among other things, in the so-called Third Capital Agreement issued in December 2010 (BIS, 2010).

From the point of view of the operation of banking entities, the most important is credit risk. Bessis (2015) defines it as the risk associated with the failure of bank customers to repay loans on time. The author also points out that credit risk in banking activities is the deterioration of the customer's financial situation and, consequently, their ability to systematically pay their obligations to the bank (p. 3). As a result of this approach, credit risk is both the currently occurring delays in repayment of money borrowed from the bank and the potential possibility that customers will default on the terms of the loan agreement in the future. The bank's exposure to this type of risk depends mainly on the nominal value of the loan at risk and its share in the bank's entire loan portfolio, as well as the duration of the loan. Its occurrence may significantly affect the bank's liquidity balance.

Credit risk monitoring is carried out, among other things, through a review of individual loan portfolio exposures based on an assessment of the borrower's financial situation and an analysis of internal ratings. The Basel Committee on Banking Supervision, in the New Capital Accord, indicates the basic parameters that should be included in the measurement of banks' credit risk using the internal ratings approach. These include the Probability of Default (PD), the Loss Given Default (LGD), the Exposure at Default (EAD) and the Effective Maturity (M) (BIS, 2006).

Another equally important risk in the activities of banking entities is operational risk. According to the definition included in Article 4(52) of the Regulation of the European Parliament and of the Council of 26 June 2013 on prudential requirements for credit institutions and investment firms, operational risk is defined as the risk related to internal procedures, human and system errors and external events, including legal risks (European Parliament & the Council). In its simplest sense, it is the risk associated with the operational functioning of banks. Within the definition quoted above, the most important operational risk factor is regulation – that of both internal and external nature that creates the infrastructure and institutional framework for banking activities. The risk in this area mainly refers to the possibility that the rules that define the functioning of banking entities may not be properly framed, so they may not operate fully efficiently.

Market risk is also a significant threat to the functioning of the banking sector. It is classified as an external banking risk, which means that its sources are not directly related to banks' activities. The Basel Committee on Banking Supervision classifies these mainly as risks related to the volatility of interest rates, prices of financial instruments, currencies as well as commodities (BIS, 2006, p. 157). From the point of view of banking entities, key are interest rate risk and currency risk. Interest rates are the basic parameter on which the pricing of most services provided by banks is based. Any deviation of these from desired levels can have a negative impact on the revenue, profits and efficiency of the business. A relatively low interest rate can lead to liquidity problems for banks due to less interest on the part of customers in placing cash in low-yielding bank deposits, while at the same time there is a high proportion of loans and advances due to the lower cost of obtaining them. Excessively high interest rates, on the other hand, contribute to a decrease in lending and an increase in liabilities to depositors, which consequently increases the risk of potential losses. Banks' foreign exchange risk is mainly related to the high volatility of exchange rates, which is characteristic of the foreign exchange market. As market risk is generated mainly by external factors, it is more difficult to manage than the above-discussed

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credit or operational risks, which depend to a large extent on the actions taken by banks. In order to hedge against this type of risk, banking entities use, among other things, derivative instruments, one of the basic functions of which is to hedge against the risk of price volatility. These include futures, options and swaps based on interest rates or currencies respectively.

The last of the main types of risk mentioned in the area of banking activities is liquidity risk. In its recommendation on liquidity risk management of banks, the Financial Supervision Authority defines it as the possibility of losing the ability to finance assets and meet obligations in a timely manner, resulting in the recording of financial losses (UKNF, 2015, p. 6). In its simplest sense, it is the risk that a bank may lose some of the cash necessary to conduct its current and long-term operations (lending and deposits). Inevitably linked to the issue of liquidity risk is the concept of liquidity gap. The Financial Supervision Authority defines it as a mismatch between the maturity of assets and the maturity of liabilities (UKNF, 2015). Inadequate portfolio construction on both the active and passive side is the main source of this type of risk in banking activities. Another source of this risk may also be the other risks discussed above, i.e. credit risk, operational risk and market risk. Negative fluctuations in the area of loan repayment or interest rates may significantly reduce the bank's cash holdings and thus lead to solvency problems, increasing the exposure of banking entities to liquidity risk. Thus, an extremely important issue with regard to liquidity risk is its monitoring, which allows potential risks to be identified. It is mainly based on the ongoing verification of liquidity ratios, liquidity gap and cash flow analysis. This area of banks' activities is also subject to periodic supervision by the Asset and Liability Management Committee. The Basel Committee on Banking Supervision in its Basel III regulation imposes additional requirements on banking entities to hedge *liquidity* risk, i.e. the *Liquidity Coverage Ratio (LCR)* and the *Net Stable Funding Ratio (NSFR)* (UKNF, 2020).

3. EFFICIENCY OF THE BANKING SECTOR

3.1. The essence of efficiency

The assessment of the performance of banking entities is one of the most relevant issues undertaken in analyses of the banking system. The basic measure relating to the verification of banks' activities is their efficiency. In its simplest sense, it expresses the relationship between effects and inputs, indicating whether banks achieve the highest possible profits for a given level of inputs. The concept of efficiency is very often confused with the concept of effectiveness, derived from the science of praxeology, which by definition is supposed to lead to a predetermined goal. There are many ways to measure efficiency in the literature. Among them, three key approaches dominate, i.e. indicator analysis, parametric and non-parametric methods, among which the DEA method, which is the subject of this article, has gained the greatest interest among researchers.

In the literature, efficiency is variously defined depending on the strand and field of economics represented by the author concerned. One of the basic definitions of efficiency derives from the microeconomic approach. Begg et al. (2007) cite the notion of efficiency in the Pareto sense understood as an optimal allocation allowing mutual benefits to be achieved. According to this approach, it is not possible to change the allocation of resources to improve the situation of some actors without worsening the situation of other actors (p. 459). It is therefore a point of equilibrium that provides the best possible combination of resources at which neither party has an incentive to change its preferences. Adopting different proportions of resources than those resulting from the equilibrium point indicates the presence of inefficiency in the Pareto sense. Because the definition of efficiency discussed above refers to the optimal choice of resources, it is referred to as allocative efficiency.

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Fried et al. (2008), on the other hand, present the concept of efficiency in more technical terms. Namely, the authors refer to the concept of achieving the maximum possible effects from the inputs possessed or minimising inputs at a given level of effects (p. 8). Within this approach, efficiency refers to the interrelationship of inputs and effects allowing the highest possible potential returns to be generated. In contrast to allocative efficiency, technical efficiency is mainly concerned with evaluating the financial aspects of a company's operation and management. Efficiency in this sense is described as when the effects exceed the inputs, resulting in a positive financial result.

With regard to the issue of technical efficiency, Capiga also draws attention to the existence of economies of scale. Their general idea refers to a decrease in the level of costs with an increase in production, which can significantly affect the efficiency of enterprises. It is also possible for economies of scale to have a negative impact on their profitability when an increase in production generates significant additional operating costs. There are two types of scale effects, i.e. fixed and variable, for which changes in the level of costs are respectively proportional or disproportional to changes in output (as cited in Harasim, 2009, p. 44).

With regard to the banking sector, the analysis of operational efficiency refers mainly to the issue of technical efficiency, the key determinant of which, as discussed above, is the ability to generate profits. This is relatively intuitive due to the fact that it is this parameter that constitutes the primary objective of banking entities. With the appropriate tools, technical efficiency makes it possible to verify the financial strategy and management methods adopted by banks. Banks are perceived as efficient if they use their inputs correctly while achieving the best results at the lowest possible cost mainly by minimising inputs or maximising profits.

Capiga distinguishes between the basic determinants of bank efficiency. At the most general level, she divides them into internal and external determinants. Internal determinants result from the organisation and management of the bank comprising a subject-oriented approach and a resource-oriented approach. 'Subject-oriented' refers to the key aspects of the bank's business, i.e. products, customers, distribution channels, business lines or organisational units, which are shaped by management, while resource performance refers to the use of inputs and their impact on the results achieved (as cited in Harasim, 2009, p. 49). In addition to internal determinants, external determinants on both macro and microeconomic scales are also important factors in the efficiency of banking entities. Macroeconomic factors refer to the existing economic conditions and the monetary and fiscal policy pursued at the national or international level, while microeconomic factors refer only to conditions within a specific region or banking sector (Harasim, 2009).

The concept of efficiency is often erroneously confused with that of operational effectiveness. Helpful in distinguishing between the above terminology are issues in praxeology, a science that covers all aspects of efficient human action (Kotarbiński, 1976, p. 319). Kotarbiński (1976), in his publication, defines effectiveness as an action that leads to the achievement of a predetermined goal (p. 113). Thus, in contrast to efficiency, which refers to the relationship between inputs and outputs and the need to generate profits in order to achieve it, the concept of effectiveness focuses instead on assessing whether specific actions and adopted strategies make it possible to achieve the set goals. An example of efficiency with simultaneous inefficiency in the operation of banking entities is illustrated, for example, by a situation in which a bank generates positive financial results, but at the same time fails to achieve the set goal of increasing its customer base to the level resulting from the adopted development strategy for a given period. The increase in profitability in this case is the result of an increase in interest margins or commission rates, rather than the acquisition of more customers. Thus, this is an activity that may be efficient, but is not effective.

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3.2. Methods of measuring performance

An extremely important aspect of considering the efficiency of banking entities is the methods of measuring it. The literature describes various approaches to the way efficiency is measured. One of the basic tools in this respect is ratio analysis. It is a key element within the broader issue of financial analysis, which mainly serves to assess the performance of companies on the basis of available financial data. Ratio analysis, as the name suggests, is based on the verification of the performance of enterprises on the basis of various types of financial ratios. As a rule, these ratios make it possible to examine the relationships and dependencies between individual financial data (Pomykalska & Pomykalski, 2017, p. 93). Ratio analysis makes it possible to identify areas in which companies are performing well, as well as those that require improvement and may contribute to a failure to achieve targets and financial benefits. The application of this method can relate to the analysis of the entire enterprise, as well as selected elements of it.

The basic source of data necessary for the analysis under this method is financial statements. Its main components include the balance sheet, the income statement, the statement of changes in equity, the cash flow statement and additional notes which detail selected financial items included in the main tables. Pomykalska and Pomykalski (2017) distinguish five basic types of indicators used in ratio analysis. These include:

- liquidity ratios,
- performance indicators,
- financing structure indicators,
- profitability indicators,
- equity ratios (p. 94).

The breakdown outlined above indicates that financial indicators make it possible to assess a company's performance in all the main spheres of business activity: those relating to its profitability, operability and financing methods. On the other hand, only an analysis of all these indicators provides a complete picture of the financial situation in which a given enterprise finds itself at any given time.

The issue of operating efficiency is mainly addressed by profitability ratios, which focus on the ability of companies to generate the maximum possible profits with the minimum level of input. Kochaniak (2010) lists the main profitability indicators analysed within the banking sector, which include (pp. 57–58):

Return on assets (ROA)

$$ROA = \frac{financial\ result}{assets}$$

Return on equity (ROE)

$$ROE = \frac{financial\ result}{equity\ capital}$$

Return on sales (ROS)

$$ROS = \frac{financial\ result}{income}$$

Cost to Income (C/I)

$$C/I = \frac{cost}{income}$$

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Profit margin (PM)

$$PM = \frac{financial\ result}{operating\ income}$$

In its published analyses of the situation of the banking sector, the Financial Supervision Authority additionally points to the importance of the interest margin indicator (NIM) for assessing the efficiency of banks, expressed as (UKNF, 2019):

$$NIM = \frac{interest\ result}{average\ assets}$$

One of the main advantages of using ratio analysis to assess performance is that it is relatively simple to apply and does not require the construction of complex statistical models or the creation of an extensive database to be analysed. In this case, only knowledge of the basic financial data contained in the financial statements is necessary. At the same time, for the same reason, it may be limited to a certain extent and produce unrealistic results without taking into account, among other things, economies of scale. In addition, the choice of appropriate indicators is often subjective and does not always correspond to the specifics of the company in question. The use of different financial indicators may give different results that do not necessarily reflect the actual situation of the company.

Econometric models are another tool for assessing the efficiency of banking entities. They belong to the so-called parametric methods with a precisely specified form which strictly define the relationship between inputs and effects. One of the main models within this approach is the stochastic frontier model SFA (Stochastic Frontier Analysis). It was presented in 1976 by Aiger et al. In their publication, the authors present, among other things, the theoretical basis of the model and its formal form and main assumptions. The general notation of the stochastic limit model is presented below (Aiger et al., 1976, p. 3).

$$y_i = f(x_i; \beta) + \varepsilon_i$$

where
y_i – effect,
$f(x_i; \beta)$ – the form of the boundary function, x_i – the input vector, β – parameter to be estimated,
ε_i – random factor.

One of the most important elements within this model is the adoption of a specific form of the production function necessary to determine the magnitude of the effects. Determining the production function within a given enterprise is very often problematic. Therefore, this tool is sometimes difficult to apply. Equally important is the assumption of random factors. They are an important element of the model that can significantly influence the results of the analyses in this area. They can contribute both to making the results more realistic and to distorting them significantly. In the context of operational efficiency, a company is assumed to be operating efficiently if the results of the analysis fall within the boundary area. If they do not meet this assumption then they are seen as inefficient.

The efficiency of the banking sector can also be measured using non-parametric methods. The primary non-parametric tool in this respect is the DEA method. It was first presented by Charnes et al. in 1978. In their publication, the authors present concepts for measuring the efficiency of given decision-making units referred to as DMUs (Decision-Making Units) using only knowledge of individual inputs and outputs (p. 431). In this type of model, unlike those described above, the relationships between inputs and effects are not strictly defined. Consequently, knowledge of the production function is not required, and no random factor is taken into account in the

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analysis. The selection of appropriate inputs and effects is made on the basis of the professional judgement of those carrying out the study, depending on the specific characteristics of the company in question or the industry in which it operates. According to the concept presented by the authors, efficiency is expressed as the maximum of the quotient of weighted effects to the quotient of weighted inputs. The solution to this optimisation problem, which indicates the full efficiency of the facilities, is a value of one (p. 430). This is the most desirable level to which the facilities should aspire. However, if they take values below one, it indicates inefficient use of inputs at a given level of effects or the possibility of not achieving the best possible effects at a given level of inputs. A detailed description and form of the non-parametric DEA method is presented in the next chapter of this article.

3.3. Review of empirical studies on bank efficiency

The issue of the efficiency of banking entities is an area of interest for many researchers. This is understandable given the fact that they are an extremely important element of the financial system, as well as the economy as a whole. The occurrence of possible instabilities caused by inadequate functioning of banks may lead to negative economic consequences and worsening of the financial situation of many entities. The main focus of analysis in this area is the measurement of bank efficiency. There are many tools available to measure their efficiency. Based on the literature review, selected studies in this area are presented below.

The application of the Stochastic Frontier Approach (SFA) in studies on bank efficiency was presented, among others, by Bonanno (2014) in his publication on the Italian banking sector. The analysis focused on the banking sector, divided into the main groups of banks, i.e. CCB, LTD and Popolari, the size of their business and their geographical location in the years 2006–2011 (p. 287). For the analysis, the author used the following dependent variables: the level of loans, non-interest income and securities. The size of employment, capital, liabilities to customers, labour costs, capital and deposits were used as independent variables (p. 289). The results of the study indicate that the efficiency of banks in the CCB group is dominant over other types of banks throughout the analysed period. In addition, small and medium-sized banks are more efficient, which may be due to the fact that they are easier to manage properly owing to the relatively smaller scale of their operations (p. 303).

Sathye (2001), on the other hand, conducted a study on the efficiency of Australian banks using the DEA method. His study referred to the performance evaluation of 29 banks (19 domestic and 12 foreign) in 1996. The author based his analysis on three inputs, i.e. labour, capital and loan funds, and two outputs, i.e. loans and deposits (pp. 618–619). The final results obtained show that, on average, domestic banks are more efficient than foreign banks taking into account both technical efficiency, allocative efficiency and overall efficiency which is the product of the previous two. Sathye, quoting from Williams (1998), points out that an explanation for this phenomenon could be the greater propensity of foreign banks to use more resources to expand their branch network, which is much smaller in size than that of domestic banks, thus potentially achieving lower profits (pp. 624–626).

A similar study was conducted by Novickytė and Droždz (2018) relating to the Lithuanian banking sector. The study analysed 7 banks operating in different forms, including as local banks and foreign branches, in 2012–2016 (p. 7). The authors analysed 5 DEA models with different assumptions on inputs and effects. The value of deposits, labour costs, liabilities to banks and other credit institutions were used as inputs, while operating profit, loans, profit before tax or net interest income were used as effects (p. 6). The analysis showed that under the assumption of variable scale effects, local banks are more efficient than foreign branches, while with fixed scale effects the relationship is reversed (p. 13).

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Ghaeli (2017) also presents the application of the DEA method to the analysis of the banking sector. The subject of the study is 26 banks operating in the US market in 2016. In the DEA method, the author considers only three parameters. He takes the size of total assets and employment as inputs while net income is taken as an effect. As a result of optimising the functions of the model in question, Ghaeli demonstrates that most banks operating in the United States are characterised by low operating efficiency. Only Santander Bank is a fully efficient bank during the period under review. Bank of America, JPMogran Chase and Wells Fargo, despite having the highest net revenues, incur correspondingly high expenses that reduce their profitability and profit potential (pp. 225–226).

It is also worth mentioning studies relating to the Polish banking sector presented by Polish authors. Pawłowska (2003) used the DEA method to analyse changes in the size structure of banks in Poland in 1997–2001. In the first half of the 1990s, the mechanism of mergers and acquisitions shaped this structure. The conclusion was that all banks involved in the M&A process significantly improved their efficiency measures and productivity indexes. The primary factor affecting efficiency is their size. Most efficient banks are «very large» banks; most extremely inefficient banks are in the «small» group.

A similar study was conducted by Pawłowska and Kozak (2008) in the context of Poland›s possible accession to the eurozone. The effects on efficiency, the level of competition and the performance of the Polish financial sector were examined. The results of the efficiency analysis obtained by the DEA and SFA methods showed an increase in the efficiency of Polish commercial banks, and the average efficiency was similar to that of selected eurozone countries.

Perek (2014) used the DEA method to study the technical efficiency of cooperative banks in 2005–2011. The analysis was based on models: BCC and CCR targeting inputs and effects. The study conducted on a sample of all cooperative banks showed a large discrepancy between the minimum and maximum values of efficiency ratios. The distribution of banks by efficiency ratio level also suggests that the cooperative bank sector is highly diversified. Analysing changes in efficiency over time, it was found that banks recorded a decline in total productivity in 2009–2010 and 2010–2011, which was mainly due to a decrease in relative efficiency.

Mielnik and Ławrynowicz (2002) conducted an analysis of efficiency measures for commercial banks in Poland (data for 1999) using the DEA method. The results reveal a relatively high value of average efficiency. A significant number of banks show decreasing and constant economies of scale, which results in the fact that further expansion of the business by means of increasing inputs will not bring greater effects, only less or equal. On the other hand, the number of bank branches (taken as a business effect) strongly influences the explanation of the efficiency of the banks studied. This may mean that the managements are pursuing an additional strategic goal – the development of the branch network. Such a goal is strategically significant, which will increase the bank›s potential in the future and may generate additional revenue the bank›s owners are looking forward to.

4. EXAMINING THE EFFICIENCY OF THE BANKING SECTOR IN POLAND AGAINST THE BACKGROUND OF SELECTED COUNTRIES IN THE REGION

4.1. Description of the research sample

The authors' study described in this chapter concerns the assessment of the efficiency of the banking sector in Poland against the background of selected countries of the region using the non-parametric DEA method in the years 2014–2018. The selected countries of the region should be understood as countries from the area of Central and Eastern Europe belonging to the European Union. Those are: Bulgaria, Croatia, the Czech Republic, Estonia, Hungary, Latvia, Lithuania,

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Romania and Slovakia. The sample was restricted to countries within the European Community due to the greater availability of financial data published by various European institutions. However, Slovenia was excluded from the analysis because it had numerous data gaps during the period under consideration. The above countries were selected because they have relatively recently undergone a major overhaul of the banking system as a consequence of the 1989 systemic transformation. The present analysis refers to the period from 2014 to 2018. This is mainly due to the desire to present the current functioning of the banking sectors in the countries of the region and to omit the period of the recent global financial crisis of 2007–2009 as well as some years immediately before and after this crisis in order to avoid possible distortions in the data that could translate into misinterpretation. The empirical data on banking sectors on which the study is based comes from data published by the World Bank, the European Central Bank and the European Banking Federation. The inputs and effects analysed in this study using the non-parametric DEA method are presented below.

Table 6
Inputs and outputs analysed as part of the banking sector efficiency study carried out

No.	Inputs	Outputs
1	Salaries	Gains or losses
2	Employment	Loans
3	Number of branches	Interest income
4	Number of ATMs	Commission revenue
5	Interest costs	
6	Commission costs	
7	Total assets	
8	Liabilities and provisions	
9	Equity	
10	Deposits	
11	Administrative costs	

Source: own elaboration.

Inputs and effects represent both financial data from the banking sector aggregated income statement and balance sheet presented in the European currency and non-financial data expressing, in this case, employment, number of branches or ATMs. Eleven inputs were selected for this study, i.e. salaries, employment, number of branches and ATMs, interest expenses, commission expenses, total assets, liabilities and provisions, equity, deposits and administrative expenses. In our opinion, the above parameters best illustrate the outlays incurred by banks, as they take into account all aspects of their functioning, i.e. the assets held, the main operating costs, the bank's operating costs, the sources of its financing, namely equity and debt capital, as well as the size of the network of branches and ATMs, which affects the availability of banking products and the size of the workforce, which translates, inter alia, into the efficiency of the execution of banking operations. The performance of banking sectors, on the other hand, is illustrated by four effects: profits and losses, loans, interest income and commission income. These are the main parameters expressing the potential profitability and viability of banks.

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4.2. Characteristics of selected countries in the region and the banking sector

A GDP level indicator has been selected to present a brief macro-economic overview of the selected countries in the region. Between 2014 and 2018, all countries surveyed recorded a systematic increase in GDP levels. The highest GDP levels in 2018 were recorded in Poland (USD 1 208.9 billion), Romania (USD 565.7 billion), the Czech Republic (USD 429.3 billion) and Hungary (USD 308.7 billion). These countries also saw the highest value growth in the index with USD 235.3 billion or 24% in Poland, USD 155.1 billion or 38% in Romania, USD 89.6 billion or 26% in the Czech Republic and USD 56.1 billion or 22% in Hungary. The rest of the countries, however, did not exceed a GDP of USD 200 billion in the analysed period. The lowest growth in value terms was recorded in Estonia (USD 9.8 billion or 25%) and Latvia (USD 11.5 billion or 24%) (OECD, 2023).

The main parameter characterising the banking sectors in the countries of the region is the level of assets held, which illustrates the size of the sectors. The sizes of the banking sectors in the countries concerned are quite diverse (Chart 1). In particular, Poland and the Czech Republic stand out for their very high level of assets compared to the other countries in the region. In the analysed period, they increased by EUR 83 billion or 23% to EUR 443.7 billion in Poland and by EUR 89.1 billion or 49% to EUR 270.8 billion in the Czech Republic. These are both the largest asset values and their changes over the period under review. The remaining countries in the region do not exceed banking assets of EUR 130 billion. One country that recorded a reduction in the size of the banking sector over the period of EUR 8.4 billion or 27% is Latvia. According to the European Banking Federation, this is due, among other things, to a reduction in foreign customer deposits (EBF, 2020).

An equally important parameter illustrating the banking sector is the number of banking entities operating within it. In this case, disproportions between individual countries are also visible. The largest number of banking entities is found in Poland. In 2018, 647 of them were recorded, a decrease of 32 entities compared to 2014, which is due to the numerous bank mergers and acquisitions carried out in recent years. In comparison, the Croatian banking sector is made up of only 22 entities. During the period under consideration, a systematic downward trend in the number of banking entities in the different countries of the region is visible. The largest decrease occurred in Hungary. Between 2014 and 2018, as many as 129 banks disappeared from the sector, which, according to the European Banking Federation, is the result of consolidation processes affecting credit and savings cooperatives in particular (EBF, 2020). Only in the Czech Republic, 3 new banks appear during the same period.

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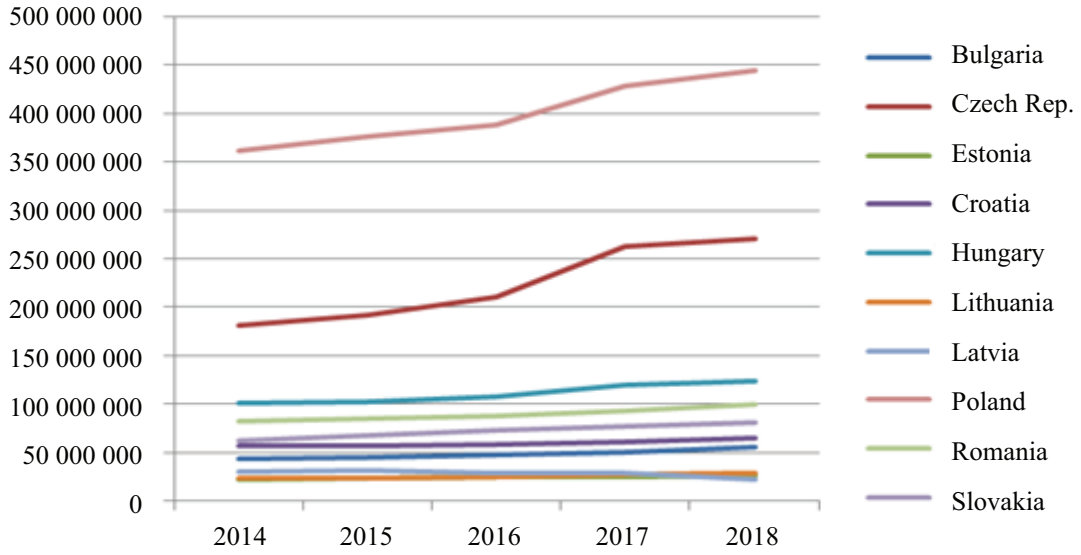
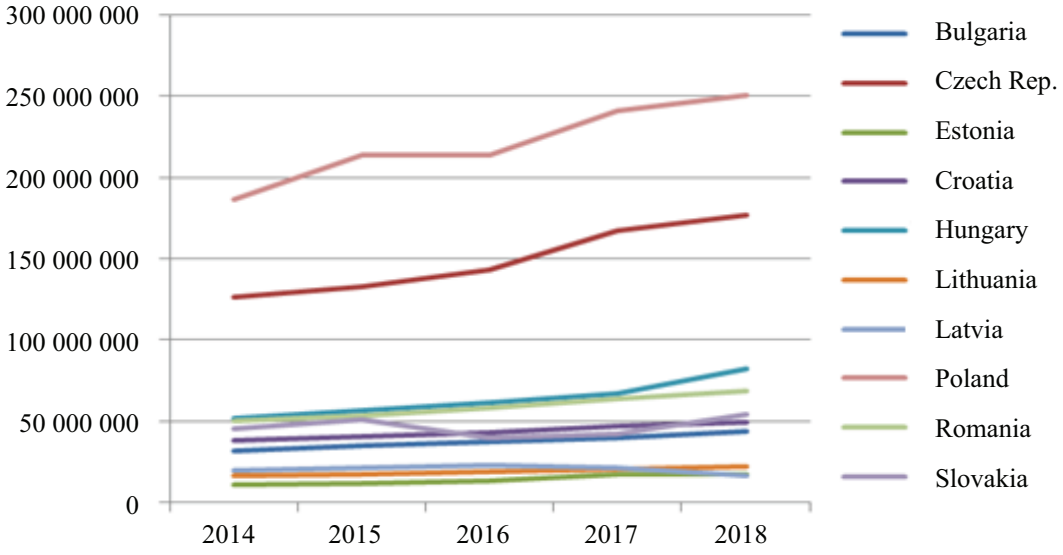
Chart 1
Assets of the banking sector from 2014 to 2018 (in thousands of euros)



Source: ECB (2019).

The main source of funding for banks' activities is deposits. As with assets, their highest level remains in Poland and the Czech Republic. In 2018, this was EUR 250.7 billion and EUR 177.1 billion, respectively. These countries also saw the highest growth in deposits in value terms between 2014 and 2018, by EUR 64.4 billion in Poland and EUR 51.1 billion in the Czech Republic. In the other countries of the region, with the exception of Latvia, cash exposures also gradually increased throughout the period under consideration, but did not exceed EUR 83 billion. In Latvia, there was a decrease of EUR 2.7 billion in bank deposits compared to 2014, which, as mentioned above, is the result of a decrease in foreign customer exponentiations.

Chart 2
Banking sector deposits in 2014–2018 (in EUR thousand)



Source: ECB (2019).

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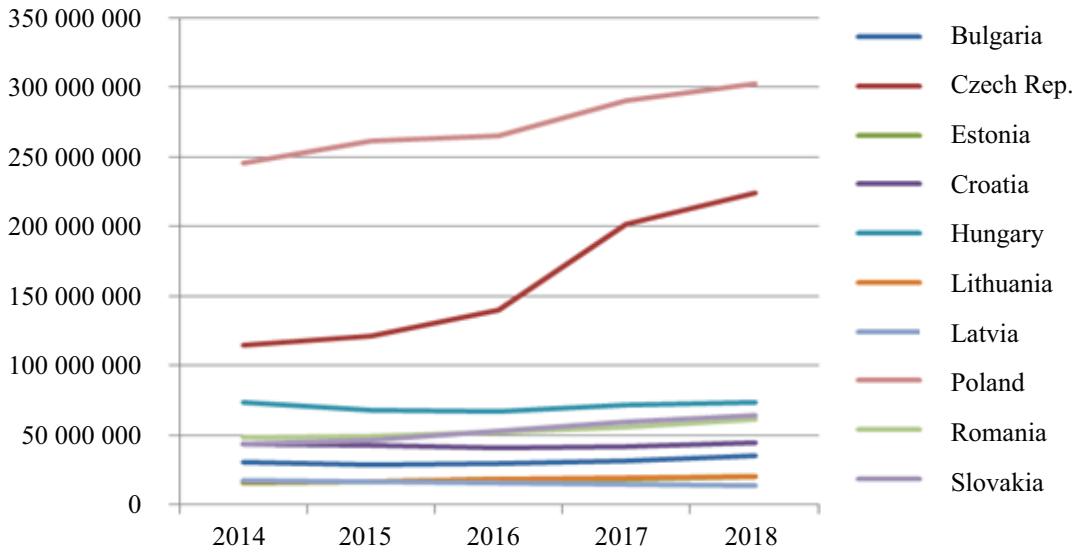
With regard to the level of lending within the individual countries of the region, a continuing positive trend between 2014 and 2018 is evident in most of them, with the largest increases in lending in the Czech Republic (of EUR 110 billion or 96%), Poland (of EUR 56.6 billion or 23%) and Slovakia (of EUR 20.6 billion or 47%). The only country with a decrease in lending during this period is Latvia. Here, its decrease reached EUR 4.5 billion, i.e. 25%. According to the European Banking Federation, this mainly affected the non-resident corporate client segment (EBF, 2020). In 2018, the highest level of loans was recorded in Poland (EUR 302.4 billion), the Czech Republic (EUR 224.4 billion) and Hungary (EUR 74.1 billion), while the lowest level was recorded in the Eastern European countries, namely Latvia (EUR 13.6 billion), Lithuania (EUR 20 billion) and Estonia (EUR 20.1 billion), which is correlated with the amount of assets and deposits in these countries.

Chart 3
Banking sector loans from 2014 to 2018 (in EUR thousand)



Source: ECB (2019).

Banks' profitability is expressed, among other things, by the profits and losses they generated. In 2018, the highest level of banking sector profits was achieved by Poland (EUR 3.4 billion), the Czech Republic (EUR 3 billion) and Hungary (EUR 2 billion) while the lowest was recorded by Latvia (EUR 275.8 million), Lithuania (EUR 355.8 million) and Estonia (EUR 377.4 million). The dynamics of change of the parameter in question throughout the analysed period varied across the countries of the region. The highest increase in profitability between 2014 and 2018 was achieved by Hungary and Romania at EUR 4 billion or 196% and EUR 2.6 billion or 245%, respectively. This is mainly due to these countries recording significant losses from their banking activities in 2014–2015, caused, in the case of Hungary, by the high cost of converting Swiss franc mortgages into domestic currency (Zsebesi, 2015) while in Romania, by a decrease in income and a persistently high level of net provisions (Deloitte, 2014). At the same time, Poland and Latvia recorded a fall in profitability of EUR 325.8 million and EUR 26.9 million in the period under review. The decrease in profitability in Poland is due, inter alia, to the gradual decrease in interest rates set by the Monetary Policy Council, the introduction of the bank tax in 2016 and, in 2018, the new IFRS 9 standard assuming changes in the classification of financial assets and the amount of write-downs on them, which may significantly reduce the potential profits of banks. The decrease in profit in Latvia is mainly due to the decrease in banking activity, i.e. both loan and deposit levels, as described above.

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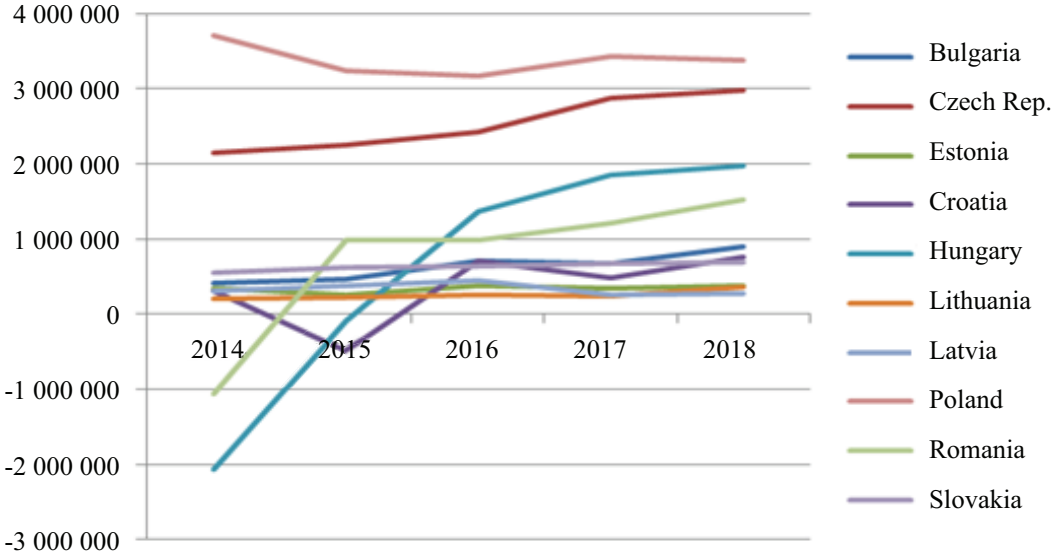
Chart 4
Profits and losses of the banking sector from 2014 to 2018 (in EUR thousand)



Source: ECB (2019).

4.3. Description of the research method

As mentioned, the Data Envelopment Analysis (DEA) method is an example of non-parametric tools most commonly used to measure the performance of data objects referred to in the literature as DMUs (Decision Making Units). Its authors, Charnes, Cooper and Rhodes, in their publication, indicate that the level of efficiency of objects can be determined based on knowledge of individual inputs and outputs under appropriate constraints (Charnes et al., 1978, p. 429). The DEA method identifies the optimum ratio of effects and inputs based on the available data, which it then compares with the actual results obtained. If the two do not coincide and the results deviate from the best possible values determined by the model, then the subject is seen as inefficient. With this method, it is possible to analyse multiple inputs and outputs at the same time, which means that the method can more accurately reflect the actual situation of the facility in question, as efficiency is, by definition, the resultant of a number of factors. These can refer to both financial and non-financial data, as the DEA method does not impose strict requirements in this respect.

The following is a form of the DEA model developed by Charnes et al. (1978, p. 430).

$$\max h_0 = \frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}}$$

where

$$\frac{\sum_{r=1}^{s} u_r y_{r0}}{\sum_{i=1}^{m} v_i x_{i0}} \leq 1$$

$$u_r, v_i \geq 0 \qquad j = 1,\ldots, n \qquad r = 1,\ldots, s \qquad i = 1,\ldots, m$$

y_{r0} – effects,
x_{i0} – inputs,
u_r, v_i – the weighting of effects and inputs.

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According to the above formal notation of the model, efficiency under this approach is calculated by maximising the ratio of the weighted product of effects to the weighted product of inputs. According to the assumption, the results of the efficiency analysis should take values in the range from 0 to 1. Those decision-making units whose results take the value of 1 are considered fully efficient, while those whose results are closer to 0 are considered inefficient. The model also assumes that the weights for individual inputs and effects are included in the analysis. These should take on positive values. The weights are set automatically by the model when solving an optimisation problem to achieve the best possible result.

In the literature, Cooper et al. (2011) distinguish between two types of DEA model, i.e. input-oriented and effect-oriented (p. 13). The form of the input-oriented and effect-oriented model in question is presented below.

Input-oriented model

$$\min \theta - \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = \theta x_{i0}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = y_{r0}$$

Effects-oriented model

$$\max \varphi + \varepsilon\left(\sum_{i=1}^{m} s_i^- + \sum_{r=1}^{s} s_r^+\right)$$

$$\sum_{j=1}^{n} x_{ij}\lambda_j + s_i^- = x_{i0}$$

$$\sum_{j=1}^{n} y_{rj}\lambda_j - s_r^+ = \varphi y_{r0}$$

$$\lambda \geq 0 \qquad j = 1,\ldots, n \qquad r = 1,\ldots, s \qquad i = 1,\ldots, m$$

where
s_r^+, s_i^- – clearance values for optimisation,
ε – fixed parameter,
φ, θ – performance parameters.

From the above formal notations of the different types of DEA model, it follows that the input-oriented model is concerned with minimising the efficiency parameter relating to inputs, while the effects-oriented model refers to maximising the efficiency parameter relating to effects. Thus, depending on the efficiency analysis objective adopted, a specific optimisation problem needs to be solved. An input-oriented model assesses a company's use of inputs at a given level of outputs, while an effects-oriented model allows verification that a company is achieving the best possible results at a given level of inputs. For each of the types of DEA model discussed above, it is possible to make the assumption of fixed or variable scale effects (Cooper et al., 2011, p. 12). The form of the DEA model presented by Charnes et al. (1978) is the so-called CCR model with fixed scale effects. The concept of variable scale effects, on the other hand, is introduced in the publication by Banker et al. (1984) and referred to in the literature as the BCC model. The form of this model adopts most of the assumptions originally included in the CCR model. The basic assumption differentiating the fixed and variable scale effects model introduced by Banker et al. is the constraint that the sum of input and effect weights should be equal to 1 (p. 1082). Its formal notation is presented below.

$$\sum_{j=1}^{n} \lambda_i = 1$$

The general concept of variable scale effects assumes that a change in inputs causes a disproportionate change in effects. The authors of the BCC model indicate that in its initial phase, an increase in inputs translates into an increase in output or profits of a given entity (these

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are increasing economies of scale). On the other hand, at a certain point, further increases in inputs cease to be profitable and do not result in the expected increase in effects (these are declining economies of scale). In this case, the facility's output or profits start to decline and it is desirable to reduce inputs to get to a point where better results can be achieved (Banker et al., 1984, pp. 1087–1088). According to the concept of Banker et al., economies of scale are expressed by the following parameter, which is contained in the form of the BCC model (p. 1082).

$$u_j = k\lambda_j$$

The non-parametric DEA method, in addition to its undoubted advantages, i.e. no need to know the production function and take into account the random factor, the relatively simple form of the model and the possibility of analysing multiple inputs and effects, also has its weaknesses. Guzik (2009) points to a significant problem with regard to the practical application of this method, i.e. redundancy, that is an excessive number of efficient entities, which significantly limits the possibility of comparing the analysed entities (p. 8). Guzik, referring to Banker and Gilford as well as Andersen and Petersen, presents in his publication the basic assumptions of the SE-CCR super-efficiency model. This model assumes the introduction of a so-called ranking index in place of the existing efficiency parameter. Other assumptions regarding inputs and effects remain unchanged. According to the author, the use of a ranking index simultaneously excludes the object under study from the analysis. If it takes on values greater than 1, the entity in question is perceived as efficient, while if it is less than 1, it is considered inefficient. The general formal form of the SE-CCR super-efficiency model is presented below, which can be adapted accordingly depending on the orientation of the model (p. 8).

$$\min \rho_o$$

where

$$\sum_{j \neq o} \lambda_{oj} y_{rj} \geq y_{r0}$$

$$\sum_{j \neq o} \lambda_{oj} x_{nj} \geq \rho_o x_{n0}$$

$$\rho_o, \lambda_{oj} \geq 0$$

ρ_o – ranking factor.

Then, in order to differentiate between the good of the objects perceived as efficient on the basis of the ranking index, Guzik indicates the need to calculate a new efficiency index expressed as the quotient of the ranking index of a given object to the maximum ranking index among all analysed entities. In this way, it is relatively easy to indicate which entities perform better than others even though they may all be perceived as efficient. The new coefficient of efficiency, like the original one, can take values from 0 to 1 (p. 9). We used the SE-CCR model in this study of the efficiency of the banking sector in Poland against the background of selected countries in the region.

Performance analysis using the non-parametric DEA method can be carried out by means of various analytical tools. One of these is to solve an optimisation problem in an Excel spreadsheet using the Solver add-in, where the objective cell returns a value identified with the level of efficiency of the unit under study while specifying the exact assumptions regarding the individual

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inputs, effects and their weights. Technically, this method can also be applied using relevant programs, i.e. EMS and DEAP, which in principle will work in the same way. Within these tools, it is also possible to specify the orientation of the model and the scale effects to be analysed.

4.4. Results of the DEA study

Presented below are the results of the analysis of the efficiency of the banking sector in Poland compared to selected countries in the region using the non-parametric DEA method in 2014–2018. The analysis was performed within the framework of the SE-CCR model oriented to both inputs and effects. Formal calculations of the model were performed using the Solver add-in in an Excel spreadsheet.

On the basis of the application of inputs and outputs described in the preceding subsections and characterising the individual countries of the region in the initial phase of the study, we obtained results indicating full efficiency of all the banking sectors in question over the entire period, i.e. efficiency ratios took the value of 1. The above results did not allow us to single out the more and less efficient countries, as they all showed the same values. A review of the literature on methods of measuring the efficiency of the entities concerned allowed us to conclude that the above results may indicate the existence of the phenomenon of over-efficiency, or so-called redundancy, in our analysis. Therefore, a modification to the CCR model used so far was introduced with assumptions derived from the SE-CCR super-efficiency model described in the previous subsection assuming the introduction of a ranking factor and then calculating a new efficiency factor on its basis.

In line with the concept of the SE-CCR model presented in the publication by Guzik, a new parameter known as the ranking index was introduced in place of the existing efficiency ratio. It allows ranking of the analysed banking sectors from the most efficient to the least efficient. Based on assumptions arising from the model, it can take values both above and below 1, with values above 1 indicating full efficiency of the sectors under consideration. When calculating the ranking indicators for individual sectors, it is also important to exclude a given sector from the analysed set forming the technology common to that sector (Guzik, 2009, p. 8). Detailed results for the ranking indicators in the input-effect-oriented SE-CCR model are presented in Tables 7 and 8.

Table 7
Ranking coefficients of banking sectors in the SE-CCR model in the surveyed countries of the region from 2014 to 2018 in the input-oriented model

Country	2014	2015	2016	2017	2018
Bulgaria	2.2237	1.9773	1.8100	1.6944	1.6379
Czech Republic	2.2279	2.4093	2.0418	2.3259	2.4836
Estonia	2.6059	2.0513	2.3815	1.7796	1.5505
Croatia	1.3038	1.3740	1.3797	1.3335	1.1037
Hungary	1.8363	1.8422	1.9206	2.0807	2.1465
Lithuania	1.1317	1.1797	1.3089	1.2754	1.3290
Latvia	1.8753	1.5348	1.4937	1.3353	1.3271
Poland	1.6806	1.6317	1.4581	1.7301	1.5235
Romania	1.1396	1.2571	1.1418	1.1484	1.2331
Slovakia	1.2256	1.1910	1.4802	1.7209	1.4138

Source: own elaboration.

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Table 8
Ranking coefficients of banking sectors in the SE-CCR model in the surveyed countries of the region from 2014 to 2018 in the effects-oriented model

Country	2014	2015	2016	2017	2018
Bulgaria	0.4497	0.5057	0.5525	0.5902	0.6105
Czech Republic	0.4488	0.4151	0.4898	0.4299	0.4026
Estonia	0.3837	0.4875	0.4199	0.5619	0.6450
Croatia	0.7670	0.7278	0.7248	0.7499	0.9060
Hungary	0.5446	0.5428	0.5207	0.4806	0.4659
Lithuania	0.8836	0.8477	0.7640	0.7841	0.7524
Latvia	0.5332	0.6515	0.6695	0.7489	0.7535
Poland	0.5950	0.6129	0.6858	0.5780	0.6564
Romania	0.8775	0.7955	0.8758	0.8708	0.8110
Slovakia	0.8159	0.8396	0.6756	0.5811	0.7073

Source: own elaboration.

The above ranking coefficients in the input-oriented model indicate that the banking sectors in all analysed countries of the region are fully efficient throughout the considered period, as they take values above 1. This means that in order to achieve the effects of a given banking sector, the other banking sectors of the CEE countries would have to consume the same or more inputs. It is therefore apparent that banks in the individual countries of the region are geared towards minimising their inputs. They want to reduce the amount of costs generated as much as possible in order to achieve a certain level of effects. Between 2014 and 2018, the highest value of the ranking index (above 2) within this model was recorded in the Czech Republic. Its high values, i.e. above 1.87 on average, are also found in Estonia, Bulgaria and Hungary, which may indicate a high level of efficiency ratios within the above countries. On the other hand, the lowest values are found in Romania, Croatia and Lithuania, whose coefficients do not exceed 1.3 on average throughout the period. The value of the ranking coefficient for Poland is in the middle of the pack, recording an average of 1.6 over the whole period. With regard to the above ranking indicators, high variability over time can be observed, without, however, a clear unambiguous trend for all countries analysed.

In contrast, different conclusions can be drawn from the analysis of the results from the effects-oriented model. The results show that none of the banking sectors of the countries in the region surveyed gets the best possible results from their inputs throughout the period. The ranking indicators within this type of model show the inefficiency of all banking sectors, as they take values below 1. Thus, they do not fully perform optimally and do not fully exploit the potential from the inputs. The increase in input costs does not translate into a correspondingly high result. The highest ranking indices during the period under study, i.e. above 0.78 on average, were recorded in Romania, Croatia and Lithuania, which is the opposite of the results obtained from the input-oriented model. Thus, their activities compared to the other countries analysed are more oriented towards achieving the best possible results rather than minimising inputs. The lowest ratios, i.e. below 0.54 on average, are achieved by Bulgaria, the Czech Republic, Estonia and Hungary. In relation to the above countries, there are banking sectors in the region that are able to generate greater results on the basis of their technology and the same level of costs. Poland and Latvia also record intermediate ranking indices averaging 0.63 and 0.67, respectively, over the entire period under consideration. From the above analysis of the ranking indicators, it can be

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concluded that, depending on the model adopted, i.e. input-oriented or output-oriented, its results may differ significantly and lead to different conclusions on the efficiency of the banking sectors.

In line with the assumptions of the SE-CCR model, new efficiency ratios were determined on the basis of the ranking ratios for each banking sector throughout the period under consideration. They are calculated as the quotient of the ranking ratio for a given banking sector to the maximum ranking ratio among all the banking sectors surveyed. Detailed results for the new efficiency ratios in the input-output oriented SE-CCR model are presented in Tables 9 and 10.

Table 9
Efficiency ratios of banking sectors in the SE-CCR model in the studied countries of the region from 2014 to 2018 in the input-oriented model

Country	2014	2015	2016	2017	2018
Bulgaria	0.8533	0.8207	0.7600	0.7285	0.6595
Czech Republic	0.8549	1.0000	0.8573	1.0000	1.0000
Estonia	1.0000	0.8514	1.0000	0.7651	0.6243
Croatia	0.5003	0.5703	0.5793	0.5733	0.4444
Hungary	0.7047	0.7646	0.8065	0.8946	0.8643
Lithuania	0.4343	0.4897	0.5496	0.5483	0.5351
Latvia	0.7196	0.6370	0.6272	0.5741	0.5343
Poland	0.6449	0.6772	0.6123	0.7438	0.6134
Romania	0.4373	0.5218	0.4795	0.4937	0.4965
Slovakia	0.4703	0.4943	0.6216	0.7399	0.5693

Source: own elaboration.

Table 10
Efficiency ratios of banking sectors in the SE-CCR model in the studied countries of the region from 2014 to 2018 in the effects-oriented model

Country	2014	2015	2016	2017	2018
Bulgaria	0.5089	0.5966	0.6308	0.6778	0.6739
Czech Republic	0.5080	0.4897	0.5592	0.4937	0.4444
Estonia	0.4343	0.5751	0.4795	0.6453	0.7119
Croatia	0.8680	0.8586	0.8276	0.8612	1.0000
Hungary	0.6163	0.6404	0.5945	0.5519	0.5142
Lithuania	1.0000	1.0000	0.8724	0.9004	0.8305
Latvia	0.6035	0.7686	0.7644	0.8600	0.8317
Poland	0.6734	0.7230	0.7831	0.6638	0.7245
Romania	0.9930	0.9385	1.0000	1.0000	0.8951
Slovakia	0.9233	0.9905	0.7714	0.6673	0.7807

Source: own elaboration.

Analysing the values of the new efficiency indicators in the input-oriented model, it can be concluded that the most efficient banking sector compared to the countries of the region operates in the Czech Republic. Throughout the period under consideration, its efficiency indicator averaged

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0.94. In 2015 and 2017–2018, the Czech Republic was the leading country in terms of banking sector efficiency, while in 2014 and 2016 the indicator oscillated around 0.85. The high efficiency of the Czech Republic under this model can be mainly attributed to the significant growth in the level of loans granted, the dynamics of which is higher than the growth of key inputs, i.e. deposits or total assets, among others, throughout the period. Significant values of the efficiency ratio were also recorded in Bulgaria, Estonia and Hungary, which exceed 0.81 on average over the analysed time period. Estonia had the highest bank efficiency in 2014 and 2016 compared to other countries in the region due to, among other things, a significant increase in profit levels and a decrease in interest expenses in 2016. On the other hand, the lowest value of the efficiency ratio was recorded in Romania, Croatia and Lithuania, not exceeding the level of 0.53 on average. The data also shows that Poland is characterised by the average efficiency of banks compared to other countries in the region, which remains at a relatively stable level adopting the value of the ratio equal to 0.66 on average. Thus, it is clear that there are better performing banking sectors that can achieve the same amount of effects with fewer inputs. The reasons for the lower efficiency of Polish banks can be found, inter alia, in the Monetary Policy Council's systematic reduction of interest rates, which are currently at a record low level. Similar levels of banking sector efficiency are also found in Lithuania and Slovakia, whose index does not exceed an average of 0.62. Based on the above data, there is also no strong correlation between the level of economic development and the banking sector efficiency index. Large countries of the region in terms of GDP size, i.e. Poland, the Czech Republic, Hungary and Romania (GDP over USD 200 billion), do not record significantly higher bank efficiency during the period under review, compared to small countries, i.e. Bulgaria, Estonia, Croatia, Lithuania, Latvia or Slovakia (GDP under USD 200 billion). While the Czech Republic and Hungary show some of the highest bank efficiencies in the entire period under consideration, Poland and Romania perform much worse on the indicator than, among others, Bulgaria or Estonia classified as small countries in the region.

In the performance-oriented DEA model, the most efficient banking sectors in 2014–2018 are Romania, Lithuania and Croatia, which achieve an average index value of 0.97, 0.92 and 0.88, respectively. The above countries are therefore able to generate the greatest results from their inputs, i.e. profits, revenues or loan volumes. In 2014–2015, Lithuania was characterised by the best performance of banks compared to the other countries in the region, while in 2016–2017 it was Romania. Slovakia, Poland and Latvia also record intermediate magnitudes of the efficiency index of banking entities within the range of 0.71–0.88 on average over the whole period within the model. In the case of the Polish banking sector, an upward trend in its efficiency is visible in 2014–2016, which was, however, halted in 2017 mainly as a result of the introduction in 2016 of a bank tax paid as a percentage of total assets generated. Thus, in the effects-oriented model, the Polish banking sector is also not the most efficient compared to other countries in the region. In Slovakia, a decline in the efficiency ratio of banks was recorded from 2017 mainly due to a systematic reduction in interest income. Its lowest level in the analysed period is in Bulgaria, the Czech Republic, Estonia and Hungary. Bulgaria and Estonia show an increasing trend in banking sector efficiency, in contrast to the Czech Republic and Hungary, which show a decreasing trend. On average, within the above countries, the efficiency indicator value is 0.62. Large countries of the region in terms of GDP size, i.e. Poland, Romania, the Czech Republic and Hungary, are not significantly better performing banking entities in the analysed period in comparison to countries considered as small, either. The best performance of the bank efficiency index among the large havens of the region is shown by Romania (0.97), while the worst by the Czech Republic (0.50) and Hungary (0.58). Thus, it is clear that the disparity in efficiency levels within these countries is relatively high. At the same time, some of the highest efficiency indicators in comparison to other countries were recorded by small countries, i.e. Lithuania (0.92) and Croatia (0.88).

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5. CONCLUSION

The aim of this paper was to examine the efficiency of the banking sector in Poland and then compare the obtained results with selected countries in the region, i.e. Bulgaria, the Czech Republic, Estonia, Croatia, Hungary, Lithuania, Latvia, Romania and Slovakia in 2014–2018 using the non-parametric DEA method. The study used the SE-CCR super-efficiency model due to the presence of redundancy and different sizes of banking sectors. Efficiency analysis was carried out in both input-oriented and effect-oriented models. The parameters selected as inputs were salaries, employment, number of branches and ATMs, interest costs, commission costs, total assets, liabilities and provisions, equity, deposits and administrative costs, while the parameters selected as effects were profits and losses, loans, interest income and commission income.

The results show that regardless of the DEA model considered (i.e. input-oriented and effect-oriented), the Polish banking sector is not the most efficient among the selected countries in the region in the period 2014–2018. In the input-oriented model, the highest efficiency ratio was recorded in the Czech Republic, Estonia, Bulgaria and Hungary adopting values above 0.76 on average throughout the period. The Polish banking sector ranks in the middle of the pack in terms of efficiency, reaching an average of 0.66.

Also in the performance-oriented model, there were countries with better performing banking entities than Polish banks, i.e. Romania, Lithuania and Croatia, for which the efficiency indicator took values above 0.88. Poland, too, had an average banking sector efficiency of 0.71.

The analysis also shows that large countries of the region in terms of GDP size (above USD 200 billion), i.e. Poland, Romania, the Czech Republic and Hungary, do not have significantly higher banking sector efficiency compared to smaller countries during the period under review.

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Cash usage in Poland in 2020: Insights into the role of the COVID-19 pandemic and spatial aspects

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ABSTRACT

The study explores the factors likely to induce Polish customers to pay by cash, instead of payment cards, for goods and services they are purchasing. The basis of our investigation is microdata obtained in 2020, during the "Payment Habits in Poland in 2020" study, which was conducted by Narodowy Bank Polski (National Bank of Poland) in 2020. The analysis is performed using the two-stage Heckman approach. In the first stage, card adoption factors are analyzed using a probit model; then, in the second stage, the OLS model is employed to analyze the propensity to pay by cash, despite having a payment card. Apart from typical factors affecting the use of different payment methods, e.g., age, income, education, or perceptions about payment methods, we find an important role of two, yet under-investigated factors, namely: the COVID-19 pandemic and spatial aspects. E.g., we find that self-reported change in payment behavior during the pandemic indeed was reflected in diary studies. Furthermore, we show that instances of merchants' refusal to accept cash significantly impacted payment choices. Moreover, the results indicate significant spatial heterogeneity in payment behavior and that aspects like distance to the nearest ATM impacted cash usage, as more cash is used when ATMs are farther away, illustrating the concept of "cash burns." Lastly, it has been noticed that during the pandemic, ownership of contactless payment cards significantly reduced cash usage, most probably due to the fear of contracting the disease by physical contact with surfaces (like cash).

JEL classification: E41, D12, L81

Keywords: cash, payment cards, payment behavior, customer payment choice, Heckman approach.

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1. INTRODUCTION

It might seem that in an era of the growing adoption of financial innovation and digitalization of financial systems, analyses focused on cash use are of little relevance. Indeed, a closer look at some countries might reinforce this view, as cash use at physical points of sale can be quite low. E.g., in 2021, about 15% of all transactions in the UK (UK Finance, 2022) and 20% in the US (Cubides & O'Brien, 2022) were done via cash. Even more, in Sweden and Norway, which are at the forefront of becoming cashless countries, cash use in 2022 was reported to be even lower: 8% in Sweden (Sveriges Riksbank, 2022) and 4% in Norway (Norges Bank, 2022). However, in many economies, cash use is significantly higher and cash still plays an important role in the settlement of day-to-day purchases, e.g., according to a recent SPACE survey (ECB, 2022), 59% of all non-recurring transactions in the euro area are done this way, and its use ranges between 19% in Finland and 77% in Malta.

Notwithstanding the above and despite a worldwide declining trend of cash use for transactional purposes (Khiaonarong & Humphrey, 2023), demand for physical money has been rising for decades now (Ashworth & Goodhart, 2020). This phenomenon, now dubbed as "cash/banknote paradox" (Jiang & Shao, 2020; Pietrucha, 2021; Zamora-Pérez, 2021), was first noticed by Bailey (2009), who observed an increasing demand for high-denomination euro banknotes during the 2007–2008 financial crisis, coupled with a declining share of retail cash transactions.

Such a situation was exacerbated even further during the COVID-19 pandemic and has since received considerable attention in the literature (see, e.g., Auer et al., 2022; Caswell et al., 2020; Chen et al., 2022; Goodhart & Ashworth, 2020). Kotkowski (2023) showed that the increase in demand for cash stemmed from people's uncertainty avoidance, further linked with a precautionary motive of cash demand. This observation was in line with other recent studies that suggest that cash is being increasingly hoarded and used as a precautionary measure – according to Tamele et al. (2021) and Rösl and Seitz (2022), cash is treated as a "safe haven" during crises. Furthermore, other studies (see, e.g., Bounie et al., 2023; Jonker et al., 2022; Kotkowski & Polasik, 2021) showed that during the COVID-19 pandemic, cashless instrument use surged. One particularly important factor that affected this change has been reported to be fear of being infected by the virus while using cash (Huterska et al., 2021; Wisniewski et al., in press).

Poland is also subjected to the "cash paradox" phenomenon (studied recently by, e.g., Kaźmierczak et al. (2021) and Pietrucha and Gulewicz (2022)). Steadily increasing demand for cash in tandem with a downward trend in cash payments has been observable for years now. Table 1 shows the results of three surveys of payment habits conducted by Narodowy Bank Polski (NBP), the Polish central bank. Between 2011/2012 and 2020, the proportion of retail transactions performed by cash decreased from 81.8% to 46.4% (by volume) and 63.7% to 29.3 (by value), while the value of cash in circulation (CIC) to GDP increased by as much as 187.5% from 2011.

Table 1
Estimated share of cash transactions in the total number and value of transactions in the NBP surveys versus circulation growth rates from the end of 2011

	2011/2012	2016	2020
Share of cash in payment transactions (in %) by:			
– volume	81.8	53.9	46.4
– value	63.7	40.7	29.3
CIC growth since 2011 (in %)	–	67.5	187.5

Source: Authors' compilation based on the following studies of payment behavior: Koźliński (2013) for 2011/2012; Manikowski (2017) for 2016, and Kotkowski et al. (2021) for 2020.

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In our opinion, relatively high cash use in Poland and the above considerations vindicate the need to examine the reasons for this widespread use of cash. In this paper, we reinvestigate the main factors of cash use known in the literature, but in a situation where customers have adopted cashless instruments, e.g. payment cards. This is done by employing the Heckman approach at the respondent level to separate the stage of adopting the card from that of its use. This approach enabled unbiased and consistent estimators of the model parameters to be obtained.

Since in this paper, we use microdata obtained during a payment diary study done in 2020, that is during the COVID-19 pandemic, we are also able to further delve into the role of the pandemic on payment behavior. We deepen our understanding in a previously researched context – the role of the merchant's refusal to accept cash for payment behavior. Furthermore, thanks to the detailed survey performed together with the payment diary, we investigate another under-researched aspect of payment choice, viz. spatial aspects.

The article consists of five sections, plus references and an appendix. The second section presents an overview of the extant econometric research on the reasons for using various financial instruments. Special attention is paid to the types of econometric tools used in the research under discussion. Section three describes the data and methodology employed in the analyses. The fourth section discusses the results. The article ends with conclusions. The appendix provides estimates of econometric models for three data sets that differ in the scale of the reduction due to missing data for certain independent variables.

2. LITERATURE REVIEW

The question of why people pay in certain ways has been under investigation for several decades now (Boeschoten & Fase, 1989) and myriads of different factors have been discovered – see, e.g., Świecka et al. (2021) and Stavins (2017) for detailed discussions. The majority of analyses explaining why consumers use different payment instruments are based on data obtained through surveys and records of payments made by respondents over a certain period (these are known as diary surveys).

This enables the use of econometric tools to uncover the reasons for the use of particular instruments. Thus, for example, Borzekowski et al. (2008), using a series of probit models, analyzed the use of debit cards in the US. Among the many influential factors, they identified the demographic makeup and financial situation of the respondents. By contrast, Borzekowski and Kiser (2008) focused on debit cards, credit cards, checks, and cash in the US. They used a characteristics-based rank-order logit model to quantify consumer substitution between payment methods. Arango, Huynh, and Sabetti (2015) used a multinomial logit model to analyze the use of cash, debit, and credit cards at points of sale.

Arango, Hogg, and Lee (2015) focused their analysis on individuals with access to both debit cards and credit cards and abstracted from issues regarding payment instrument adoption. They used a probit model for this purpose. On the other hand, Wakamori and Welte (2017) modeled payment choice on a generalized logit model. This allowed them to account for the observed heterogeneity of the data and focus on determining whether consumers do prefer to use cash or whether merchants discourage the use of cards for small transactions. In turn, Stavins (2018) analyzed the influence of consumer preferences on specific payment instruments and how price discounts and surcharges based on the payment method affect payment instrument choice. For this purpose, the author used transaction-level probit regressions.

The analyses discussed so far primarily used discrete-choice models, e.g., logit and probit, to determine the probability of using different kinds of payment instruments at the transaction level. However, the literature also describes a slightly different approach: one that assumes a two-stage use of payment instruments and that can be adopted on either respondent level or transaction level

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– the so-called "Heckman correction" (Heckman, 1976, 1979). The first stage of this approach describes the adoption of the instrument, while the second stage describes its use.

For example, Koulayev et al. (2016) developed a structural model of adoption and use of payment instruments, where consumers select payment instruments to adopt in stage 1, and then decide on how to use them in stage 2. The same approach was used by Schuh and Stavins (2010, 2013). They proved that the characteristics of payment instruments are the most important determinants of instrument use by estimating econometric models of consumer adoption (extensive margin) and the use (intensive margin) of seven payment instruments. By contrast, Trütsch and Marcotty-Dehm (2021), using a two-step Heckman model, focused primarily on the impact of financial literacy on payment behavior. They used data from a payment diary and an online survey conducted in Switzerland in 2018.

One of the most recent analyses available in the literature was carried out on eurozone countries by Kajdi (2022). Three main research areas were investigated: (i) the socioeconomic characteristics (that can be associated with financial inclusion), (ii) the factors behind consumers' payment choices, and (iii) the underlying factors for holding cash in a wallet. To this end, the author used the data from the SPACE survey which was conducted by the ECB in 2019 and implemented the Heckman approach at both the transaction and respondent levels.

In most of the studies described above, several characteristics were considered to explain payment behavior among consumers. These can be grouped as follows: (i) socioeconomic characteristics (mainly age, income, education, gender, and employment status) and (ii) the specific features of the transaction environment. Heckman's respondent-level approach typically did not include payment characteristics (such as transaction value, the type of good or service purchased, card acceptance by a merchant, day of the week, etc.) or the importance/usefulness of the different attributes of payment instruments (mainly ease of use, record keeping, security, budget control). In the case of payment cards, a set of variables quantifying the characteristics of the debit and credit card plans people have when they begin to complete the diary was sometimes considered. By contrast, when a location was considered, only its nature (rural or urban) was taken into account. Many analyses additionally factored in on-hand cash holdings at the beginning of the diary study. The Internet access status was also considered in many analyses.

The vast majority of these analyses confirm the fact that cash is used more often by the elderly and by people with lower educational and/or income levels. Furthermore, those who do not use cash for daily transactions tend to keep less of it in their wallets, while those who indicate a preference for cash payments or who claim to place greater importance on cash payment options are more likely to carry more of it.

3. METHODOLOGY AND DATA

3.1. Data

This paper uses data obtained during a study entitled "*Payment Habits in Poland in 2020*", which was conducted by Narodowy Bank Polski in 2020 (Kotkowski et al., 2021). The study was carried out on a representative sample of 1,265 respondents from September 15 to October 15, 2020 (i.e., during the COVID-19 pandemic but between waves). The study consisted of a survey (completed using the CAPI method) and a 3-day payment diary (completed using the PAPI and CAWI survey methods).

The payment diary recorded 3,759 retail transactions having a total value of PLN 258 291.26 (approx. USD 66,240.42). Approximately 88% of these were performed by respondents who had a payment card and 82% were performed in places with an installed payment terminal. The

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division of registered transactions in our sample with respect to payment card ownership and the presence of EFT-POS (payment) terminals is presented in Table 2.

These characteristics can be assessed as representative of the Polish economy, as at the end of 2020 payment card ownership in Poland was approx. 81.7%, with 38.7m payment cards issued to individuals in Poland (1.01 cards per capita). Furthermore, about 1m payment terminals (approx. 27 payment terminals per thousand people) were being operated by 458,000 merchants. According to POLASIK Research, a consulting agency, approx. 43% of merchants accepted payment cards in Poland in 2019. However, it is estimated that only about 14% of all cash transactions were completed with merchants that did not accept payment cards (Polasik et al., 2020).

Table 2
Card ownership and EFT-POS terminal presence among registered transactions

		Payment card ownership		Sum
		Yes	No	
EFT-POS terminal presence	Yes	2,795	283	3,078
	No	401	92	493
	Don't know	125	63	188
Sum		3,321	438	3,759

Source: Based on Kotkowski et al. (2021).

As the analyses in the present article are concerned with choosing between cash and payment cards, data on payments made with other payment instruments were excluded. Of the 3,759 transactions mentioned, only 26 were concluded with payment instruments other than cash or payment card. These were performed by seven respondents who did not use either cash or a payment card during the diary survey. The restriction to cards and cash reduced the number of diary survey respondents from 991 to 984 (i.e., a 0.71% reduction). These 984 respondents constituted the first of three data sets (Dataset 1) subjected to econometric analysis. Further data sets were constructed by the exclusion of respondents that had not provided the data about the time that was needed for them to reach the nearest ATM (reduction to 929 respondents; Dataset 2) or had not assessed their payment instrument perceptions (reduction to 921 respondents; Dataset 3). A summary of all three data sets is presented in Table 3.

Table 3
Data sets subjected to econometric analysis

Type of data	Sample size R = respondents T = transactions	The amount of reduction in relation to base data	
		pcs.	%
Base data All respondents	R = 991 T = 3,759	–	–
Dataset 1 No transactions other than cash and card	R = 984 T = 3,733	6	0.71
Dataset 2 with *minutes to closest ATM*	R = 929 T = 3,579	62	6.26
Dataset 3 with *minutes to closest ATM* and variables describing perceptions about cash and payment cards	R = 921 T = 3,561	67	6.76

Source: Authors' calculation.

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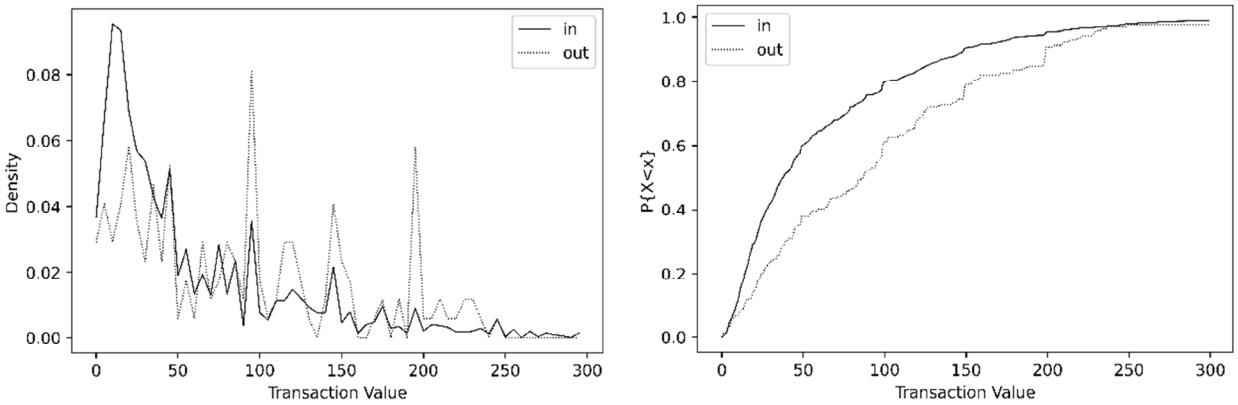
To determine whether these reductions are random, the concept of Missing Completely at Random (Wakamori & Welte, 2017) was used. For this purpose, it was decided to analyze the value of transactions as one of the most important factors influencing the decision to use cash at points of sale. The probability density and distribution $P\{X < x\}$ were determined for both the excluded and resulting data. These are shown in Figure 1.

Figure 1
Probability density function (on the left side) and probability distribution $P\{X < x\}$ (on the right side) of the variable transaction value for deleted (out) and post-deleted (in) data (transaction-level analysis)



Source: Authors' calculation.

Figure 1 illustrates the differences in the distributions of the transaction values in the two data sets (out and in). There are more large cash transactions in the deleted data sets. The two-sample Kolmogorov-Smirnov test proved that the sample data sets (remaining and deleted) do not come from the same distribution (test statistic $D = 0.2577$, p-value $= 4.28 \cdot 10^{-10}$). At the very least, this suggests the presence of what is known as Missing at Random (MAR).

MAR means that the propensity for a data point to be missing is not related to the missing data but to some of the observed data (e.g. the *TRX value*). This, in turn, can lead to obtaining overestimates for smaller transactions and underestimates of cash probabilities for larger transactions. However, due to the size of the reduction (less than 7%), the scale of the possible burden should not be significant. This is analyzed below.

The analyses assume that every respondent has cash or can obtain it relatively easily. This assumption is justified by the statistics of the data from the diary survey. Using the imputation techniques of Roystone (2009), a *cash-holding status* variable was determined. A respondent is assumed to be in possession of cash if at least one of the following conditions is met:

– the respondent had cash at the beginning of the survey according to the diary;
– the respondent withdrew cash during the survey and noted this in the diary;
– the respondent made at least one cash payment and recorded this in the diary.

When cash holding status was defined this way, only 19 (0.5%) of the 3,759 retail transactions were performed by respondents that did not possess cash, and this only concerned 5 respondents (0.5%). Therefore, if the Datasets were further truncated by excluding those respondents who did not have cash, the reduction would be too small to significantly affect the estimates. Because of that, we abstained from further truncation.

3.2. Model

To obtain the results presented in the paper, we used a two-step approach invented by Heckman and originally implemented for wage equations at the microdata level. Heckman (1979, p. 160) considered such a calculated estimator as useful for "*provid(ing) good starting values*

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for maximum likelihood estimation". Later papers criticized some features of Heckman's two-step approach (see Puhani, 2000), like:

– Heckman estimators are inefficient and subsample OLS may be more robust;
– a high correlation between the exogenous variables in the selection and the use model often exists in the selection problems, which may cause the collinearity between the inverse Mills ratio and the other regressors, which may impact the robustness of estimators. Therefore, it is indicated to investigate whether there are collinearity problems in the data.

Notwithstanding the above critique, we use a two-step Heckman approach to analyze each of the three defined Datasets. The first step describes the adoption of card payment in the form of a probit model with a binary dependent variable A_{ij} of the following form:

$$A_{ij} = \begin{cases} 1 \text{ if consumer } i \text{ has adopted card payment} \\ 0 \text{ otherwise} \end{cases} \tag{1}$$

The second step describes the use (intensity) of cash under the form of an OLS model with a continuous dependent variable U_{ij} denoting the proportion of each i-th individual's payments made in cash.

The two-step Heckman approach resulted in the following models:

$$P(A_i = 1) = A\left(\mathrm{X}_i^1\right) + \varepsilon_i^A - \text{adoption (selection) model} \tag{2}$$

$$U_i = U\left(\mathrm{X}_i^2, MR_i^{-1}\right) + \varepsilon_i^U - \text{use (regression) model} \tag{3}$$

where X_i^1 means a set of explanatory variables expressing the factors with impact on card possession (adoption), X_i^2 means a set of explanatory variables expressing the factors with impact on cash choice (use), ε_i^U and ε_i^A mean errors terms. In the use model, there is MR_i^{-1} which means the inverse Mills ratio (named later as a *lambda*) obtained for the first model. As long as ϵ_i^A has a normal distribution and ϵ_i^U is independent of the inverse ratio MR_i^{-1}, Heckman's two-step estimator is consistent (see, e.g., Puhani, 2000).

The following elements of the set X_i^1 can be distinguished: *DEMOGRAPHICS*, *ECONOMY,* and *LOCATION*. *DEMOGRAPHICS* includes gender, age, education, and financial knowledge. Financial knowledge was assessed using the Big Three questions (Mitchell & Lusardi, 2011). The *ECONOMY* feature group includes income and economic activity. The *LOCATION* group considers two spatial aspects. The first distinguishes between rural areas and different-sized places of residence. The second takes into account the administrative division of Poland into 16 provinces.

The variables from the set of X_i^2, determining the choice of cash as an instrument for making payments for goods and services by cash at points of sale (POS), not only included variables from the X_i^1 set, but also from the *FACTORS AT THE POS*, *PORTFOLIO FEATURES*, *COVID VARIABLES*, and *PERCEPTIONS* classes. The *FACTORS AT THE POS* set includes transaction characteristics (e.g. average transaction value and the type of goods purchased) and a Boolean variable indicating the presence of a payment terminal that allows payment card transactions. It should be noted that, unlike other types of data, *FACTORS AT THE POS* were determined based on diaries recording individual payment transactions.

Let's discuss the legitimacy of using variables as instruments in the use model grouped into the before-mentioned classes. The first class (*FACTORS AT THE POS*) of variables refers to factors like *TRX value*, *TRX place type*, and *POS terminal*. These variables are strictly related to payments (were collected during the diary survey) and therefore it seems that they should not influence the decision regarding payment card adoption. However, the question is whether the consumption structure of an individual (expressed by the variables) can affect their decision to

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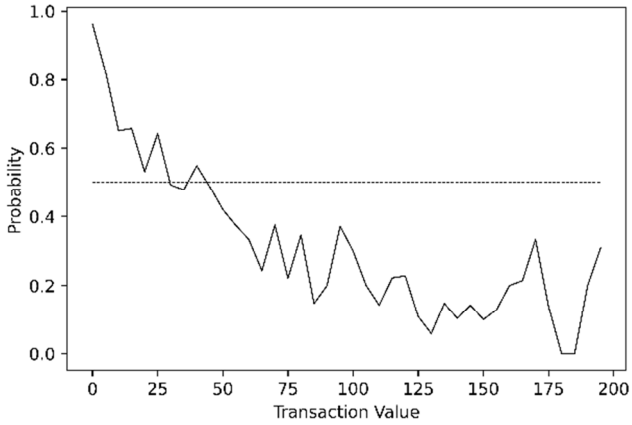
adopt a payment card or whether there is an inverse relationship. We assumed a one-way relation: from the adoption to the consumption structure. The variable of *TRX value* is one of the more important characteristics of this group, and other studies show that it significantly influences the decision of whether to pay by cash (see, e.g., Świecka et al., 2021). The distribution of this variable was used above to examine the nature of the reduction in the Datasets. The analysis of the frequency of cash use shown in Figure 2 confirms that the value of POS transactions can influence the choice of payment instrument. The results show that transactions not exceeding PLN 25 are more likely to be performed by cash than by payment cards. According to the 2016 survey, the threshold was PLN 46 (Manikowski, 2017). The presence of payment terminals is another variable belonging to the *FACTORS AT THE POS* set. It should be noted that this variable is vulnerable to the risk of endogeneity. As shown by Arango, Huynh, et al. (2015), individuals who prefer to use cards may choose to frequent establishments that are more apt to accept them. Consequently, the extent to which card acceptance affects the probability of using cards at low-value transactions may have been underestimated, and conversely, the probability of using cash overstated.

Figure 2
Cash payment frequencies



Note: Cash payment frequencies for the transactions to 200 zlotys. These frequencies were calculated based on a sample of 3,759 transactions in the diary without the use of weights.

Source: Authors' calculation.

The *PORTFOLIO FEATURES* set contains such variables of the payment instruments analyzed here as *contactless card adoption* and *minutes to closest ATM*. The use of the *minutes to closest ATM* was dictated by several considerations. First, we wanted the analyses to include the potential difficulty of accessing cash through its most important source, viz. ATMs. Second, this variable obviated the inclusion of the initial cash balance. Arango, Huynh, et al. (2015), among others, included such variables in their analyses but found that it could cause undesirable endogeneity. They argued that possessing or not possessing cash determines the marginal cost of using it; possession makes its marginal cost close to zero, while non-possession can incur the cost of acquiring it or postponing a purchase. Therefore, cash status should be one of the determinants of payment choices. However, respondents who prefer to use cash adjust their cash balances accordingly. This may suggest the presence of a two-way dependency relationship. To control for the possibility of this sort of endogeneity, Arango, Huynh, et al. (2015) used an extended version of the probit model with such exogenous variables as the number of nearby ATMs deemed highly correlated with initial cash on hand. We opted for the use of *minutes to closest ATM* instead.

However, we struggled with the question of whether to include *minutes to closest ATM* in the adoption model. On the one hand, the findings of Beckmann et al. (2018) revealed that households without a bank account in Central, Eastern, and Southeastern Europe countries were significantly farther away from bank branches (2.8 km) compared to households with a bank account (2.1 km),

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which suggests that a shorter distance to bank branches may encourage households to establish a formal relationship with banks (such as having an account or taking out loans) and further this correlation implies a potential causality between access to cash (or cash services in general) and account (and consequently card) ownership. On the other hand, we suffered from a significant lack of data for this variable – 133 out of 921 respondents from the Dataset 3 set did not provide an answer regarding the distance to a close ATM. Consequently, the sample size would be reduced from 921 to 788. Ultimately, we decided to exclude this variable from the adoption model and only use it in the use model.

Contactless card adoption shows whether the respondent owns a payment card that allows NFC (proximity) payments. On the one hand, this feature – already the subject of other research (see, e.g., Brown et al., 2022; Polasik et al., 2012, 2013; Trütsch, 2020) – is very common in Poland (during the time of the study, about 92% of all issued cards and 100% of EFT-POS had such characteristic); on the other hand, emphasis on using contactless payments might have been present during the COVID-19 pandemic, as a remedy for fear associated with the risk of contracting the disease during cash handling or even manual payment card usage (Wisniewski et al., in press).

The next set of variables – *COVID VARIABLES* – covers two aspects of the COVID pandemic: (i) changes in payment behavior during the COVID-19 pandemic [*COVID change behavior*] and (ii) experience of problems with cash payments at the POS, e.g., refusal from merchant [*problem with cash payments*]. The main objective of the *COVID change behavior* variable is to measure whether respondents' opinion about their change of behavior was consistent with their actions. In turn, measuring the effect that p*roblem with cash payments* could have on payment behavior might bring important policy implications. Furthermore, it seems that adding the *COVID VARIABLES* class only to the use model does not raise any doubts. For example, *COVID change behavior* expresses the change in the payment behavior of respondents because of the pandemic without any impact on card adoption. Even if the pandemic affected the account holding, the effects of this impact would be visible only after some time. A similar explanation applies to the *problem with cash payments* variable.

The set of attributes called *PERCEPTIONS* consists of five method-of-payment *CHAR* attributes, viz. time taken to make a payment, cost of making a payment, ease of making a payment, the safety of using a particular payment method, and the perceived range of acceptance of a payment method. The econometric analyses used indicators of *RCHAR* as relative ratings of the above *CHAR* attributes calculated for each *i-th* respondent according to the following formula (Schuh & Stavins, 2010):

$$RCHAR_{kji} = \frac{CHAR_{kji}}{\sum_{l=1}^{m} CHAR_{kli}} \tag{4}$$

where the subscript k specifies the payment instrument attribute number of the set {time, easy, safe, cost, widespread}, and the subscript j specifies the payment instrument number from the set {cash, card}. However, it should be noted that since we had doubts about the credibility of the data collected among respondents without cards, viz. whether the person who does not have any card knows the real benefit of the card, we used this data only in the use model, and not for the adoption model. Our decision was further backed by the fact that we lacked 80 values of the perceptions variables, which could reduce the number of observations from 921 to 841.

In Table 4, we present a list and definitions of all explanatory variables we have used in the study. Furthermore, in Table 9 (see the Appendix), we provide descriptive statistics of variables (based on Dataset 3, that is, as will be shown in the next section, the base model for our analysis).

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Table 4
Definitions of variables

Class	Variables	Definition
FACTORS AT THE POS	*TRX value*	The average value of the transaction [in PLN].
	TRX place type	Variables that show what type of payment the respondent made: for goods (trade), for services (service), or P2P.
	POS terminal	A binary variable capturing whether the respondent noticed the payment terminal during the transaction (1) or not (0).
PORTFOLIO FEATURES	*contactless card adoption*	A binary variable capturing whether the payment card owned by the respondent was contactless (1) or not (0).
	minutes to closest ATM	Self-reported average time required by the respondent to reach the closed ATM [in minutes].
COVID VARIABLES	*COVID change behavior*	Dummy variables that capture the self-reported change in the payment behavior of the respondent during the COVID-19 pandemic: yes, towards cashless; yes, towards cash; no change.
	problem with cash payments	Dummy variables capturing the self-reported experience of the respondent of not accepting cash by the merchant during the COVID-19 pandemic: yes, often; yes, rarely; no.
PERCEPTIONS	*cash faster*	Time of use: relative assessment of cash vs. card.
	cash easy	Ease of use: relative assessment of cash vs. card.
	cash safe	Safety: relative assessment of cash vs. card.
	cash cheap	Costs: relative assessment of cash vs. card.
	cash widespread	Acceptance: relative assessment of cash vs. card.
DEMOGRAPHICS	*female*	A binary variable that captures whether the respondent was female (1) or otherwise (0).
	age	Dummy variables capturing age categories: 18–24; 25–39; 40–64; 55–64; 65+.
	education	Dummy variables capturing the respondent's level of formal education: primary, lower secondary, or no education; basic vocational or professional; secondary; higher.
	financial knowledge	Dummy variables that capture the financial knowledge of the respondent: low; average; high.
ECONOMY	*income*	Dummy variables that capture the respondent's disposable and discretionary income (in PLN): ≤1300; 1301–1800; 1801–2400; 2401–3800; >3800 PLN; refuse or do not know.
	economic activity	Dummy variables capturing the respondent's activity: employment; student; stay at home; unemployed; retired; self-employed.
LOCATION	*type of region*	Dummy variables capturing the size of the location where the respondent lives: rural area; suburban area (formally a "village", but within 20 km from a city of size greater than 100,000 inh.); small towns (fewer than 20,000 inh.); medium-size cities (20,000–100,000 inh.); large cities (more than 100,000 inh.).
	voivodships	Respondent's place of residence within the highest-level administrative division of Poland (voivodships correspond to provinces in many other countries).

Source: Authors' preparation.

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In summary, the sets of explanatory variables for the adoption and use models are defined as follows:

$$X_i^1 = \{DEMOGRAPHICS, ECONOMY, LOCATION\} \tag{5}$$

$$X_i^2 = X_i^1 \cup \{FACTORS\ AT\ THE\ POS, PORTFOLIO\ FEATURES, COVID\ VARIABLES\ PERCEPTIONS\} \tag{6}$$

In summary, we calculate two sets of models: adoption models and use models. Each set consists of three models. Each adoption model consists of the same variables, hidden under *DEMOGRAPHICS*, *ECONOMY*, and *LOCATION* classes. It differs, however, in the sample size (see Table 3). On the other hand, use models include variables under the following classes: *FACTORS AT THE POS*, *PORTFOLIO FEATURES* (with the notable exclusion of *minutes to closest ATM* variable in Model 1), and *COVID VARIABLES*. Model 3 is the only one that also encapsulates *PERCEPTIONS* variables.

Similarly to the analysis conducted by Koulayev et al. (2016), the weights assigned to the survey and diary data were not used for the Heckman model estimates. We feared that they could hinder the interpretation of the resulting model parameter estimates.

4. RESULTS

Heckman's approach yields two types of results. The first concerns the reasons for adopting a payment card. The second concerns the use of cash at points of sale. Respondent-level results were obtained for both. Model 3 (based on Dataset 3) was used as the basis for further discussion. The result for the remaining Dataset 1 and Dataset 2 is given in the Appendix (see Tables 11 and 12).

4.1. Adoption model

The first stage of Heckman's approach yielded an adoption model in the form of a probit model. The dependent variable is *card ownership*, which is binary and has a value of 1 for respondents with at least one payment card and 0 otherwise. The model has a relatively high pseudo-R2 value of 0.5723. The other characteristics, including the results of the chi-2 test showing the significance of the variables in the model, are shown in Table 5.

Table 5
Results of the 1st stage probit regression

Number of obs	921
LR chi2(36)	460.87
Prob > chi2	0.0000
Pseudo R2	0.5723
Log likelihood	–172.2368

Source: Authors' calculation.

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Table 6 gives the results of the *lambda* estimates as a product of *rho* and *sigma*. A positive *rho* value indicates a positive correlation between the random components ε_i^A and ε_i^U of Model 2 and Model 3 respectively. Although the p-value is 0.128, which is higher than the significance levels, it is not too far above the highest value usually adopted in analyses.

Moreover, the results for Model 2, which are presented in Table 10 (see the Appendix), show that the parameter significance levels are 0.1 and 0.05. This justifies the validity of using the Heckman approach for the analyses conducted here and enables an unconstrained and consistent parameter estimates model to be obtained.

Table 6
Lambda, *rho*, and *sigma* values

	Coeff.	StdErr.	z	P>|z|	[95% conf. interval]	
Lambda	0.0838	0.0550	1.52	0.13	–0.0241	0.1916
Rho	0.3380					
Sigma	0.2478					

Source: Authors' calculation.

Table 7 shows the estimated values of marginal effects of the characteristics that affect the decision to have a payment card. Positive values indicate a higher propensity to own a payment card, and conversely, negative values indicate a lower propensity.

Table 7
Heckman's 1st stage adoption model probit regressions (marginal effects*)). Dependent variable: *card ownership*

		Coeff.	StdErr.
female		0.0215	0.0175
age (base: 15–24)	25–39	0.0172	0.0425
	40–54	0.0284	0.0428
	55–64	–0.1264***	0.0384
	65+	–0.1586***	0.0381
education (base: high)	primary	–0.2949***	0.0569
	basic voc/prof	–0.1611***	0.0508
	secondary	–0.0708	0.0514
financial knowledge (base: high)	low	–0.0871***	0.0304
	average	–0.0540*	0.0314
income (base: >3,800)	<1300	–0.0667	0.0446
	1301–1800	–0.0299	0.0417
	1801–2400	–0.0230	0.0388
	2401–3800	–0.0090	0.0398
	refuse/don't know	–0.0660*	0.0388

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continued Table 7

		Coeff.	StdErr.
economic activity (base: self-employed)	employed	0.1108	0.0833
	student	0.0714	0.0912
	stay at home	0.0033	0.1082
	unemployed	0.5860***	0.0396
	retired	0.1235	0.0839
type of region (base: large cities)	rural	–0.0220	0.0242
	suburban village	0.0435	0.0293
	small towns	0.0252	0.0335
	medium cities	0.0457*	0.0261
voivodships (base: mazowieckie)	dolnośląskie	0.5990***	0.0405
	kuj.-pomorskie	–0.1020***	0.0366
	lubelskie	0.0659	0.0498
	lubuskie	0.6758***	0.0457
	łódzkie	0.0283	0.0510
	małopolskie	–0.0763**	0.0369
	opolskie	–0.0859	0.0552
	podkarpackie	–0.1327***	0.0407
	podlaskie	–0.1239***	0.0430
	pomorskie	–0.0738*	0.0392
	śląskie	–0.0602*	0.0333
	świętokrzyskie	–0.1730***	0.0412
	warm.-mazur.	–0.1089**	0.0440
	wielkopolskie	0.1259**	0.0621
	zachodniopom.	0.0821	0.0626
constant		3.1669***	0.9911

*) All independent variables are binary. Therefore, marginal effects measure discrete change, i.e. how predicted probabilities of having a card change as the binary variable changes from 0 to 1.

Source: Authors' calculation.

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4.1.1. Demographics

The results obtained for the variables in the *DEMOGRAPHICS* group show that the propensity to have a payment card does not differ significantly between men and women. This is not the case with the other groups.

The age groups 25–39 and 40–54 are most likely to have payment cards.

The best-educated respondents have a higher propensity to hold a payment card. This is true for both general education (*education*) and financial knowledge (*financial knowledge*). The greater the general or financial knowledge, the greater the propensity to own a card. Importantly, differences with respect to the variables removed from the model (base) are mostly statistically significant.

4.1.2. Economy

Once *income* is taken into account, it can be seen that the higher the income, the higher the propensity to have a payment card. The level of reluctance to have a card is similar for those in the lowest income bracket and those who either did not know their level of income or refused to answer this question.

As for *economic activity,* employed and retired people have a surprisingly similar propensity to have a payment card. Interestingly, they have a lower propensity than students. The lowest likelihood of having a card can be observed for stay-at-home and self-employed.

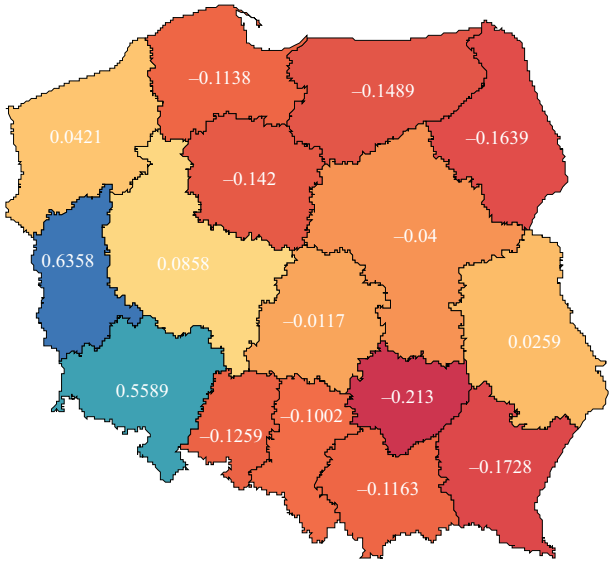
4.1.3. Location

In line with the earlier description of the variables, the adoption model also took into account the types of regions in which the respondents lived, as well as the highest-level administrative units to which they belonged (i.e. their provinces).

As expected, the likelihood of having a card increases with the size of the respondent's residential settlement. Curiously, however, the residents of large cities are slightly more likely than rural residents to have a card.

When analyzing the propensity to have a card by geography (Figure 3), it can be concluded that there is statistically significant variation. As a rule, residents of the westernmost provinces are more likely to have a card.

Figure 3
A map of Poland with a propensity to card adoption in different provinces



Source: Authors' calculation.

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4.2. Use model

The second phase of the Heckman approach yields an OLS use model. The dependent variable is the *share of cash payment* in term of volume. This is a continuous variable and takes a value in the range <0–1>. As card payment is the only alternative considered, it follows that its share is equal to 1 – *share of cashless payment*. The parameter estimates are shown in Table 8.

Table 8
Heckman's 2nd stage use model OLS regressions. Dependent variable: *share of cash payment*

		Coeff.	StdErr.
TRX value		–0.0008***	0.0002
TRX place type (base: P2P)	trade	–0.2198*	0.1244
	service	–0.1399	0.1294
POS terminal		–0.5692***	0.0497
contactless card adoption		–0.1434***	0.0463
minutes to closest ATM		0.0030**	0.0015
COVID change behavior (base: no change)	towards cashless	–0.0408*	0.0219
	towards cash	0.1423***	0.0406
problem with cash payments (base: no)	often	–0.1767***	0.0670
	rarely	–0.0815**	0.0338
perceptions of cash	cash faster	0.2355**	0.1058
	cash easy	0.0838	0.1494
	cash safe	0.1723*	0.1016
	cash cheap	0.1516	0.1321
	cash widespread	–0.1255	0.1169
female		0.0181	0.0189
age (base: 15–24)	25–39	0.0387	0.0392
	40–54	0.0912**	0.0393
	55–64	0.0644	0.0476
	65+	0.1501***	0.0461
education (base: high)	primary	0.1465*	0.0754
	basic_voc/prof	0.0584*	0.0344
	secondary	0.0379	0.0262
financial knowledge (base: high)	low	0.0119	0.0282
	average	–0.0069	0.0248

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continued Table 8

		Coeff.	StdErr.
income (base: >3800)	<1300	0.1762***	0.0609
	1301–1800	0.0554	0.0444
	1801–2400	0.0553	0.0342
	2401–3800	–0.0075	0.0298
	refuse/don't know	0.0405	0.0338
economic activity (base: self-employed)	employed	0.0830	0.0969
	student	0.0615	0.1075
	stay at home	0.3143**	0.1496
	unemployed	–0.0277	0.1747
	retired	0.1028	0.0979
type of region (base: large cities)	rural	–0.0198	0.0285
	suburban_village	–0.0418	0.0339
	small_towns	–0.0194	0.0312
	medium cities	0.0263	0.0270
voivodships (base: mazowieckie)	dolnośląskie	0.0894*	0.0530
	kuj.-pomorskie	–0.0393	0.0464
	lubelskie	0.0093	0.0476
	lubuskie	0.2332***	0.0528
	łódzkie	0.0101	0.0459
	małopolskie	–0.0713*	0.0432
	opolskie	–0.1049	0.0653
	podkarpackie	–0.1217**	0.0611
	podlaskie	–0.0004	0.0679
	pomorskie	–0.1059**	0.0483
	śląskie	0.0979***	0.0370
	świętokrzyskie	0.0143	0.0638
	warm.-mazur.	0.2415***	0.0668
	wielkopolskie	0.0394	0.0381
	zachodniopom.	0.2028***	0.0495
constant		0.9913***	0.1687

Source: Authors' calculation.

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4.2.1. Factors at the POS

The results obtained in the area of transaction and POS characteristics confirm the relevance of the value of payments made: the smaller the value, the higher the probability of paying in cash. The probability of using cash also depends on the type of goods or services purchased and is highest for P2P transactions and lowest for trade.

For obvious reasons, the presence (or rather sighting) of a payment terminal significantly reduces the likelihood of using cash.

4.2.2. Portfolio Features

The *PORTFOLIO FEATURES* include a variable associated with the possession of a payment card that allows performing contactless transactions. This feature significantly discourages the use of cash. This is somewhat in opposition to the results obtained by Brown et al. (2022). Those authors found that contactless cards only slightly dampened the demand for cash. Moreover, they found that more significant changes in payment behavior and cash demand can only be triggered by stronger shocks to the nonpecuniary benefits of cashless payments (relative to cash). One of the possible explanations for this observation might be the fact that the study was performed during the COVID-19 pandemic and contactless payments were seen as a remedy for fear associated with the risk of contracting the disease during cash handling or even manual payment card usage (Wisniewski et al., in press).

The analyses presented here also factor in the time required to get to the nearest ATM. The results show that the farther away the ATM, the more inclined consumer is to use cash. The apparent rationale is that a distant ATM induces more cash to be withdrawn (and consequently to be on hand) and that this cash is more likely to be used at the POS than a payment card. This phenomenon, referred to as "cash burns" in the literature, is consonant with the results obtained by, e.g., Alvarez and Lippi (2017), who showed that cash is used whenever the agent has enough of it, and credit is used when cash holdings are low, a pattern recently documented by household data from several countries.

It should be noted, however, that there are limitations to this observation. At first glance, it could suggest that, *ceteris paribus*, cutting ATM network (and cash access in general) could increase the use of cash. In our view, there is an inflection point of cash access, beyond which the costs of obtaining cash (e.g., in terms of time) would become too great to continue using cash. This, however, does not seem like a policy for reliable withdrawal of cash from circulation (cash-out). Zamora-Pérez (2022), citing available research (Doerr et al., 2022; Mancini-Griffoli et al., 2018), suggests that in certain situations, ensuring that cash is widely available may be more effective than other strategies, e.g., those based on the digital solution. Furthermore, it does not seem possible that a decrease in the ATM network would keep other important factors (like a network of alternative cash access points or POS terminals density) constant.

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4.2.3. Covid Variables

The survey demonstrates that the COVID-19 pandemic, which arrived in Poland in early March 2020, has significantly altered consumer POS behavior. This, in turn, has translated into different propensities to use particular payment instruments. The estimation results confirm the changes in preferences declared in the survey. The declared move away from cash is manifested by a significant decrease in its use. On the other hand, the change toward cash was confirmed by positive parameter estimates (0.1423).

Furthermore, problems with the acceptance of cash at POS during the pandemic resulted in a significant decline in the willingness to use cash by respondents who experienced such a situation. Moreover, the more frequent the problems, the greater the decline was.

COVID VARIABLES appear only in the use model. Therefore, the coefficients in the use equation can be interpreted as the marginal effect of a one unit change in that variable on a dependent variable (see Puhani, 2000). Consequently, according to the estimations parameters of *COVID VARIABLES*, we can observe that the pandemic restrictions affected the cash share decline in the following ways:

– problems with cash acceptance by merchants could reduce the *share of cash payments* by 8.15 percentage points for rare occurrences and by 17.67 percentage points for frequent occurrences of acceptance problems;
– the change of behavior towards cashless could reduce the share of cash by 4.08 percentage points.

4.2.4. Perceptions

The perception of cash in relation to payment cards was also used to assess the use of cash. The results indicate that the perception of cash as being a faster and more secure payment instrument should significantly increase the willingness to use it. Other characteristics (besides the universality of its acceptance) influence this in a similar way, but the results suggest a non-significant role for them.

4.2.5. Demographics

The results for cash use are consistent with those obtained in the adoption model for *card ownership*: an increase in consumer age increases the propensity to use cash, as does a decrease in education level. However, it can be seen that respondents in the lowest age group (15–24), despite having a lower propensity to have a card, have the lowest propensity to use cash at the POS. Differences can also be observed when considering financial expertise. While it has a significant impact on deciding whether to acquire a card, it does not play a significant role when choosing a payment instrument at the POS.

4.2.6. Economy

The decision to use cash at the POS is also determined by income level: the higher it is, the lower the propensity to use cash. Employment status also plays a role in such decisions. The highest propensity to pay in cash primarily characterizes those who stay at home. Retirees rank second. According to the adoption model, they were among the most likely to have a payment card.

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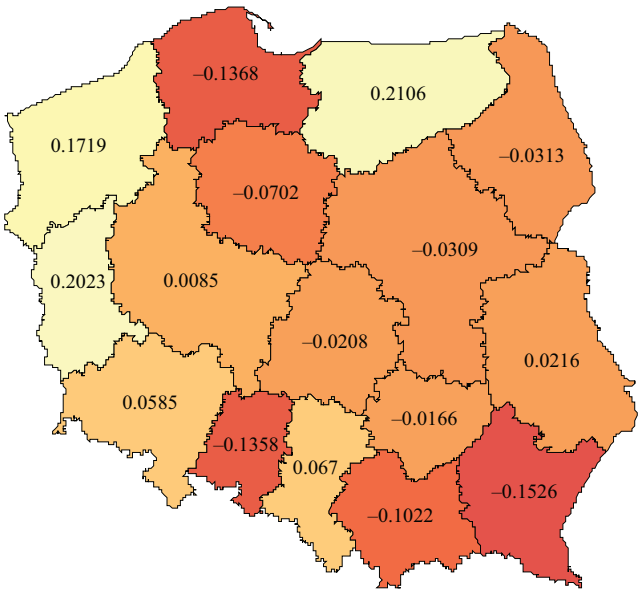
4.2.7. Location

When choosing a payment instrument, the type of region one lives in also matters (although not significantly). It is worth noting the indication of large-medium cities, where the propensity to use cash is the highest. As in the case of the adoption model, there is also a significant geographical variation in the results obtained (see Figure 4). There is a greater propensity to use cash in the western and northern regions.

Figure 4
A map of Poland illustrating the propensity to use cash in the different provinces



Source: Authors' calculation.

4.3. Comparison analysis of the different models

When the analyses presented above were performed on Dataset 3, *minutes to closest ATM*, along with five other variables expressing how various aspects of cash are perceived (*PERCEPTION* class variables), were included. This involved removing those respondents who refused to answer these questions in the survey. The random nature of the data exclusion analysis performed earlier indicated that more respondents with a propensity to use cash for larger payments could be removed, i.e. the distribution of the removed data differed somewhat from that of the data subjected to econometric analysis. This carries the risk of obtaining loaded estimates with an overestimation of the probability of using cash for small payments.

The Heckman approach was used because of removing data of respondents without payment cards. However, there was no reduction due to the data gaps described here. Two models were also estimated to test the possible magnitude of bias. There was no data reduction in the first (Model 1). This is because the variables mentioned above were excluded in the second stage of the Heckman approach. This model was estimated using a sample of 984 respondents (Dataset 1). Model 2 only assumed the inclusion of the *minutes to closest ATM* variable in the second stage of the Heckman approach. This involved reducing the data set to 929 respondents (Dataset 2). A comparison of the results obtained in the variants described above is presented in the Appendix (Tables 10, 11, and 12). These show that there are no significant differences between the estimates of the parameters of the different adoption and use models.

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5. CONCLUSIONS

The present study allows for an understanding of why, and under what circumstances, Polish consumers use cash to pay for goods and services. The obtained results are mostly in line with expectations and results obtained in other countries. They point to several consumer characteristics generally associated with cash payments, such as advanced age, lower income, and lower level of education. We show that perceptions about different payment instruments matter greatly.

Notwithstanding the above, we provide additional observations. The inclusion of variables representing self-reported changes in payment behavior as a result of the COVID-19 pandemic shows that the declared changes are reflected in diary studies. This is especially important, as an eventually unfounded perception that viruses were easily transmitted through banknotes and coins prompted many customers to change their habits and also induced some merchants as far as to refuse to accept cash. Our analyses have shown the relevance of these factors in the choice of payment instruments at the POS – such an experience significantly decreased the probability of using cash during the time of the study.

Furthermore, our study shows that the adoption of contactless payment cards, which is widespread in Poland, significantly increases the likelihood of cash payments being abandoned. In our view, this could be related to two factors: firstly, contactless transactions are generally as fast as cash transactions (and often happen to be quicker) and, secondly, the before-mentioned fear of contracting the disease by cash handling could have inclined customers to use methods of payment that did not require physical contact with any surface.

The analyses also included the spatial aspect. They were not limited to only distinguishing rural and urban types of regions. Specific administrative units of the 16 provinces were also included. The results indicate significant spatial heterogeneity in payment behavior. The spatial aspect was further taken into account by including the time required to reach the nearest ATM. The estimation of the parameters showed that the farther away the ATM, the more inclined the consumer to use cash. This confirms the phenomenon of "cash burns", i.e. cash is used more often when it is on hand, and people possess larger amounts of it when they are distant from withdrawal points.

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APPENDIX

Table 9
Descriptive statistics of variables from Dataset 3

Variables		Obs	Mean	Std.dev.	Median	Min	Max
card ownership		921	0.8415	0.3654	1	0	1
share of cash payment		775	0.3934	0.3437	0.5	0	1
Features of TRX and	TRX value	775	75.3003	61.7640	58.99	6.67	1175.67
POS (base: P2P)	trade	775	0.8560	0.1929	1	0	1
	service	775	0.1169	0.1826	0	0	1
	POS terminal	775	0.8492	0.2174	1	0	1
contactless card adoption		775	0.9548	0.2078	1	0	1
minutes to closest ATM		775	12.1936	6.8149	10	0	60
COVID change behavior (base: no change)	towards cashless	775	0.3587	0.4799	0	0	1
	towards cash	775	0.0632	0.2435	0	0	1
problem with cash payments (base: no)	often	775	0.0219	0.1466	0	0	1
	rarely	775	0.0890	0.2850	0	0	1
perceptions of cash	cash faster	775	–0.0316	0.1042	0	–0.7	.48
	cash easy	775	–0.0088	0.0722	0	–0.4	.22
	cash safe	775	0.0072	0.1030	0	–0.7	.4
	cash cheap	775	0.0250	0.0833	0	–0.48	.4
	cash widespread	775	0.0349	0.0925	0	–0.48	.4
gender	female	921	0.5364	0.4990	1	0	1
age (base: 15–24)	25–39	921	0.2834	0.4509	0	0	1
	40–54	921	0.2845	0.4514	0	0	1
	55–64	921	0.1368	0.3438	0	0	1
	65+	921	0.2237	0.4169	0	0	1
education (base: high)	primary	921	0.0652	0.2469	0	0	1
	basic_voc/prof	921	0.3051	0.4607	0	0	1
	secondary	921	0.4680	0.4992	0	0	1
financial knowledge (base: high)	low	921	0.3952	0.4892	0	0	1
	average	921	0.3388	0.4735	0	0	1

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continued Table 9

Variables		Obs	Mean	Std.dev.	Median	Min	Max
income (base: >3800)	<1300	921	0.0521	0.2224	0	0	1
	1301–1800	921	0.0988	0.2986	0	0	1
	1801–2400	921	0.2106	0.4080	0	0	1
	2401–3800	921	0.2638	0.4410	0	0	1
	refuse/don't know	921	0.2367	0.4253	0	0	1
economic activity (base: self-employed)	employed	921	0.6699	0.4705	1	0	1
	student	921	0.0369	0.1887	0	0	1
	stay at home	921	0.0098	0.0984	0	0	1
	unemployed	921	0.0033	0.0570	0	0	1
	retired	921	0.2714	0.4449	0	0	1
type of region (base: large cities)	rural	921	0.2519	0.4343	0	0	1
	suburban village	921	0.1140	0.3180	0	0	1
	small towns	921	0.1292	0.3356	0	0	1
	medium cities	921	0.2139	0.4103	0	0	1
voivodships (base: mazowieckie)	dolnośląskie	921	0.0413	0.1990	0	0	1
	kuj.-pomorskie	921	0.0619	0.2411	0	0	1
	lubelskie	921	0.0554	0.2288	0	0	1
	lubuskie	921	0.0358	0.1860	0	0	1
	łódzkie	921	0.0565	0.2309	0	0	1
	małopolskie	921	0.0836	0.2769	0	0	1
	opolskie	921	0.0261	0.1594	0	0	1
	podkarpackie	921	0.0521	0.2224	0	0	1
	podlaskie	921	0.0369	0.1887	0	0	1
	pomorskie	921	0.0554	0.2288	0	0	1
	śląskie	921	0.1346	0.3415	0	0	1
	świętokrzyskie	921	0.0380	0.1913	0	0	1
	warm.-mazur.	921	0.0315	0.1747	0	0	1
	wielkopolskie	921	0.0955	0.2941	0	0	1
	zachodniopom.	921	0.0434	0.2039	0	0	1

Source: Authors' calculation.

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Table 10
Comparison of models

	Model 1	Model 2	Model 3
No of obs	984	929	921
Selected	838	783	775
Non-selected	146	146	146
Lambda	0.0883	0.1111**	0.0838
Rho	0.3448	0.4409	0.3380
Sigma	0.2560	0.2521	0.2478

Note: The models differ in the set of variables at the second stage concerning the use of the model: Model 1 does not contain variables determining the time to reach the nearest ATM and variables expressing the perception of cash; Model 2 does not contain variables expressing the perception of cash; Model 3, described in the main part of the article, contains all, previously highlighted variables.

Source: Authors' calculation.

Table 11
Adoption models for Datasets 1, 2, and 3. Dependent variable: *card ownership*

		Model 1	Model 2	Model 3
female		0.2256	0.2182	0.2060
age (base: 15–24)	25–39	0.1372	0.0780	0.1644
	40–54	0.1841	0.1914	0.2722
	55–64	–1.2454***	–1.2956***	–1.2101***
	65+	–1.6036***	–1.5991***	–1.5185***
education (base: high)	primary	–2.8141***	–2.8540***	–2.8234***
	basic voc/prof	–1.5626***	–1.5453***	–1.5427***
	secondary	–0.7564	–0.7091	–0.6775
financial knowledge (base: high)	low	–0.7756***	–0.8254***	–0.8338***
	average	–0.4815	–0.5211*	–0.5165*
income (base: >3800)	<1300	–0.6837	–0.6545	–0.6387
	1301–1800	–0.2160	–0.2695	–0.2859
	1801–2400	–0.2084	–0.2292	–0.2201
	2401–3800	–0.0809	–0.0991	–0.0857
	refuse	–0.5923	–0.6269	–0.6320

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continued Table 11

		Model 1	Model 2	Model 3
economic activity (base: self-employed)	employed	1.1648	1.0878	1.0612
	student	1.0493	0.7908	0.6833
	stay at home	0.1392	0.0453	0.0320
	unemployed	5.7323	5.6588	5.6104
	retired	1.2524	1.1998	1.1823
type of region (base: large cities)	rural	–0.1668	–0.1716	–0.2107
	suburban village	0.4701*	0.4216	0.4161
	small towns	0.2788	0.2551	0.2414
	medium cities	0.4446*	0.4477*	0.4374*
voivodships (base: mazowieckie)	dolnośląskie	5.6866	5.7207	5.7346
	kuj.-pomorskie	–1.0152***	–0.9826***	–0.9767***
	lubelskie	0.6812	0.6160	0.6314
	lubuskie	6.4363	6.5186	6.4705
	łódzkie	0.4067	0.4007	0.2713
	małopolskie	–0.7636**	–0.7352**	–0.7307**
	opolskie	–0.8614*	–0.8265	–0.8221
	podkarpackie	–1.0427***	–1.2747***	–1.2708***
	podlaskie	–1.2715***	–1.2090***	–1.1859***
	pomorskie	–0.6812*	–0.6628*	–0.7061*
	śląskie	–0.5628*	–0.5695*	–0.5761*
	świętokrzyskie	–1.7024***	–1.6731***	–1.6565***
	warm.-mazur.	–1.0013**	–1.0436**	–1.0425**
	wielkopolskie	1.1914**	1.2018**	1.2051**
	zachodniopom.	0.9853*	0.7862	0.7859
constant		3.0809***	3.2109***	3.1669***

Source: Authors' calculation.

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Table 12
Use models for Datasets 1, 2, and 3. Dependent variable: *share of cash payment*

		Model 1	Model 2	Model 3
TRX value		–0.0009***	–0.0009***	–0.0008***
TRX place type (base: P2P)	trade	–0.2546**	–0.2291*	–0.2198**
	service	–0.1451	–0.1405	–0.1399
POS terminal		–0.5783***	–0.5799***	–0.5692***
contactless card adoption		–0.1414***	–0.1438***	–0.1434***
minutes to closest ATM			0.0031**	0.0030**
COVID change behavior (base no: change)	toward cashless	–0.0495**	–0.0486**	–0.0408*
	toward cash	0.1378***	0.1440***	0.1423***
problem with cash payments (base: no)	often	–0.1510**	–0.1582**	–0.1767***
	rarely	–0.0952***	–0.0848**	–0.0815**
perceptions of cash	cash faster			0.2355**
	cash easy			0.0838
	cash safe			0.1723*
	cash cheap			0.1516
	cash widespread			–0.1255
female		0.0200	0.2189	0.0181
age (base: 15–24)	25–39	0.0413	0.0362	0.0387
	40–54	0.0999**	0.1008***	0.0912**
	55–64	0.1087**	0.0713	0.0644
	65+	0.1993***	0.1587***	0.1501***
education (base: high)	primary	0.1175*	0.1485*	0.1465*
	basic_voc/prof	0.0570*	0.0690**	0.0584*
	secondary	0.0363	0.0347	0.0379
financial knowledge (base: high)	low	0.0443*	0.0313	0.0119
	average	0.0073	–0.0008	-0.0069
income (base: >3800)	<1300	0.1996***	0.1834***	0.1762***
	1301–1800	0.0919**	0.0729*	0.0554
	1801–2400	0.0641*	0.0574*	0.0553
	2401–3800	0.0121	–0.0034	–0.0075
	refuse/don't know	0.0561*	0.0410	0.0405

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continued Table 12

		Model 1	Model 2	Model 3
economic activity (base: self-employed)	employed	0.0866	0.0844	0.0830
	student	0.0900	0.0732	0.0615
	stay at home	0.2839*	0.2895*	0.3143**
	unemployed	–0.0413	–0.0402	–0.0277
	retired	0.1029	0.0985	0.1028
type of residence (base: large cities)	rural	0.0158	–0.0167	–0.0198
	suburban village	–0.0364	–0.0538	–0.0418
	small_towns	–0.0091	–0.0235	–0.0194
	medium cities	0.0372	0.0208	0.0263
voivodships (base: mazowieckie)	dolnośląskie	0.0667	0.0633	0.0894*
	kuj.-pomorskie	–0.0395	–0.0535	–0.0393
	lubelskie	–0.0190	–0.0086	0.0093
	lubuskie	0.2723***	0.2484***	0.2332***
	łódzkie	0.0148	–0.0015	0.0101
	małopolskie	–0.0746*	–0.0853**	–0.0713*
	opolskie	–0.0898	–0.0957	–0.1049
	podkarpackie	–0.0736	–0.1564***	–0.1217**
	podlaskie	–0.0219	–0.0273	–0.0004
	pomorskie	–0.1000**	–0.1207**	–0.1059**
	śląskie	0.0996***	0.0815**	0.0979***
	świętokrzyskie	–0.0101	–0.0231	0.0143
	warm.-mazur.	0.2242***	0.2226***	0.2415***
	wielkopolskie	0.0490	0.0394	0.0394
	zachodniopom.	0.2101***	0.1987***	0.2028***
constant		1.0020***	0.9953***	0.9913***

Source: Authors' calculation.

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Determinants of Liquidity Risk in the Countries of the European Economic Area

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ABSTRACT

The paper documents cross-country variation in the relationship between the deposit insurance scheme and liquidity risk in banks and explores the banking sector specific and macroeconomic determinants that can explain the variation. There is a lack of articles exploring the phenomenon in Europe, authors studying the issue focus on the United States and other parts of the world, so it is difficult to apply their results to Europe. The results of their research are also ambiguous. Using data from 28 countries of the European Economic Area by means of panel regression calculated with the use of GLS estimator with random effects, I established that an increase in deposit insurance coverage reduces the risk of liquidity. The study provides new information to help evaluate deposit insurance schemes across EEA countries.

JEL classification: G01, G21, G22, G28

Keywords: Financial Institution, Liquidity Risk, Deposit Insurance.

1. INTRODUCTION

Liquidity risk is the risk of a situation in which a bank is unable to finance daily financial operations (Shelagh, 2007), (Acharya 2006, 2012). It may be caused by inadequate risk management by a financial institution or by systemic reasons – the occurrence of a market collapse (e.g., the Great Depression 1929–1933, the Financial Crisis 2007–2009), oil crises (e.g., the one from 1973) and stock exchange (e.g., in the USA in 1987). There have been various methods of estimating liquidity risk used for many years. The most popular is the Loan to Deposit Ratio LTD, the ratio of illiquid assets (loans) to deposits. The higher the LTD ratio is, the less liquid the bank is (Klepková Vodová et al., 2016), (Tucker, 2009).

To counteract the collapse of the economy around the world, various security systems were introduced, including deposit insurance. The protection was established in 1934 in the USA and was a response to the Great Depression. Calomiris and Jaremski (2016) described the process of its creation, pointing to the fact that the implementation of the solution took over 50 years.

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In theory, deposit insurance was intended to prevent a run on the banks, i.e., a situation when many depositors withdraw their deposits during a crisis, which may result in a temporary liquidity shortage. This, in turn, can lead to the insolvency of a bank, and may even cause a failure of the entire banking system. What is more, implementing deposit insurance was supposed to increase the bank competition and reduce concentration. The intention was for depositors to distribute their money among various banks.

Many researchers point out, however, that introducing deposit insurance did not reduce the risk of a bank failure. Implementation of the protection increased the moral hazard since bank management and shareholders felt encouraged to take larger risks in order to increase profits. Depositors, on the other hand, lost their motivation to monitor the risk inherent in management's behavior. They also do not penalize banks by withdrawing deposits when the risk increases. This, in turn, reduces the market discipline. Deposit insurance may also increase prices of the banking services. Banks may partially impose the financing costs of the insurance mechanism on depositors.

The study of the phenomenon is particularly interesting since the literature on the subject indicates different consequences of the introduction of deposit insurance in different countries, and there is no clear opinion on whether the consequences of introducing the instrument have a negative or a positive impact on the stability of the banking sector. It seems justified to continue research in this regard, in particular by using empirical data.

The paper is structured as follows: Section 2 presents the relevant literature on liquidity risk in banks. Section 3 explains dependent and independent variables used in the model. Section 4 shows the data sample and estimated method applied. Section 5 presents the results of my analysis. Section 6 concludes the survey.

2. LITERATURE REVIEW

Theory suggests that deposit insurance can either increase or decrease the banking system risk. It can make the banking system more stable by reducing liquidity risk – in case of instability depositors do not feel the need to withdraw their funds from banks right away, which helps to prevent bank runs to occur (Calomiris et al., 2020). At the same time, deposit insurance may be a source of moral hazard. It causes depositors to no longer fear for their portfolios, and thus, they lose incentive to monitor banks' financial stability (Barth et al., 2006).

There is an ongoing discussion in the literature on the impact of the introduction of deposit insurance on the stability of the banking sector. There are many supporters and opponents of the solution. Results of the research conducted by many authors are also ambiguous.

Supporters of the solution include such authors as Cook and Spellman (1996), Huizinga and Nicodème (2006), Guizani and Watanabe (2016), Johari et al. (2020), who, like Ashraf et al. (2020) found that stricter capital requirements not only reduce risk in the banking sector under normal economic conditions, but also have a stabilizing effect in the event of a crisis. In the event of a crash, positive impact is even stronger in countries that implement deposit insurance. Karels and McClatchey (1999) and Imai (2006) assessed that the reform had a positive effect on market discipline. In turn, they made the relocation of deposits between banks dependent on the tactics of "banks too big to fail".

Flannery and Sorescu (1966), Jones and Oshinsky (2009), Bartholdy et al. (2003), Qian et al. (2019), Chiang and Tsai (2020) and Bergbrant et al. (2016) have a different opinion in relation to the supporters of the use of deposit insurance. They showed that the long-term impact of the introduction of deposit insurance strongly depends on the legal situation of a given country. In poorly regulated countries, the result is always clear – there is a weakening of the development of the banking, non-banking and stock markets. Kane (1989), Keeley (1990), and Grossman (1992)

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also examined periods of frequent bank failures and linked them to the moral hazard effect and the strength of deposit insurance institutions. Demirgüç-Kunt and Detragiache (2000), DeLong and Saunders (2011), on the other hand, have shown, based on empirical research, that deposit insurance has a negative impact on bank stability. The stronger the effect, the greater the coverage of losses in given countries.

Other authors, i.e., Govern (2006), Demirgüç-Kunt and Huizinga (2004), Anginer, Demirgüç--Kunt and Zhu (2013) Chernykh and Cole (2011), Nys et al. (2015) as well as Ji et al. (2018) drew attention to the unexpected, negative consequences of introducing deposit insurance in that depositors lost their incentive to control banks, making them much more inclined to take risks.

In turn, Calomiris (1990), Grossman (1992), Alston (1994), Hutchison and McDill (1999), Demirgüç-Kunt and Detragiache (2002), as well as Khan and Dewan (2011) showed that the introduction of deposit insurance leads to an increase in the likelihood of a crisis in the banking sector. Shy et al. (2016), in addition to the existence of moral hazard and other important problems, also showed that the top-down limit deposit insurance weakens competition between banks and overall welfare.

Another problem was pointed out by Fecht et al. (2019), they concluded that the heterogeneous nature of deposit insurance coverage causes depositors to relocate funds between banks due to the fear of a possible collapse of financial institutions. In the Eurozone, depositors tended to take funds from indebted countries to more solvent ones, only worsening the risk of collapse.

Demirgüç-Kunt et al. (2015) considered the 2013 deposit coverage arrangements and noted that bonuses have become more widespread and more extensive over the years. After the crisis in 2008, the state‘s protection of non-deposit liabilities and bank assets increased. Most of the guarantees have been lifted. However, deposit insurance remains at a higher level than it was before the economic collapse, which may lead to increased moral hazard.

Based on the literature, the following hypotheses are made:

1. **The size of the LTD ratio depends not only on banking variables, but also on macroeconomic variables.**

2. **The higher the deposit insurance coverage ratio, the higher the liquidity risk.**

To the best of author’s knowledge, no previous study has investigated the relationship between deposit insurance and liquidity risk. Most research on deposit insurance concerns the United States and other large countries in the world, while there is no research focused on Europe.

3. DETERMINANTS OF LIQUIDITY RISK

The following section describes the explanatory variables used to analyze liquidity risk in banks. They include banking-sector-specific and macroeconomic variables. Table 1 lists the variables used in the study.

Loan to Deposit Ratio is the most popular method of estimating liquidity risk. It shows the relation between the financial resources provided to the private sector by domestic money bank total deposits. Domestic money banks comprise commercial banks and other financial institutions that accept transferable deposits, such as demand deposits. Total deposits include demand, time and saving deposits in deposit money banks. LTD is expressed as a percentage and it should be less than 100%. Typically, the ideal LTD is 80% to 90%. LTD larger than 100% means that a bank may not have enough liquidity to cover any unforeseen fund requirements.

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The European Systemic Risk Board (2018) points out that while LCR and NSFR address some of the externalities of liquidity, as presently designed, they are not sufficient to do so comprehensively. They point out that LTD provides some signaling power regarding the build-up of the systemic liquidity risk.

Many authors prove that macroprudential policy should be built around the LTD ratio (Satria et al., 2015; van den End, 2016). Jorda et al. (2021) stated that the LTD ratio is very useful in signaling financial fragility. Other researchers, like Cecchetti et al. (2011) established that the economies which performed better during crises featured lower LTD ratios.

Anginer et al. (2013) examined the impact of deposit insurance on bank risk and system fragility in the years to and during the 2007–2009 financial crisis but they did not focus on liquidity risk and did not use the LTD ratio as a measure. Overall, they found that deposit insurance increases bank risk in pre-crisis years and decreases bank risk in crisis years, with an average negative effect for the entire sample period.

Table 1
Definitions and sources of variables

Variable	Source	Description
Dependent variable		
LTD	Anginer et al. (2013) Boda et al. (2021) Cecchetti et al. (2011) Dia et al. (2019) Satria et al. (2015) van den End (2016)	Bank credit to bank deposits
Independent variables		
Banking sector specific:		
Activity Restrictions	Ashraf (2020) Barth et al. (2008) Beck et al. (2013) Claessens et al. (2004) Demirguc-Kunt et al. (2010) Laeven et al. (2009)	Range of non-interest income activities banks can participate in, dummy variable that takes the value of 1 when there are any restrictions
Credit/GDP	Anginer et al. (2013) Bergbrant et al. (2016) Boda et al. (2021) Cecchetti et al. (2011) Demirguc-Kunt (1998)	Domestic credit by deposit money to private sector (% of GDP)
Deposit Insurance Coverage	Allen et al. (2015) Anginer et al. (2014, 2019) Ashraf et al. (2020) Ashraf et al. (2020) Barth et al. (2008) DeLong et al. (2011) Demirguc-Kunt (2002, 2004, 2005) Houston (2010) Lambert et al., (2017)	Deposit insurance coverage relative to GDP

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continued Table 1

Variable	Source	Description
Deposits/GDP	Boda et al. (2021) Cecchetti et al. (2011)	Ratio of total deposits to GDP
Ex-ante or ex-post	DeLong et al. (2011)	Defining the approach to the method of financing deposit insurance
Lerner Index	Anginer et al. (2014) Jimenez et al. (2006) Qian et al. (2019)	Measure of market power in the banking market. An increase in the Lerner index indicates a deterioration of the competitive conduct of financial intermediaries
Multiple Supervisors dummy	Demirguc-Kunt et al. (2005, 2015)	Dummy equal one when there are multiple bank supervisors
ROA	Anginer et al. (2013, 2019) Kim et al. (2017)	Return on total assets
Z-Score	Anginer et al. (2013) Beck et al. (2013) Boyd et al. (1993) Boyson et al. (2014) Laeven at. al. (2009)	Probability of default of a country's banking system calculated as a natural logarithm of the sum of ROA and equity ratio (ratio of book equity to total assets), averaged over the past five years, divided by the standard deviation of ROA over the past five years
Macroeconomic:		
Crisis dummy	Anginer et al. (2013, 2019) Ashraf (2020) Cornett et al. (2011) Jorda et al. (2021)	Indicator variable that assumes a value of 1 when crisis occurred
Inflation	Ashraf (2020) Cecchetti et al. (2011) Demirguc-Kunt et al. (1998, 2004) Houston (2010)	Consumer price index (2010 = 100)
GDP Growth	Bergbrant et al. (2016) Cecchetti et al. (2011) Demirguc-Kunt (1998, 2004)	Logarithm difference of successive GDP values
GDP per Capita	Anginer et al. (2013) Ashraf et al. (2020) Demirguc-Kunt et al. (1998, 2004) Houston (2010) Jorda et al. (2021)	Natural logarithm of GDP divided by its total population

Source: Author's development.

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3.1. Banking sector specific variables

Risk measures (i.e., Z-Score, Activity Restrictions), operating efficiency measures (ROA), and measures related to deposit insurance scheme (i.e., Deposit Insurance Coverage, Ex-ante or ex-post, Multiple Supervisors dummy) have been chosen ss the banking sector specific determinants of liquidity risk.

Activity Restrictions is a dummy variable which explains the conditions under which banks can engage in nonfinancial business except those businesses that are auxiliary to the banking business (e.g., IT company, debt collection company etc.). This variable comes from the Bank Regulation and Supervision Database and it takes the value of zero if nonfinancial activities can be conducted directly in banks. Otherwise, when there are any restrictions, it takes the value of 1.

Beck et al. (2013) documented large cross-country variation in the relationship between bank competition and bank stability. They used the Activity Restrictions variable as an index measuring the degree to which banks are prohibited from engaging in fee-based activities related to securities, insurance and real estate and thus diversify away from more traditional interest spread-based activities. In their case, lower values of the index indicate that fewer restrictions are placed on this type of diversification by banks. They proved that activity restrictions are negatively and significantly correlated with systemic stability. Countries with riskier banking systems also experience higher activity restrictions. Their findings also show that activity restrictions are positively and significantly correlated with the competition-stability relationship in the banking system.

Demirguc-Kunt et al. (2010) showed the implications of bank activity and short-term funding strategies for bank risk and return. They provided a very interesting insight into activity restrictions. Their paper proved that activity restrictions, among other things, are associated with bank circumventing such regulations by increasing nondeposit funding. The practice allows them to increase their risk-taking.

Ashraf (2020) showed that bank risk is lower in countries with higher restrictions on bank activities, which is consistent with research by Claessens et al. (2004) proving that lower activity restrictions make banks risky by promoting banking industry competition. Contrary to the fact, Barth et al. (2008) established that regulatory restrictions on banking activities increase the probability of banking crisis.

To the best of author's knowledge, there is no research which examined the impact of activity restrictions on LTD. Conclusions from literature are ambiguous, but based on Ashraf (2020), it is assumed that countries which have Activity Restrictions have lower LTD.

Following Anginer et al. (2013), **Credit/GDP** was used to control differences in financial development and structure. Their research has proven that countries with lower private credits have banks with lower stock return volatility. What is more, stock return volatility is significantly higher in crisis years. They found that bank risk is negatively correlated with credits offered by financial institutions.

Bergbrant et al. (2016) examined how the introduction of deposit insurance affected equity market and the banking sector. They used Credit/GDP as one of their main variables. They found out that the introduction of deposit insurance declined the banking sector activity by approximately 20% of GDP, but only if the country has a mean law and order score of zero. With law and order score equal to or greater than 4 the effect of deposit insurance on the baking sector activity is neutralized. For the countries with the highest law and order score of 6 (Denmark, Iceland, and Sweden) introducing deposit insurance had a large positive effect on the banking sector activity.

Boda et al. (2021) proved that banking LTD ratios are negatively and strongly correlated with relative levels of bank credit. Cecchetti et al. (2011) established that Credit/GDP is negatively correlated with the cumulative GDP gap which is a measurement of country's relative

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macroeconomic performance over the crisis period. On the other hand, Demirguc-Kunt's (1998) research showed that Credit/GDP ratio had no significant impact on banking crisis risk.

Based on the literature, i.e., Cecchetti et al. (2011), it is expected that the higher the Credit/GDP is, the higher the LTD ratio is.

Data on the variable comes from the Global Financial Development Report and is expressed in USD. In my sample, only a minority of countries have activity restrictions. The countries are Austria, Belgium, France, Germany, Netherlands, Poland, Romania and Sweden.

Deposit Insurance Coverage is a variable used by Demirguc-Kunt in a comprehensive database created in 2005. It was counted by the author of the paper as a ratio between deposit coverage limit and GDP per Capita. Data on deposit coverage limit comes from the International Association of Deposit Insurers database and from the database created by Demirguc-Kunt in 2015. The data on GDP per Capita comes from the Global Financial Development Report.

Houston (2010) found that Deposit Insurance Coverage is negatively and statistically significantly correlated with bank risk.

Anginer et al. (2019) stated that the Global Financial Crisis led to unprecedented government interventions to rescue distressed banks. Deposit insurance systems around the world have become more generous, expanding in both scope and coverage. The expansions may have reinforced investor expectations of government support for financial institutions, thus reducing the long-term incentives of depositors to monitor and discipline banks.

Many researchers proved that because of moral hazard, the explicit deposit insurance scheme increases the probability of banking crisis and decreases banking stability (Anginer et al., 2014; Ashraf et al., 2020; DeLong et al., 2011; Demirguc-Kunt et al., 2002, 2004; Houston, 2010 and Lambert et al., 2017). However, capital regulation can be used to counter that effect (Allen et al., 2015; Ashraf et al., 2020).

Values of the variable vary greatly from country to country, with the lowest value being equal to 0.20 and the largest being equal to 19.35. The variable is expressed in USD.

Based on the other authors' research, the assumption is that the higher Deposit Insurance Coverage is, the higher the LTD ratio is.

Deposits/GDP was used by Boda et al. (2021) as a relation between bank deposits to GDP. It is the total value of demand, time and saving deposits at domestic deposit money banks as a share of GDP. Deposit money banks comprise commercial banks and other financial institutions that accept transferable deposits, such as demand deposits. Cecchetti et al. (2011) proved that Deposits/GDP have positive but statistically insignificant impact on a country's performance during crisis.

Data on the variable comes from the Global Financial Development Report and is expressed in USD.

Based on the literature, it is expected that Deposit/GDP has a negative impact on the LTD ratio.

Ex-ante or **Ex-post** are deposit insurance scheme characteristics. The distinction was used by Demirguc-Kunt (2015) and DeLong et al. (2011).

The Ex-ante system resembles the classic insurance in which the insurer collects a specific contribution and then creates a fund from it to be used for possible damage coverage. In the event of a bank failure, the institution makes payments with the use of a permanent accumulative fund, and the system members are obliged to pay regular contributions so that the fund level does not fall below the required minimum. As a result, a greater stabilization of the sector is achieved when banks pay fees to the fund they use in case of problems in the sector. After the collapse of a given institution, they do not have to incur additional costs. Thus, Ex-ante financing enables anti-cyclical premium collection and the use of the fund in times of recession, when collecting increased contributions would be difficult. In an Ex-post system, the guarantee institution obliges the system members to the payment of funds for guarantee payments in the event of a bank failure, therefore banks are not charged earlier than necessary, but on the other hand at the moment crisis

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must take into account additional costs of contributions. Data on ex-ante and ex-post approaches comes from the European Banking Authority and Bank Regulation and Supervision Survey. What is worth noting is that some countries changed their approach during the period of 2005–2017. For example, Ireland used both Ex-ante and Ex-post up to 2015, and then changed it to only Ex-ante. Italy used Ex-post up to 2014 and changed it to Ex-ante in 2016. The Netherlands used to use both to 2016, and then decided to only use Ex-ante. Slovenia gave up Ex-post in favor of Ex-ante in 2016. As of 2017, there were no countries which only used the Ex-post approach. Almost all the countries in my sample use the Ex-ante approach with only few exceptions: Austria, Malta and Poland use both Ex-ante and Ex-post approaches.

To the best of author's knowledge, there is no research which examines the impact of using either the Ex-ante or Ex-post approach on the LTD ratio. However, based on the theoretical assumptions, it is an expected result that LTD is lower in countries which use the Ex-ante approach.

Lerner Index is a measure of market power in the banking market. It compares output pricing and marginal costs (that is, markup). An increase in the Lerner index indicates a deterioration of the competitive conduct of financial intermediaries.

The Lerner index is a proxy for profits that accrue to a bank as a result of its pricing power in the market. It is a competition measure and was used by Anginer et al. (2014) and Jimenez et al. (2006) to determine how it affects systemic bank risk. They proved that the relationship between the Lerner index and the bank systemic risk remains positive and statistically significant.

Qian et al. (2019), on the other hand, proved that a one-standard deviation increase in the Lerner index leads to a decrease in the probability of a banking crisis ranging approximately from 3.9% to 4.6% which is economically important. They found that an increase in bank competition makes an explicit deposit insurance scheme ineffective and therefore it leads to banks taking more risk. However, their results confirm that improved regulatory ability could decrease that effect.

To the best of author's knowledge, no author has examined the impact of the Lerner Index on the LTD ratio. Based on the work by Anginer et al. (2014) and Jimenez et al. (2006) it is assumed that the higher the Lerner Index is, the higher the LTD is.

Data on the variable comes from the Global Financial Development Report.

Multiple Supervisors dummy is a variable which indicates whether there is more than one deposit insurance supervision institution in a given country. This variable takes the value of zero when there is only one supervision institution, otherwise it takes the value of one. Data on this value comes from Demirguc-Kunt's databases created in 2005 and 2015 and directly from the institutions' websites.

To the best of author's knowledge, there is no research which examines the impact of presence of multiple supervisors on LTD, nor there is for any type of banking risk.

ROA is bank return on assets. It is measured as a commercial banks' after-tax net income to yearly averaged total assets.

It was used by Kim et al. (2017) and Anginer et al. (2013, 2019). Their findings prove that ROA has negative and statistically significant effect on bank risk.

Based on the literature, it is expected that the higher ROA is, the lower LTD is.

Data on the variable comes from the Global Financial Development Report and is expressed in USD.

Z-Score is a measure of systemic risk. It captures the probability of default of a country's commercial banking system. Z-score compares the buffer of a country's commercial banking system (capitalization and returns) with the volatility of the returns. The variable shows the number of standard deviations by which returns would have to fall from the mean to wipe out all equity in the bank (Boyd et al., 1993). A higher Z-score implies a lower probability of insolvency, providing a more direct measure of soundness than, for example, simple leverage measures

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(Beck et al., 2013). Because the Z-score is highly skewed, it was decided to use the natural logarithm of Z-score to smoothen out higher values.

Beck et al. (2013) proved that there is a strong dependence between bank soundness (measured using Z-Score) and bank competition. Their paper shows that increased competition results in a much lower Z-Score which means that more competition is harmful for bank stability.

Laeven et. al. (2009) conducted an empirical assessment of theories concerning risk taking by banks, their ownership structures, and national bank regulations. They also used Z-Score as a measure of bank risk taking. They found out that more stable banks have lower cash flow rights and are located in countries with fewer activity restrictions.

Other researchers, like Houston et al. (2010), explored interactions between the level of creditor rights, information sharing and risk taking among banks. They also used Z-Score as a primary measure of bank risk taking and proved that stronger creditor rights are correlated with higher bank risk taking.

Anginer et al. (2013) examined the relationship between deposit insurance and bank risk. They used Z-Score to measure the standalone risk of an individual bank. Their findings prove that deposit insurance has a positive and statistically significant effect on Z-Score during crisis. In pre-crisis years, however, it has a negative and statistically significant effect on Z-Score. Still, the average effect of deposit insurance during the entire examined period is negative. It means that generous financial safety nets increase bank risk and reduce systemic stability in non-crisis years. On the other hand, during financial crisis the effect is opposite – bank risk is lower. Despite the fact, the overall impact of deposit insurance remains negative since the destabilizing effect during normal times is greater in magnitude, as compared to the stabilizing effect during global turbulence.

Based on the literature, it is expected that Z-Score has negative impact on the LTD ratio.

Data on the variable comes from the Global Financial Development Report.

3.2. Macroeconomic variables

In addition to the banking specific variables described above, the analysis also includes macroeconomic determinants, which are expected to have an impact in liquidity risk. I have decided to focus on four macroeconomic variables – Crisis dummy, Inflation, GDP per Capita, and also the natural logarithm of GDP per Capita.

Crisis dummy is a variable for the presence of banking crisis. It takes the value of one when a crisis occurred in a given year, and zero otherwise. A banking crisis is defined as systemic if two conditions are met: firstly, significant signs of financial distress in the banking system (as indicated by significant bank runs, losses in the banking system, and/or bank liquidations); secondly, significant banking policy intervention measures in response to significant losses in the banking system. The first year that both criteria are met is considered as the year when the crisis starts becoming systemic.

This variable comes from Anginer et al. (2013) and it is defined it to be equal to 1 for years 2007–2009 and 0 for the remaining years. They found that during financial crisis, the banking system is more stable and the bank risk is lower in countries with generous deposit insurance coverage. However, the countries which use the safety net creates moral hazard effect and this effect in fact dominates in stable times.

The variable was used by Cornett et al. (2011) examined how banks' efforts to manage the liquidity risk led to a decline in credit supply. They used the crisis indicator to define the quarters affected by crisis. Their results suggest that the mean and median changes in loans and total credit are both lower in the crisis quarters relative to noncrisis ones. This effect was stronger for larger banks. Overall, they determined that during the crisis, liquidity risk exposure led to greater increases in liquid assets, mirrored by greater decreases in credit origination. They also suggest

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that banks that were more reliant on core deposit financing faced fewer liquidity problems during the crisis than banks that relied more heavily on wholesale sources of debt financing.

Jorda et al. (2021) proved that the LTD ratio is positively related to financial crisis, and Ashraf (2020) showed that the crisis dummy variable has positive and significant impact on bank risk which means that probability of a bank default rises during the financial crisis.

Based on the literature, it is assumed that occurrence of banking crisis has a positive impact on the LTD ratio.

Data on the variable comes from the Global Financial Development Report.

The Consumer Price Index is understood by **Inflation**. The CPI is used to index the real value of wages, salaries and pensions. It can also represent the buying habits of urban consumers. Consistent with the objective of the CPI as a measure of price inflation for the household sector as a whole, the price index covers all services acquired by households in relation to the acquisition, holding and disposal of financial and real assets. The index measures the price change for some of the most significant financial services acquired by households – deposit and loan facilities provided by financial institutions. The CPI is calculated as an average yearly change in the price of goods and services between two periods – in the research the year 2010 is taken as a 100.

Cecchetti et al. (2011) showed that inflation rate did have a negative but statistically insignificant impact on country's performance during crisis. Demirguc-Kunt et al. (2004) discussed how deposit insurance affects market discipline. Among other macroeconomic variables they used inflation and proved that it has a negative and statistically significant impact on liquidity. Demirguc-Kunt (1998) proved that inflation is positively associated with risk of banking crisis. Similarly, Ashraf (2020) established that inflation is positively correlated with bank risk.

On the other hand, Houston (2010) found that inflation is negatively and statistically significantly correlated with bank risk.

Conclusions from the literature are ambiguous, but based on Demirguc-Kunt's (1998) and Ashraf's (2020) research, it is expected that Inflation has a positive impact on the LTD ratio.

Data on the Consumer Price Index comes from the Global Financial Development Report.

Following the research by Anginer et al. (2013), **GDP Growth** was used as a measure of the size of the economy and how an economy is performing. It is an often-used indicator of the general health of the economy.

Most researchers, like Cecchetti et al. (2011), Bergbrant et al. (2016) and Demirguc-Kunt (1998, 2004) agree that GDP growth is negatively correlated with banking crisis and that banking sector development is positively related to the size of the country's GDP. Their research proved that GDP growth is positively correlated with liquidity. They also found that GDP growth is negatively associated with a higher probability of banking crisis.

Contrary to this, Ashraf (2020) proved that GDP growth is positively correlated with bank risk which suggests that bank risk is higher in growing economies.

Conclusions from the literature are, once again, ambiguous, but based on Cecchetti's et al. (2011), Bergbrant's et al. (2016) and Demirguc-Kunt's (1998, 2004) research, it is expected is that the higher GDP growth is, the lower the LTD ratio is.

GDP growth is calculated as a logarithm difference of successive values. Data on the variable comes from the Global Financial Development Report and is expressed in USD.

The final variable is **GDP per Capita**. It is a financial metric that breaks down a country's economic output per person and is calculated by dividing the GDP of a nation by its population. It is used to analyze a country's prosperity based on its economic growth. Small, rich countries and more developed industrial countries tend to have the highest per capita GDP. The International Monetary Fund shows that there are Ireland, Norway and Denmark among the top 10 nations with the highest GDP per capita. They are use in the research. Because GDP per Capita is highly skewed, it was decided to use the natural logarithm of GDP per Capita to smoothen ut higher values.

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Anginer et al. (2013) found that countries with higher GDP per capita have banks with lower stock return volatility, while Jorda et al. (2021) proved that GDP is slightly lower for high LTD ratios but the difference between the coefficients are not statistically significant. Demirguc--Kunt (1998, 2004) established that GDP per Capita is positively correlated with liquidity and is negatively associated with a higher probability of banking crisis.

Ashraf (2020) proved that GDP per Capita is negatively correlated with bank risk. It indicates that bank risk is lower in high-income countries. Likewise, Houston (2010) found that GDP per Capita is negatively and statistically significantly correlated with bank risk.

Based on the literature, it is expected that GDP per Capita has a negative impact on the LTD ratio.

Data on the variable comes from the Global Financial Development Report and is expressed in USD.

3.3. Data characteristics

Table 2 demonstrates summary statistics for the variables used in the analysis and Table 3 reports the degree of correlation amongst dependent and independent variables. Table 4 presents countries grouped according to different factors. Table 5 shows sources of data and expected impact of the variables on the LTD ratio.

Table 2
Summary statistics

Variable	Mean	Median	S.D.	Min	Max
LTD	127.4	119.4	57.79	17.79	367.1
Credit/GDP	89.38	83.81	43.91	16.70	260.7
Deposit Insurance Coverage	3.787	2.642	3.660	0.2030	19.35
Deposits/GDP	80.92	64.09	65.93	21.88	472.0
GDP Growth	0.02787	0.04041	0.1051	-0.3254	0.3895
GDP per Capita	10.23	10.26	0.6829	8.624	11.63
Inflation	101.0	102.9	8.203	72.14	115.5
Lerner Index	0.2351	0.2521	0.09869	-0.06694	0.4672
ROA	0.4552	0.6504	1.376	-10.47	4.241
Z-Score	2.258	2.249	0.7771	-4.092	3.862
Activity Restrictions	0.2865	0.000	0.4528	0.000	1.000
Crisis dummy	0.1841	0.000	0.3881	0.000	1.000
Ex-ante	0.7335	1.000	0.4427	0.000	1.000
Ex-post	0.06044	0.000	0.2386	0.000	1.000
Ex-ante & Ex-post	0.2060	0.000	0.405	0.000	1.000
EURO	0.6786	1.000	0.4947	0.000	1.000
CEE	0.3571	0.000	0.4798	0.000	1.000
Multiple Supervisors dummy	0.1429	0.000	0.3504	0.000	1.000

Source: Author's calculation.

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Table 3
Correlation matrix

	LTD	Activity Restrictions	Credit/GDP	Deposit Insurance Coverage	Deposits/GDP	Ex-ante	Ex-post	Ex-ante & Ex-post	GDP Growth	GDP per Capita	Crisis dummy	Inflation	Lerner Index	Multiple Supervisors dummy	ROA	Z-Score
LTD	1															
Activity Restrictions	-0.1010	1														
Credit/GDP	0.5626	-0.1464	1													
Deposit Insurance Coverage	-0.1332	-0.0877	-0.2676	1												
Deposits/ GDP	-0.3876	-0.1159	0.2909	-0.2208	1											
Ex-ante	0.1178	-0.1440	0.0719	0.0597	0.0613	1										
Ex-post	0.0112	-0.1588	-0.0721	-0.0345	-0.0822	-0.4231	1									
Ex-ante & Ex-post	-0.1357	0.2517	-0.0358	-0.0449	-0.0180	-0.8435	-0.1298	1								
GDP Growth	-0.0194	0.0091	-0.1877	-0.1474	-0.0416	-0.0117	-0.0532	0.0440	1							
GDP per Capita	0.1732	0.1264	0.4894	-0.5288	0.4831	-0.0066	0.0210	-0.0052	-0.0574	1						
Crisis dummy	0.0949	-0.0106	0.3213	-0.1225	0.1898	-0.0183	0.0866	-0.0313	-0.2065	0.1275	1					
Inflation	-0.0782	0.0400	0.0968	0.5117	0.0943	-0.0066	-0.0389	0.0303	-0.3875	0.1413	-0.0034	1				
Lerner Index	0.1366	-0.2507	0.0351	0.2043	-0.1262	0.0984	-0.2796	0.0774	0.0173	-0.1940	-0.2105	-0.0010	1			
Multiple Supervisors dummy	0.0206	0.1921	0.1239	-0.1470	-0.0163	-0.1693	0.2622	0.0299	-0.0620	0.2050	0.0923.	0.0558	-0.2543	1		
ROA	-0.1065	0.0373	-0.3028	-0.0801	-0.0927	0.0457	-0.1483	0.0379	0.3374	-0.0901	-0.3357	-0.2204	0.2886	-0.0502	1	
Z-Score	-0.2064	0.1084	0.1229	-0.2202	0.5698	-0.0281	-0.1110	0.0951	-0.0093	0.4566	-0.0857	-0.1698	-0.0576	0.3465	0.1469	1

Source: Author's calculation.

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Table 4
Countries grouped according to different factors as of 2017

Country	Activity Restrictions	Crisis	Ex-ante	Ex-post	Ex-ante & Ex-post	EURO	CEE	Multiple Supervisors
Austria	X				X	X		X
Belgium	X		X			X		
Bulgaria			X				X	
Croatia			X				X	
Cyprus			X			X[1)]		
Czech Republic			X					
Denmark			X					
Estonia			X			X[2)]		
Finland			X			X		
France	X		X			X		
Germany	X		X			X		X
Greece			X			X		
Hungary			X					
Ireland			X[3)]			X		
Italy			X[4)]			X		X
Latvia			X			X[5)]		
Lithuania			X			X[6)]		
Luxembourg			X			X		
Malta					X	X[7)]		
Netherlands	X		X[8)]			X		
Norway			X					
Poland	X				X		X	
Portugal			X			X		
Romania	X		X					
Slovak Republic			X			X[9)]		
Slovenia			X[10)]			X		
Spain			X			X		X
Sweden	X		X					

[1)] Cyprus adopted the euro as the national currency in 2008.
[2)] Estonia adopted the euro as the national currency in 2011.
[3)] Ireland used both Ex-ante and Ex-post approaches up to 2015.
[4)] Italy used both Ex-ante and Ex-post approaches up to 2014.
[5)] Latvia adopted the euro as the national currency in 2014.
[6)] Lithuania adopted the euro as the national currency in 2015.
[7)] Malta adopted the euro as the national currency in 2008.
[8)] Netherlands used both Ex-ante and Ex-post approaches up to 2016.
[9)] Slovak Republic adopted the euro as the national currency in 2009.
[10)] Slovenia used the Ex-post approach up to 2015.

Source: Author's calculation

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Table 5
Sources of data and expected impact of the variables

Variable	Source	Expected impact on LTD
Banking sector specific:		
Activity Restrictions	Bank Regulation and Supervision Database	–
Credit/GDP	Global Financial Development Report	+
Deposit Insurance Coverage	International Association of Deposit Insurers Demirguc-Kunt's 2015 database Global Financial Development Report	+
Deposits/GDP	Global Financial Development Report	–
Ex-ante or Ex-post	European Banking Authority Bank Regulation and Supervision Survey	LTD should be lower in countries which use the Ex-ante approach
Lerner Index	Global Financial Development Report	+
Multiple Supervisors dummy	Demirguc-Kunt's 2005 and 2015 databases Supervisor institutions' websites	–/+
ROA	Global Financial Development Report	–
Z-Score	Global Financial Development Report	–
Macroeconomic:		
Crisis dummy	Global Financial Development Report	+
Inflation	Global Financial Development Report	+
GDP Growth	Global Financial Development Report	–
GDP per Capita	Global Financial Development Report	–

Source: Author's calculation.

4. METHODOLOGY AND DATA

The survey covers the period 2005–2017. It is a very interesting period due to the numerous events and changes that took place. First and foremost, the Global Financial Crisis of 2007–2009. In addition to this, in 2009 the European Commission announced an amending directive which required the EU members to increase their protection of deposits firstly to the minimum of €50 000, and then to a uniform level of €100 000 by the end of 2010. In 2014, the European Union adopted another directive requiring the EU countries to introduce laws setting up at least one deposit guarantee scheme that all banks must join.

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The research covers 28 countries of the European Economic Area. There is no data on Iceland and Liechtenstein in the Global Financial Development Report, which is the main source used in the survey. It is a particularly interesting sample because even though the European Union countries' deposit insurance schemes seem very similar (since 2010 they all have had a universal guarantee limit) it is in fact a diverse area. The EEA members took a different approach to deposit insurance scheme. Not all of them use the Ex-ante approach. Some of them have more than one supervisor institution. Finally, not all the countries are the EU and Eurozone members. Many variables also vary widely – most notably GDP per Capita and the Deposit Insurance Coverage.

Using the model presented by Beck et al. (2013) and adjusting it to define the importance of individual factors determining liquidity risk, the final model can be presented as follows:

$$Risk_{i,t} = bc + \alpha I_{t\text{-}1} + \Sigma\beta BSV_{i,t\text{-}1} + \gamma C_{i,t} + \varepsilon_i$$

where *i* means country, *t* – year. *Risk* means the liquidity risk ratio (in the survey the LTD ratio is used). *I* defines a vector of variables containing the size of deposit guarantees in a given country in a given year. *BSV* is a vector of variables defining parameters characterizing banks, i.e., Activity Restrictions, Credit/GDP, Deposits/GDP, Ex-ante or Ex-post, Lerner Index, Multiple Supervisors dummy, ROA and Z-Score. *C* is a vector of variables defining a given country, i.e., Crisis dummy, Inflation, and GDP per Capita. ε_i is the estimation error; *bc*, α, β, and γ are vectors of estimated coefficients.

The analysis of liquidity risk in banks in a given country is carried out taking into account the dependent variable – by means of panel regression calculated with the use of the GLS estimator with random effects. In order to eliminate the potential problem of endogeneity, the econometric analysis uses data related to the amount of deposit guarantees and parameters characterizing banks in the previous year. Thanks to it, it can be assumed that the estimated relationship between the amount of deposit guarantees, the characteristics of banks and the characteristics of a given country is not burdened with an error resulting from the failure to consider unobservable factors that affect all the variables (Angrist, Krueger 2001). The selection of explanatory variables for the model was based on the literature on the subject – mainly Demirgüç-Kunt et al. (1998, 2004, 2005), Bart et al. (2008), Beck et al. (2013), Boyson et al. (2014), and Anginer et al. (2014). The research in the study is based on the data of commercial banks from the European Economic Area. Data on information on the economic situation of countries and the amount of deposit coverage in a specific year was obtained from the World Bank, European Systemic Risk Board, International Association of Deposit Insurers and International Monetary Fund. The research period covers the years 2005–2017 and shows the dependence of the obtained results on the economic situation, including the financial crisis 2007–2009.

5. ESTIMATION RESULTS

This chapter presents estimation results. Table 6 reports the results when all countries are simultaneously considered. Table 7 presents results related to bank management i.e., whether a country has activity restrictions and multiple supervisors. Table 8, 9 and 10 show the results for countries split according to the banking sector specific and macroeconomic factors.

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Table 6
Estimation results for the full sample

	Dependent variable LTD
	Full sample
Explanatory variables	1
Banking sector specific:	
Activity Restrictions	-7.40938
Credit/GDP	0.832694***
Deposit Insurance Coverage	-0.733256*
Deposits/GDP	-0.443872***
Ex-ante	17.3053
Ex-post	20.7321
Lerner Index	-32.1815**
Multiple Supervisors dummy	-17.7628
ROA	4.33197***
Z-Score	-3.45838
Macroeconomic:	
Crisis dummy	2.49024
Inflation	-0.200537
GDP Growth	16.5806*
GDP per Capita	12.1421
No. of observations	253

*, ** and *** denote significance at 1%, 5% and 10%, respectively.
Source: Author's calculation.

Table 7
Estimation results related to bank management

	Dependent variable LTD			
	Activity Restrictions	**No Activity Restrictions**	**Multiple Supervisors**	**One Supervisor**
Explanatory variables	2	3	4	5
Banking sector specific:				
Credit/GDP	0.446028	0.782946***	0.528176*	0.760040***
Deposit Insurance Coverage	0.326539	-1.07521***	-2.35048	-0.995193**
Deposits/GDP	-2.03710***	-0.378006***	-2.26909***	-0.381521***
Lerner Index	-24.9579	-29.1532*	28.9865	-33.1344**

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continued Table 7

	Dependent variable LTD			
	Activity Restrictions	**No Activity Restrictions**	**Multiple Supervisors**	**One Supervisor**
ROA	4.93325	3.40848***	-2.26877	3.94944***
Z-Score	-0.00115360	-0.450362	0.732788	-1.90171
Macroeconomic:				
Inflation	1.05290**	-0.157570	1.00639	0.00991986
GDP Growth	-41.6852*	24.2323**	-10.9069	17.2962*
GDP per Capita	0.000990842	10.5239	-0.000233634	8.81769
No. of observations	245	245	249	249

*, ** and *** denote significance at 1%, 5% and 10%, respectively.

Source: Author's calculation.

Table 8
Estimation results related to the euro currency

	Dependent variable LTD	
	EURO	**Not EURO**
Explanatory variables	6	7
Banking sector specific:		
Credit/GDP	-0.500358***	1.25543***
Deposit Insurance Coverage	-0.468811	-0.483000
Deposits/GDP	0.395688***	-0.715754***
Lerner Index	-16.3737	-0.158770
ROA	4.65507**	4.84495***
Z-Score	-0.0298420	-10.4917**
Macroeconomic:		
Inflation	0.103177	-0.273833
GDP Growth	-6.75160	9.11580
GDP per Capita	-0.000285218	8.61110
No. of observations	234	234

*, ** and *** denote significance at 1%, 5% and 10%, respectively.

Source: Author's calculation.

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Table 9
Estimation results related to Central and Eastern Europe countries

	Dependent variable LTD	
	CEE	**Not CEE**
Explanatory variables	8	9
Banking sector specific:		
Credit/GDP	1.79643***	0.657309***
Deposit Insurance Coverage	-0.0963871	0.0777179
Deposits/GDP	-1.97657***	-0.326532***
Lerner Index	-20.6264	-24.6599**
ROA	-0.0682531	4.15905***
Z-Score	1.33935	-2.45514
Macroeconomic:		
Inflation	0.113665	-0.398455*
GDP Growth	11.5562	7.55492
GDP per Capita	-0.00043880	14.3762
No. of observations	243	243

*, ** and *** denote significance at 1%, 5% and 10%, respectively.
Source: Author's calculation.

Table 10
Estimation results related to Ex-ante, Ex-post and both Ex-ante and Ex-post approaches

	Dependent variable LTD		
	Ex-ante	**Ex-post**	**Ex-ante & Ex-post**
Explanatory variables	10	11	12
Banking sector specific:			
Credit/GDP	0.255136*	1.14531	0.744571**
Deposit Insurance Coverage	0.329385	-0.546583	-0.919003
Deposits/GDP	-0.141788	-1.94465	-1.39073**
Lerner Index	-40.7225**	16.5108	-34.9576
ROA	1.63906	0.602643	2.20912
Z-Score	-0.42079	1.52688	0.299232
Macroeconomic:			
Inflation	0.196164	0.615804	0.481603
GDP Growth	-21.2030	-11.3449	2.50694
GDP per Capita	-0.0275207	-3.74549	-2.07754
No. of observations	234	251	248

*, ** and *** denote significance at 1%, 5% and 10%, respectively.
Source: Author's calculation.

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Overall, some significant differences between the estimation results of the different country samples have been observed, both with respect to the significance and the size of the coefficients.

In the **full sample** findings show that **activity restrictions** have a negative, statistically insignificant on the LTD ratio. To the best of author's knowledge, there were no previous researches which would examine the impact of activity restrictions on LTD. The paper findings are somewhat consistent with the conclusions made by Ashraf (2020) and Claessens et al. (2004) taking into account the impact direction, but, contrary to their results, the impact of activity restrictions in the sample is not statistically significant.

Referring to the relation between **Credit and GDP**, it has significant and positive impact on LTD which is consistent with the literature, i.e., Cecchetti et al. (2011) and Bergbrant et al. (2016) who got similar results. The paper findings contradict those by Boda et al. (2021) and also Demirguc-Kunt (1998).

Deposit insurance coverage has a negative and statistically significant impact on LTD, which is particularly interesting, because it contradicts other researchers' papers, i.e., Anginer et al. (2014), Ashraf et al. (2020), DeLong et al. (2011), Demirguc-Kunt et al. (2002, 2004), Houston, (2010) and Lambert et al. (2017). Literature suggests that the difference is due to the focus on a different area. None of the mentioned authors focused on Europe. The results prove that Hypothesis 2 is false.

As for **Deposits/GDP**, it has a significant and negative impact on LTD which is consistent with the findings by Boda et al. (2021) and Cecchetti et al. (2011), the difference is that in the case of the latter, the results were statistically insignificant.

Using either the **Ex-ante** or **Ex-post** approach does not have a significant impact on the LTD ratio in the full sample. Results regarding using both Ex-ante and Ex-post approaches were omitted due to exact collinearity. The paper results are not statistically significant but the impact direction is consistent with the expatiation.

The empirical results show that **Lerner Index** has a negative and statistically significant impact on LTD. The findings contradict theoretical assumptions based on research by other authors, i.e., Anginer et al. (2014) and Jimenez et al. (2006) who proved that the higher Lerner Index is, the higher the systemic bank risk is. However, my results are consistent with Qian et al. (2019).

When it comes to the **Multiple Supervisors dummy**, it has a negative, statistically insignificant impact on LTD. To the best of author's knowledge, there was no previous research which would examine the impact of presence of multiple supervisors on LTD, nor there was for any type of banking risk.

Referring to the **ROA** variable, it has a positive and statistically significant impact on the LTD ratio. It is intriguing because it contradicts other authors' papers, i.e., Kim et al. (2017) and Anginer et al. (2013, 2019).

The findings show that **Z-Score** has a negative and statistically insignificant impact on LTD. It is somewhat consistent with (Beck et al., 2013) and Laeven at. al. (2009) when it comes to the impact direction , but, contrary to their results, the impact of Z-Score in the sample used in the paper is not statistically significant.

As for **Crisis dummy**, it has a positive, but statistically insignificant impact on LTD which again, when it comes to the direction of the impact, is consistent with Jorda et al. (2021) and Cornett et al. (2011).

As to examining **Inflation**, my results show that it does not have a significant impact on the LTD ratio. It contradicts other papers, i.e., Demirguc-Kunt et al. (1998, 2004) and Ashraf (2020). On the other hand, the findings are consistent with Cecchetti et al. (2011), who also got negative and statistically insignificant results.

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Referring to **GDP Growth** it has a positive and statistically significant impact on LTD which contradicts papers by Cecchetti et al. (2011), Bergbrant et al. (2016) and Demirguc-Kunt (1998, 2004). It is consistent with Ashraf (2020), who established that bank risk is higher in growing economies.

GDP per Capita is positively correlated with the LTD ratio but its impact is statistically insignificant. It contradicts research by Anginer et al. (2013), Jorda et al. (2021), Demirguc--Kunt (1998, 2004), Ashraf (2020) and Houston (2010). It is my opinion that this variable is not significant because all the countries in my sample are high-income countries.

When it comes to the countries with **Activity Restrictions**, the results are similar for the **Deposits/GDP** variable but the impact is stronger. Other variables lost their significance. **GDP Growth** has the opposite effect – it is negatively and statistically significantly correlated with LTD. **Inflation** has a positive and statistically significant impact on LTD.

Results for the countries with no **Activity Restrictions** are very similar to those concerning the full sample. All of the variables have the same impact direction. **Deposit Insurance Coverage** has stronger and still negative impact on LTD.

When considering the countries with **Multiple Supervisors**, most of the variables lose their significance. Only **Credit/GDP** and **Deposits/GDP** still have statistically significant impact on LTD.

The impact of variables among the countries with only one supervisor are almost the same as for the full sample. **Deposit Insurance Coverage** has stronger and still negative impact on LTD.

Referring to the countries in the **Eurozone**, only **ROA** has the same impact as for the full sample. This impact is the same for both euro and non-euro area countries. However, when it comes to **Credit/GDP** and **Deposits/GDP** the results are especially interesting. When it comes to the countries which have not adopted the euro as their currency, the impact of the two variables are the same as it is for the full sample. The opposite is true for the euro area countries – **Credit/GDP** has a negative and statistically significant impact on LTD, and **Deposits/GDP** has a positive and statistically significant impact on LTD. The rest of the variables do not have statistical significance except for **Z-Score**, it has a negative impact within the non-euro area countries.

When it comes to geographic location, **countries from Central and Eastern Europe** only have two statistically significant variables. **Credit/GDP** has a positive, and **Deposits/GDP** has a negative impact on LTD, the same as for the full sample. Countries outside Central and Eastern Europe have the same impact when it comes to the **relation of Credit and Deposits to GDP**. In addition, **Lerner Index** and **Inflation** both have a negative and statistically significant impact on LTD. **ROA** is positively and statistically significantly correlated with LTD. The results are very similar to those regarding the full sample. The other variables havge no significant impact.

The division of countries according to the chosen method of deposit insurance sadly did not bring interesting information. For countries which use the **Ex-ante** approach **Credit/GDP** has a positive, and **Lerner Index** has a negative impact on the LTD ratio, which is in line with the test for the whole sample. The other variables have no statistical significance. When it comes to the countries which use the **Ex-post** approach, no variables have any statistical significance which may be because the sample is very small. Within countries using both **Ex-ante and Ex-post** approaches, both Credit/GDP and Deposits/GDP have the same impact as for the full sample. Credit/GDP has a positive, and Deposits/GDP has a negative impact on LTD. The other variables have no significant impact. The above results confirm Hypothesis 1.

The findings were subject to a battery of robustness tests. The results are robust to (1) adding random macroeconomic variables from the Global Financial Development Report database, (2) dropping random variables from the model, (3) using a different bank risk measure, and finally (4) a regression was run in which fixed effects were used. None of the alternative setups has a major impact on the findings.

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6. CONCLUSIONS

The paper examined how banking sector specific and macroeconomic factors, as related to deposit insurance, affected liquidity risk in banks in 28 of the European Economic Area countries over the period from 2005 to 2017.

Results show that the impact varies between subsamples. For the full sample, higher ratios of Credits/GDP cause banks to be less liquid. The same goes for ROA and GDP Growth. Higher Deposits/GDP and Lerner Index on the other hand both increase liquidity, which suggests that within the European Economic Area worse competition in the banking market actually reduces liquidity risk. However, the most interesting results concern the Deposit Insurance Coverage variable. The paper results show that increasing the coverage makes banks more liquid which contradicts most of the studies for different regions.

When it comes to the division due to restrictions in banking activity, GDP Growth has the opposite impact depending on the criterion. Growing economy reduces liquidity risk within countries with activity restrictions. The effect is opposite for countries without such restrictions. Higher Deposits to GDP ratio makes banks more liquid for both subgroups. For the countries with activity restrictions, higher inflation exposes banks to the risk of insufficient liquidity. When it comes to the countries without activity restrictions, the results are very similar to those for the full sample. The Deposit Insurance Coverage has even stronger, and still negative, impact on liquidity risk. The paper results suggest that having higher deposit coverage has a beneficial effect for countries without activity restrictions for bank liquidity.

Referring to the countries divided due to the adoption of the euro as a currency, higher ROA reduces liquidity risk, the same as for the full sample. However, ratios of credits and deposits to GDP have the opposite effect on liquidity. Among the countries in the euro area higher ratio of credits to GDP reduces liquidity risk, while higher deposits to GDP ratio analogously makes banks more exposed to liquidity risk. Systemic risk measured by Z-Score only has an impact for the countries outside the euro area. Lower systemic risk reduces liquidity risk.

Geographic location did not appear to have a major impact on the results. In case of both CEE and not CEE countries Credit/GDP and Deposits/GDP ratios have similar effect on liquidity as they have in the full sample. In addition, the higher Lerner index and inflation are, the lower the liquidity risk is. The opposite is true for ROA – higher ROA makes banks more exposed to liquidity risk.

Lastly, it has been tested how chosen financing approach would affect the paper results. It sadly did not bring interesting information. The subsample consisting of countries which use the Ex-post approach is unfortunately very small, so no variables turned out to be statistically significant. When it comes to the Ex-ante subgroup only Credit/GDP and Lerner index have an impact which is similar to the one in the full sample, while among the countries which use both Ex-ante and Ex-post approaches only Credit/GDP and Deposits/GDP ratios have a statistically significant impact, which again, is similar to the full sample.

Overall, the paper results provide a large amount of new information to help evaluate the deposit insurance scheme in the countries of the European Economic Area. No previous study of this type has focused on the area so the article is an interesting contribution to research on risk in banks.

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Millennials' willingness to pay for socially responsible investment and its institutional and individual antecedents – evidence from Italy, Poland, and Ukraine

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ABSTRACT

The readiness to sacrifice profit while making socially responsible investments among millennials, as future investors and managers, was examined. Specifically, a multi-level perspective on willingness to pay for socially responsible investment was assumed to understand how nationality, personal values and investment knowledge affect millennials' readiness to sacrifice profit to achieve sustainability goals. Using survey data of 521 business students from Italy, Poland and Ukraine, it is showed that a considerable share of millennials prefer social and environmental performance of investment over financial return and that their nationality is the most powerful factor in explaining willingness to pay for socially responsible investment along with their sensitivity to environmental issues that takes the leading role among all personal values motivating investors to accept lower rates of return. The results can be relevant for financial institutions

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aiming at developing socially responsible investment products. Policy implications of the results are insights into nationality-related tensions while Europe-wide regulation of socially responsible investment could enter into force.

JEL classification: F36, G11, G41, Q56

Keywords: Sustainable investment, Willingness to pay, Financial performance, Multi-level approach, Sustainable finance.

1. INTRODUCTION

Integration of environmental, social and governance (ESG) criteria in investment decisions, often referred to as socially responsible investment (SRI), can give a push to the global economy's transition toward a sustainable model (Scholtens, 2006). Results of studies on SRI financial performance are mixed (Barber et al., 2021; Kim, 2019; Lopez-de-Silanes et al., 2020; Matallín-Sáez et al., 2019). Thus the demand for SRI products may highly depend on investors' preference for sustainability, including willingness to sacrifice profits to achieve sustainability goals. The greatest hopes lie in the millennials, they are an ethical generation and are aware of business practices (Chatzopoulou and de Kiewiet, 2021). Yet their willingness to scarify profit to achieve sustainability goals remains unexplored in academic literature. The study examines the choices of millennials made in terms of trade-offs between financial gain and sustainable goals drawing on the public goods and externalities theory. There is a strong rationale behind focusing research on millennials in general and students of economics and finance in particular. *First*: attitudes toward dividends and capital gains continue to change as new generations of investors take turns (Hood et al., 2014). New investors entering a market are a chance for a change towards sustainability. The generation that is to be examined seems to be the most globally and socially oriented in history (Desai and Lele, 2017; Priporas et al., 2017). *Second*: business schools are the "nurseries" of the corporate world (van Baardewijk and de Graaf, 2020) where those who will be future fund managers and professional advisors are studying now. To make SRI market development possible, SRI fund managers have to be able to place priorities on social considerations while managing fund portfolios. It is reported that SRI fund managers are under a strong pressure to meet financial targets first and soften the edges of rigid ethical stances (Cetindamar and Ozkazanc-Pan, 2017; Haigh and Jones, 2006). Genuine personal commitment of SRI fund managers to sustainability is thus necessary to keep SRI truly social. It is also pointed, that socially responsible investors who want to integrate their personal values into their investment decisions, look for professional advisors who empathize with their goals and do not lecture them about the folly of such integration (Laskin, 2018; Statman, 2008). *Third*: due to the change from materialist to post-materialist values observed in developed societies (Diekmann and Preisendörfer, 2003) it is likely that new generations of investors will represent different patterns of sustainable investment decisions making than present ones. *Fourth*: previous research demonstrates also that highly educated individuals invest more often in SR mutual funds and accounts (Diouf et al., 2016; Rossi et al., 2016). Consequently, examining students may provide insight into forthcoming financial products consumers' demand for SRI.

It is argued here that the potential to trace the public good portion submerged in SRI is offered by contingent valuation. The method reveals the monetary value of goods (willingness to pay) that are not properly traded on the market via surveys revealing the use values along with the non-use values (Navrud and Strand, 2018). Although the concept of measuring value through surveys is used to determine ESG characteristics for various goods (Schäufele and Hamm, 2017), the studies on willingness to pay (WTP) for ESG attributes in financial products are rare (Brodback

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et al., 2020) and new insights are urgently needed. This paper seeks to determine whether or not millennials exhibit WTP for socially responsible characteristics of investment and what guides their WTP.

Few extant studies point to rather diverse antecedents of sacrificing profit while making SRI decision (Borgers and Pownall, 2014; Riedl and Smeets, 2017; Rossi et al., 2016). Demographic factors are widely reported on (Cheah et al., 2011; Borgers and Pownall, 2014). However, the complexity of the psychological factors has not been adequately addressed in the existing literature as investor psychological profiles are rather broadly defined as "attitudes" or "concerns". The study focuses on stable psychological constructs – personal values – as antecedents of WTP for SRI. Since Wins and Zwergel (2014) have noticed that investors interested in SRI investments feel insufficiently informed, a new area of factors of WTP for SRI is added, SRI's decision-making competence. It is contoured with financial expertise, risk attitudes and SRI background knowledge.

Following the call by Riedl and Smeets (2017) to investigate if and how the relationship between social preferences and SRI relates to variations in institutional aspects, an institutional level to the research framework is added. Next to individual level antecedents of WTP for SRI (personal values and SRI decision making competence) an institutional-level factor – nationality – is accounted for. A combination of theories related to institutional-level and individual-level factors of WTP for SRI is used, which enables us to properly address different levels of analysis.

The method used is based on a contingent-valuation approach. A survey is used in which participants – business students from Italy, Poland and Ukraine – are asked to state their willingness to pay for a SRI fund comparable in terms of risk with a conventional mutual fund to elicit WTP for SRI. The experiment is followed by a questionnaire on financial knowledge, risk attitude, SRI background and personal values to investigate the factors of WTP.

The study provides several contributions. The existing literature on market inefficiencies related to ESG impacts perceived as public goods by studying financial products is added. By examining millennials, insights are provided into the multi-facet prospects of future SRI market development. Adoption of a novel framework to study antecedents of WTP for SRI provides well-structured insights into the relative importance of factors of WTP for SRI and, in the context, it can elicit more precise responses to consumer preferences for financial products. Finally, making comparisons between countries adds to the discussion on universal regulations in the SRI sector, when local and universal ethics may clash. The paper adds the insight on the demand for SRI in Italy, Poland and Ukraine – countries that (to the authors' knowledge) so far never have been included in empirical studies on SRI investor profiles. The paper structure is as follows: first, there is a review of the literature on non-use values of financial products and contingent valuation method. Then, it is elaborated on institutional- and individual-level factors of SRI and a hypothesis is developed. In the next section, data and methodology are presented. It is followed by showcasing the results. Finally, results and limitations of the study are discussed.

2. LITERATURE REVIEW

2.1. Willingness to sacrifice financial profit while making SRI decisions

SRI can be perceived as a composite phenomenon, constituting a mixture of purely private gain (financial profit) and public or quasi-public effects (i.e., environmental improvements) (Sandberg et al., 2009). However, the non-financial aspects of SRI portfolio may not be reflected properly in market prices as such impacts have features of externalities (Consolandi et al., 2020). When a market operates efficiently, the price reflects the fair value of the good as the demand curve mirrors the true willingness-to-pay (WTP) that offsets the buyer's utility gain from the purchase. However, with market distortions (externalities), the market price may diverge from

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WTP leading to allocative inefficiency (Boardman et al., 2014). The long-established contingent valuation methods (CVM) allow to capture the total value of externalities in capital investment appraisal (Boardman et al., 2014; Florio, 2014). The method uses a survey to create a hypothetical market (when the real one is non-existing) and thus allows for capturing not only the value of public good for its user, but also non-use values incorporated in public goods (Fujiwara et al., 2019; Tonin, 2019). This makes CVM potentially interesting for reflecting ESG impacts of financial investments as SRI aims both at achieving financial performance as well as increasing social welfare.

Although measuring non-use values of consumer good (e.g., fair-trade) via WTP is often practiced (Yu et al., 2014; Schäufele and Hamm, 2017), research has been scant in terms of WTP for ESG attributes of financial products. In the SRI literature, there are studies examining the demand for SRI that do not directly examine WTP for SRI (Barreda-Tarrazona et al., 2011; Wins and Zwergel, 2016). However, the studies show the importance of non-financial issues among investors and thus warrant further investigation of willingness to forego financial reward. Few studies examine the conditions under which investors are willing to make economic sacrifices to buy SRI products. Glac (2009) finds a positive correlation between the return level of conventional investment options and the level of trade-offs that investors are willing to make when considering SRI. Pasewark and Riley (2010) find that the propensity to sacrifice profit was highly dependent on individual concerns about societal implications of such investments. Borgers and Pownall (2014) reveal that WTP for pension plans possessing SR features is lower for men, rises as education and income levels rise, and is stronger among those with positive attitudes towards social and environmental issues. Apostolakis et al. (2016) also investigate WTP for pension investments and also report that the willingness to sacrifice profits is positive. Rossi et al. (2016) find that in the Netherlands, a latent demand exists for SRI, even when SRI investments are less profitable than conventional ones and found more evidence of demographic factors' importance. The paper adds to the previous results by investigating explicitly WTP for SRI using a hypothetical market approach allowing respondents to state their preferences towards accepting a lower return on investment bringing about positive ESG impacts.

Assuming that some millennials are willing to bear economic sacrifices to buy SRI it is hypothesized that:

H1: WTP for SRI is positive for a certain proportion of the respondents.

2.2. Institutional level antecedents of WTP for SRI

Institutional approach allows for dismissing silent assumptions that individuals have solely private value systems, proposing that they share a set of principles with others guiding their actions (Geels, 2004). Such sets of principles are particularly distinctive among nations. Extant studies have discovered significant differences in WTP for ESG features in consumer goods among different countries (Basu and Hicks, 2008). National social settings can also be influential in terms of consumer demand for financial products with ESG attributes (Sandberg et al., 2009; Scholtens and Sievänen, 2013; Waring and Edwards, 2008). However, comparative studies covering SRI demand parameters in European countries have not been conducted yet. Especially the differences between Western, Central and Eastern Europe remain uncovered. Comparative analysis of Poland, Italy and Ukraine can bring about interesting results for several reasons: (1) their populations are relatively homogenous (there are no major ethnicities other than domestic, which could impact study results) with respect to language, cultural, religious and historical background; (2) no large studies on attitudes towards SRI in Italy, Poland or Ukraine have been conducted; (3) they have not adopted any regulations to enforce or encourage institutional investors to allocate part of their assets to SRI; (4) Italy and Poland are European Union (EU) members and, thus, may be

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influenced by any future Europe-wide regulations of SRI while Ukraine is not an EU member country; (5) Poland and Ukraine are transitioning from command economies to mixed-market economies; and (6) SRI markets in the three countries are on the early stage of development and will be shaped by future investors and financial market professionals.

Italy is the biggest economy in Southern Europe and the fourth-largest economy in the European Union, but its SRI presence is still marginal (EUROSIF, 2018). Poland has been transitioning economically towards a democratic and market-oriented system, with its well-developed Warsaw Stock Exchange (WSE) being the most important exchange in Central and Eastern Europe. However, Poland's SRI market presence is negligible (Doś and Foltyn-Zarychta, 2017). Ukraine is a former Soviet republic with a weak economic system and is presently trying to address an urgent need to accelerate development of its domestic financial markets, which include a practically non-existent SRI market presence (Shkura, 2017). Considering the differences, it is expected that WTP for SRI may vary between countries and it is hypothesized:

H2: Nationality influences WTP for SRI among millennials.

2.3. Individual level antecedents of WTP for SRI

2.3.1. Personal values

Personal values commonly are identified as "beliefs that a specific mode of conduct or end-state of existence is personally and socially preferable to alternative modes of conduct or end-state of existence" (Rokeach, 1973). Because of their stability and centrality in an individual's cognitive structure, personal values are functional in focusing attention on what is essential in a decision situation, thereby assisting the person in making more efficient decisions (Dietz and Stern, 1995; Schwartz, 1992). As such, values serve as a powerful drive for action. So far, many different personal values have been identified (e.g. Elizur et al., 1991; Rokeach, 1973; Schwartz, 1992). To choose the values to focus on, it was drawn from the consumer behavior literature (Barber et al., 2012; Tsen et al., 2006). It suggests that some values have a greater impact on WTP for ESG attributes of consumer goods than others. The set encompasses: ethics, environmentalism, religiosity, collectivism, and materialism. Accordingly, the focus was on the set of personal values to their impact on WTP for financial products.

In practice, SRI often means that investors exclude companies from their investment sphere, as well as they do with intermediaries and practices that betray their convictions (Dembinski et al., 2003). Richardson (2009) describes the deontological type of SRI, involving investors who personally do not wish to profit from unethical activities. Hunt and Vitell (1986) emphasize that the tendency to follow deontological norms when assessing the set of alternatives in a given situation (ethicality) qualifies as a personal value. Thus, it is expected that the higher level of ethicality influences WTP for SRI positively.

Environmentalism is the belief that the individual and other social actors have an obligation to alleviate environmental problems (Stern et al., 1995). As the number of SRI funds have an explicitly pro-environmental profile, it is expected that environmentalism positively influences WTP for SRI.

SRI developed from being merely a religious phenomenon towards investments increasingly concerned about environmental, geopolitical, and democratic issues (Schwartz, 2003). Nevertheless, religiosity seems to remain as one of the important characteristics of SRI investors (Hoepner et al., 2011; Kurtz and Di Bartolomeo, 2005). Religiosity is conceived as the general attitude of a person towards religious issues and themes, regardless of their affiliation with a given religion. Therefore, it is expected that religiosity will correlate positively with WTP for SRI.

Dembinski et al. (2003) and Starr (2008) stress how SRI had been associated with the common good, which implies considering the consequences that actions will have on absent third parties.

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Thus SRI can be associated with collectivism, a value related to putting the goals of the collectives over personal goals (Lászlό, 2013). Consumer studies reveal that collectivistic consumers are willing to pay more for sustainability-linked products (Barber et al., 2012; Tsen et al., 2006). Therefore, it is expected that collectivism will impact WTP for SRI positively.

WTP for SRI relates to forgoing some part of an investor's profit in exchange for SR characteristics. The financial goal is associated most closely with materialism. Materialism sees material possessions as the most important component of happiness (Richins and Dawson, 1992; Ward and Wackman, 1971). Chowdhury and Fernando (2013) find that the individuals who exhibit higher levels of materialism tend to be less critical of unethical actions that lead to beneficial outcomes than the ones who behave unethically. Additionally, materialism is negatively correlated with people having higher ethical standards as consumers (Muncy and Eastman, 1998). Thus, it is expected that materialism negatively affects investors' WTP for SRI.

Assuming that personal values impact WTP for SRI the third hypothesis is formulated:

H3a: Ethicality positively affects WTP for SRI,
H3b: Environmentalism positively affects WTP for SRI,
H3c: Religiosity positively affects WTP for SRI,
H3d: Collectivism positively affects WTP for SRI,
H3e: Materialism negatively affects WTP for SRI.

3.2.2. SRI decision-making competence

Information on SRI constitutes relevant investment decision frames that may channel the impact of psychological factors on the decisions being made (Døskeland and Pedersen, 2016). Financial decision making requires not only appropriate information, but also relevant knowledge to effectively use the information (Clark et al., 2017). Thus, the possible significance of having information about SRI and of financial knowledge in the model of factors of WTP for SRI is taken into account.

Investors may see responsible investment as an opportunity for equivalent return at relatively lower risk or higher returns for the same level of risk, as compared with other funds (Beal et al., 2005). Thus, investors willing to pay for SRI may look for other than social and environmental benefits which substitute forgone profit. Lowered risk can be one of such benefits (Bauer and Smeets, 2015). Because some investors seem to be moving to SRIs by focusing on a risks-returns balance decision making (Benson and Humphrey, 2008; Galema et al., 2008) adopt a two-dimensional financial framing of SRI decisions is assumed and it is expected that risk attitude will be influential in terms of WTP for SRI. SRI background, financial knowledge and risk attitude constitute a set of factors determining investors preparation to make SR investment decisions. Thus, a set of hypotheses was formulated:

H4a: Having information about SRI positively affects WTP for SRI,
H4b: Financial knowledge positively affects WTP for SRI,
H4c: Risk aversion positively affects WTP for SRI.

The hypotheses and their relation to the two-level conceptual framework assumed in the study are presented in Figure 1.

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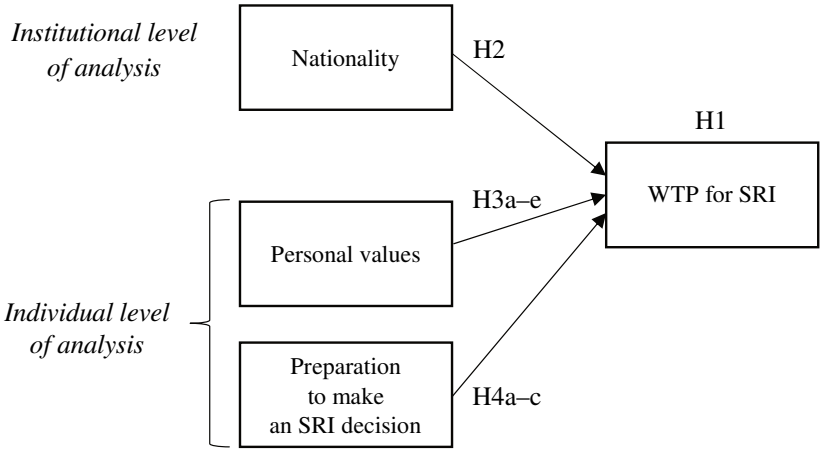
Figure 1
Conceptual framework



Source: Authors' own elaboration.

3. METHODOLOGY AND DATA

3.1. Survey design

The survey consisted of three parts: the experiment for deriving bids for SRI, questions referring to preparation for SRI decision making and questions investigating personal values.

3.1.1. Dependent variable: WTP for SRI

To elicit WTP for SRI the survey was equipped with a hypothetical scenario aiming at deriving WTP for the SRI fund. At first, respondents are asked to imagine that they are intending to make a long-term investment of 5,000 EUR. Than they are asked to state their preferences in a scenario when they can choose between fund A and B. Fund A is described as "a conventional mutual fund investing in companies with a stable market position, average risk and average growth forecasts" and expected long-term rate of return set at 10%. The long-term level of return is settled based on average long-term stock performance for mature financial markets (Shen, 2005; RamseySolutions, 2021). The B fund is described as the fund that "fulfills SRI requirements, which means that firms in B's portfolio are companies where activities are based on environmental criteria (non-harmful for environment), social criteria (not making profits on e.g., pornography, gambling, respects human rights), fair competition and good employment policy criteria (fair advertising, non-discrimination in workplace etc.)".

The participants are asked to state what is their required annual minimum rate of return for the SRI fund to choose it over the non-SRI mutual fund (cf. Borgers and Pownall, 2014; Glac, 2009). This question is open-ended to allow participants to make an unrestricted choice (cf. Carson and Hahneman, 2005). This format allows to avoid an anchoring bias (Gordillo et al., 2019).

The design of experiments serves eliciting WTP for the SRI fund, holding the level of risk stable. Thus, investing in the non-SRI mutual fund (A fund) and possessing a certain financial gain (x) is equivalent in terms of utility to holding the SRI fund (B fund) with the gain lower by WTP:

$$U(\text{A fund},x) = U(\text{B fund},x - \text{WTP}) \qquad \text{Eq. (1)}$$

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With holding the utility level unchanged the difference in declared rates of return can explain respondents' WTP for non-financial characteristics of the B fund. Considering, that the rate of return on conventional fund was set at 10% level, three options were possible: the first: that a respondent states less than 10% to choose the SRI fund instead of conventional one; the second: that a respondent states exactly 10%, or the third: a respondent states more than 10% to choose the SRI fund instead of the conventional one. The three options represent three ways of expressing preference for SRI. In the first one the respondent is ready to scarify financial profit to make a sustainable investment (WTP for SRI is positive). In the second scenario a respondent prefers the SRI fund over the conventional one but is not willing to pay for it (WTP for SRI is equal to 0). In the third scenario, the investor follows primarily financial goals – they choose the SRI fund only if it offers higher return than the conventional one.

3.1.2. Personal values

In the survey all values are rated on a seven-point scale ranging from 1 (don't agree at all) to 7 (totally agree), except for one value (student's ethics) where the 7-point Likert scale is reversed. To measure personal values, the already tested scales were adopted, as described below.

To measure "environmentalism", three items from the most widely accepted scale of New Ecological Paradigm (NEP) by Dunlap et al. (2000) were adopted. The scale is originally made of 15 items, however considering the methodological necessity to limit the questionnaire, the scale is narrowed. The narrowed NEP scales maintain consistency (Dunlap, 2008).

"Religiosity" was measured, following the suggestion by McDaniel and Burnett (1990) who pointed out that religiosity can be measured in terms of cognitive and behavioral dimensions. Thereof to measure religiosity, a 2-item scale developed by Ramasamy et al. (2010) was adopted, where one item refers to cognitive dimension and the second item – to the behavioral dimension.

Collectivism is measured using a three-item measure developed by Chan (2001). To measure materialism 3 items from the scale of Richins and Dawson (1992) were adopted, they were selected to create a validated shortened scale (Richins, 2004; Stanton et al., 2002). The scale includes one item from each category: success, centrality, and happiness.

Students are surveyed. Thereof two scales to measure ethicality among students were used. The first scale consists of two items selected from a larger scale for measuring dishonesty in academic settings by McCabe (2005). The second scale is a three-item scale developed by Lawson (2004) to measure students' ethicality in a non-academic setting (the reverse scale). The results of Lawson's study (2004) indicate that there is a very strong relationship between students' propensity to engage in unethical behaviors in an academic setting and their attitude towards such behaviors in the business world.

3.1.3. SRI decision making competence

To capture competences to make SRI decisions, first respondents were asked whether they participated in a course devoted to SRI (binary choice). Next Likert's scale-based questions were asked on risk attitude and financial knowledge. Following Bauer and Smeets (2015) respondents were directly asked how they self-rate their financial knowledge. Following Bauer and Smeets (2015) risk attitude was self-rated from 1 (strongly risk averse) to 7 (high risk-seeker).

3.2. Data collection and sample characteristics

The data was collected via questionnaires distributed among business students. Survey was conducted in three countries among solely domestic students, thereof nationality was determined by country. Three large universities were investigated: Università Cattolica del Sacro Cuore in Milan (Italy), University of Economics in Katowice (Poland) and Alfred Nobel University

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in Dnipro (Ukraine). All locations represent highly dense urban and industrial areas. The survey was conducted online. Participation in the survey was voluntary, non-incentivized and anonymous. Respondents filled questionnaires translated to their national languages (Italian, Polish and Ukrainian). 521 questionnaires were collected out of which 455 were used in the analysis: 85 from Italy, 215 from Poland and 155 from Ukraine. The remaining 66 questionnaires were rejected due to missing data or extreme WTP bids, identified via the Tukey (1977) method.

Respondents are mainly graduate business students (68% of respondents held bachelor degrees and studied master programs). The respondents' age is between 17 and 26 with the average of 21,67-year-old, 73% of them are female, 45% with income lower than the country average (the average per capita net income for Italy, Poland and Ukraine was set at, respectively 1860 EUR, 1386 PLN, 5100 UAH based on countries statistics offices (Statistics Poland, 2021; Istat, 2021; Ukrstat, 2021)). Since the relevance of demographic factors for SRI decisions is widely reported in the literature and because a relatively homogenous group of respondents is investigated, demographic factors are not treated as explanatory variables in the analysis.

Table 1 provides respondents' characteristics on the country. Table 2 shows the structure of respondents based on having a course on SRI and Table 3 demonstrates risk attitude, financial knowledge and personal value questions for the general sample, while tables 4, 5 and 6 separately for Italy, Poland and Ukraine.

Table 1
Respondents by country

	Italy	Poland	Ukraine
Country (%)	18.68	47.25	34.07

Source: Authors' calculation.

Table 2
Share of respondents having course related to SRI

	Yes (%)	No (%)
Have you had a course on SRI or contents related to SRI in previous courses	27.91	72.09

Source: Authors' calculation.

Table 3
Attitude to risk, financial knowledge and personal values questions for general sample (all countries)

Question	% of responses						
	1	2	3	4	5	6	7
Risk attitude							
How would you describe your attitude towards risk-taking in investment?	4.62	12.09	30.55	30.99	16.04	3.74	1.98
Financial Knowledge							
How would you assess your knowledge on finance?	1.32	7.03	23.96	34.73	27.03	5.49	0.44

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continued Table 3

Question	% of responses						
	1	2	3	4	5	6	7
Materialism							
I admire people who own expensive homes, cars, and clothes.	20.22	20.44	20.88	20.22	9.89	5.05	3.30
Buying things gives me a lot of pleasure.	3.52	9.89	18.02	21.76	22.64	11.43	12.75
My life would be better if I owned certain things I don't have.	8.79	14.07	17.58	20.00	19.56	9.01	10.99
Religiosity							
Do you consider yourself to be religious?	12.75	9.23	12.09	29.01	15.38	14.07	7.47
Apart from weddings and funerals how often do you attend religious services these days?	21.32	22.20	9.89	12.53	12.53	11.87	9.67
Environmentalism							
Humans are severely abusing the environment.		2.64	3.74	10.33	21.54	26.15	35.60
Despite our special capabilities humans are still subject to the law of nature.	1.10	1.98	7.69	16.26	25.05	22.86	25.05
Balance of nature is very delicate and easily upset.	1.10	1.76	7.03	11.21	20.44	29.23	29.23
General ethics							
It is OK to lie to a potential employer on an employment application.	38.90	28.35	14.51	9.23	5.05	2.42	1.54
It is OK to use a fake ID or someone else's ID to purchase alcohol.	73.85	12.31	5.05	4.18	1.76	1.32	1.54
Using insider information when buying and selling stock is unethical behavior.	40.66	16.04	13.63	10.99	7.47	5.27	5.93
Student's ethics							
How often do you use crib notes on a test or copy from another student during a test.	25.71	32.75	16.92	9.89	8.79	3.30	2.64
How often do you copy material and turn it in as your own work or turn in work done by someone else.	57.80	21.76	10.55	4.40	3.08	1.32	1.10
How often do you copy a few sentences of material from a published source without footnoting it.	25.93	25.71	15.38	9.67	11.65	6.59	5.05
Collectivism							
Well-being of others is important to me.	1.54	3.52	8.57	13.85	24.18	30.11	18.24
It is important to me that I respect the decisions made by my groups.	1.10	2.20	4.84	15.38	30.33	31.43	14.73

Source: Authors' calculation.

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Table 4
Attitude to risk, financial knowledge and personal values questions for Italy

Question	% of responses						
	1	2	3	4	5	6	7
Risk attitude							
How would you describe your attitude towards risk-taking in investment?	1.18	15.29	23.53	35.29	20.00	3.53	1.18
Financial Knowledge							
How would you assess your knowledge on finance?	2.35	17.65	30.59	30.59	17.65	1.18	
Materialism							
I admire people who own expensive homes, cars, and clothes	18.82	21.18	25.88	20.00	10.59	3.53	
Buying things gives me a lot of pleasure	7.06	14.12	27.06	23.53	16.47	5.88	5.88
My life would be better if I owned certain things I don't have	20.00	17.65	22.35	15.29	15.29	5.88	3.53
Religiosity							
Do you consider yourself to be religious?	20.00	21.18	7.06	18.82	12.94	5.88	14.12
Apart from weddings and funerals how often do you attend religious services these days?	32.94	24.71	3.53	9.41	8.24	5.88	15.29
Environmentalism							
Humans are severely abusing the environment			1.18	4.71	20.00	36.47	37.65
Despite our special capabilities humans are still subject to the law of nature		1.18	1.18	10.59	25.88	21.18	40.00
Balance of nature is very delicate and easily upset			1.18	5.88	17.65	30.59	44.71
General ethics							
It is OK to lie to a potential employer on an employment application.	24.71	23.53	28.24	14.12	8.24	1.18	
It is OK to use a fake ID or someone else's ID to purchase alcohol.	62.35	15.29	11.76	7.06	2.35	1.18	
Using insider information when buying and selling stock is unethical behavior.	5.88	16.47	9.41	16.47	14.12	22.35	15.29
Student's ethics							
How often do you use crib notes on a test or copy from another student during a test;	58.82	24.71	9.41	4.71	2.35		
How often do you copy material and turn it in as your own work or turn in work done by someone else;	78.82	15.29	4.71	1.18			
How often do you copy a few sentences of material from a published source without footnoting it.	38.82	30.59	17.65	2.35	7.06	3.53	
Collectivism							
Well-being of others is important to me		3.53	3.53	9.41	31.76	32.94	18.82
It is important to me that I respect the decisions made by my groups			2.35	5.88	29.41	41.18	21.18

Source: Authors' calculation.

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Table 5
Attitude to risk, financial knowledge and personal values questions for Poland

Question	% of responses						
	1	2	3	4	5	6	7
Risk attitude							
How would you describe your attitude towards risk-taking in investment?	7.91	14.42	35.35	25.12	13.49	2.79	0.93
Financial Knowledge							
How would you assess your knowledge on finance?	0.47	3.72	18.60	37.67	32.09	6.98	0.47
Materialism							
I admire people who own expensive homes, cars, and clothes.	19.07	20.93	20.93	18.14	10.70	6.98	3.26
Buying things gives me a lot of pleasure.	1.86	11.16	15.35	21.86	27.44	13.02	9.30
My life would be better if I owned certain things I don't have.	6.98	16.28	20.00	18.60	20.47	9.77	7.91
Religiosity							
Do you consider yourself to be religious?	6.51	5.58	10.23	25.58	23.72	21.86	6.51
Apart from weddings and funerals how often do you attend religious services these days?	8.37	17.67	9.30	12.56	17.67	21.40	13.02
Environmentalism							
Humans are severely abusing the environment.		4.19	5.58	15.81	25.58	23.72	25.12
Despite our special capabilities humans are still subject to the law of nature.	0.47	0.93	3.72	9.77	23.26	30.23	31.63
Balance of nature is very delicate and easily upset.	0.93	2.33	6.98	10.70	21.86	30.70	26.51
General ethics							
It is OK to lie to a potential employer on an employment application.	36.74	34.42	11.63	7.44	2.79	4.19	2.79
It is OK to use a fake ID or someone else's ID to purchase alcohol.	77.67	13.02	3.26	3.26	0.93	0.47	1.40
Using insider information when buying and selling stock is unethical behavior.	65.12	16.28	8.84	4.65	2.79		2.33
Student's ethics							
How often do you use crib notes on a test or copy from another student during a test.	25.12	46.51	16.28	7.91	3.26	0.93	
How often do you copy material and turn it in as your own work or turn in work done by someone else.	70.70	21.40	6.05	0.47	1.40		
How often do you copy a few sentences of material from a published source without footnoting it.	33.02	29.77	16.28	7.91	8.84	2.79	1.40
Collectivism							
Well-being of others is important to me.			2.79	11.63	22.79	38.60	24.19
It is important to me that I respect the decisions made by my groups.	0.47	1.86	1.40	12.56	32.56	37.67	13.49

Source: Authors' calculation.

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Table 6
Attitude to risk, financial knowledge and personal values questions for Ukraine

Question	% of responses						
	1	2	3	4	5	6	7
Risk attitude							
How would you describe your attitude towards risk-taking in investment?	1.94	7.10	27.74	36.77	17.42	5.16	3.87
Financial Knowledge							
How would you assess your knowledge on finance?	1.94	5.81	27.74	32.90	25.16	5.81	0.65
Materialism							
I admire people who own expensive homes, cars, and clothes.	22.58	19.35	18.06	23.23	8.39	3.23	5.16
Buying things gives me a lot of pleasure.	3.87	5.81	16.77	20.65	19.35	12.26	21.29
My life would be better if I owned certain things I don't have.	5.16	9.03	11.61	24.52	20.65	9.68	19.35
Religiosity							
Do you consider yourself to be religious?	17.42	7.74	17.42	39.35	5.16	7.74	5.16
Apart from weddings and funerals how often do you attend religious services these days?	32.90	27.10	14.19	14.19	7.74	1.94	1.94
Environmentalism							
Humans are severely abusing the environment.		1.94	2.58	5.81	16.77	23.87	49.03
Despite our special capabilities humans are still subject to the law of nature.	2.58	3.87	16.77	28.39	27.10	13.55	7.74
Balance of nature is very delicate and easily upset.	1.94	1.94	10.32	14.84	20.00	26.45	24.52
General ethics							
It is OK to lie to a potential employer on an employment application.	49.68	22.58	10.97	9.03	6.45	0.65	0.65
It is OK to use a fake ID or someone else's ID to purchase alcohol.	74.84	9.68	3.87	3.87	2.58	2.58	2.58
Using insider information when buying and selling stock is unethical behavior.	25.81	15.48	22.58	16.77	10.32	3.23	5.81
Student's ethics							
How often do you use crib notes on a test or copy from another student during a test.	8.39	18.06	21.94	15.48	20.00	8.39	7.74
How often do you copy material and turn it in as your own work or turn in work done by someone else.	28.39	25.81	20.00	11.61	7.10	3.87	3.23
How often do you copy a few sentences of material from a published source without footnoting it.	9.03	17.42	12.90	16.13	18.06	13.55	12.90
Collectivism							
Well-being of others is important to me.	4.52	8.39	19.35	19.35	21.94	16.77	9.68
It is important to me that I respect the decisions made by my groups.	2.58	3.87	10.97	24.52	27.74	17.42	12.90

Source: Authors' calculation.

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3.3. Personal values – factor analysis

To check the consistency of personal values questions as well as for the purpose of distinguishing psychological factors which may potentially influence WTP, Principal Component Analysis and varimax rotation are used. Each value is measured by a 2–3 item scale. Cronbach's alpha is calculated on the dataset to determine the internal consistency and reliability of scales. Upon evaluation of eigenvalues and scree plot six factors are detected. Five factors load strongly. In case of ethics in non-academic setting alfa is at 0.53 level. Nevertheless, it is decided to include the factor due to the fact that ethics is particularly important for SRI as well as because the scale was used successfully before (Lawson, 2004). Factors overlap perfectly with scales used to measure all considered values: environmentalism, collectivism, religiosity, materialism, ethics in academic setting and ethics in non-academic setting. Results of factor analysis are available in table 7.

Table 7
Factor analysis of personal values

Dependent	Loading value
Factor 1 (α = 0.711) Materialism	
I admire people who own expensive homes, cars, and clothes	0.794
Buying things gives me a lot of pleasure	0.788
My life would be better if I owned certain things I don't have	0.758
Factor 2 (α = 0.873) Religiosity	
Do you consider yourself to be "very religious", (7)	0.927
Apart from weddings and funerals how often do you attend religious services these day	0.925
Factor 3 (α = 0.616) Environmentalism	
Humans are severely abusing the environment	0.812
Despite our special capabilities humans are still subject to the law of nature	0.587
Balance of nature is very delicate and easily upset	0.798
Factor 4 (α = 0.530) Ethics	
It is OK to lie to a potential employer on an employment application	0.705
It is OK to use a fake ID or someone else's ID to purchase alcohol	0.708
Using insider information when buying and selling stock is acceptable	0.670
Factor 5 (α = 0.748) Student ethics	
Using crib notes on a test or copying from another student during a test	0.841
Copying material and turning it in as your own work or turning in work done by someone else	0.768
Copying a few sentences of material from a published source without footnoting it	0.759
Factor 6 (α = 0.618) Collectivism	
Well-being of others is important to me	-0.807
It is important to me that I respect the decisions made by my groups	-0.839

Source: Authors' calculation.

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4. RESULTS

To investigate the antecedents of WTP for SRI the declared rates of return on the SRI fund in the general sample and each country are initially analyzed separately.

The descriptive statistics (Table 8) show that for the whole sample the mean of WTP for SRI is 11.87% with standard deviation of 6.33% and median rate of 10%. Such discrepancy between negative average WTP and median respondent can be assigned to the positive skewness of the bids and high discrepancy of Ukrainian bids, with maximum declared rates reaching 50%. Polish average bids are slightly above 10%, while Ukrainians declare the highest required returns, ranging from 15% to almost 17%. However, the median value for the whole sample and for Italy and Poland are all equal to 10%, indicating that half of respondents in those two countries are willing to sacrifice some of their profit to achieve ESG goals. The results support the H1 hypothesis that a considerable share of students are willing to pay for SRI.

The declared rates of return differ between countries (ANOVA Kruskal-Wallis with p value < 0,05 indicate that differences are statistically significant).

Table 8
Means, medians, standard deviations, skewness and kurtosis of self-declared rates of return (%) for the socially responsible fund

	Mean	Median	SD	Skewness	Kurtosis
All countries (N = 455)					
Declared rate	11.87	10.00	6.33	2.71	9.48
Italy (N = 85)					
Declared rate	9.71	10.00	2.67	1.16	3.39
Poland (N = 215)					
Declared rate	10.15	10.00	3.42	1.95	7.54
Ukraine (N = 155)					
Declared rate	15.44	15.00	8.86	1.65	2.73

Source: Authors' calculation.

The question on WTP bids allows participants to give unrestricted required rate of return for the SRI fund. Due to skewness of the declared rates of return the bids are grouped into three categories: positive WTP (representing participants declaring rates below 10%), neutral WTP (when participants declared rates equal to 10%, meaning they are willing to choose the SRI fund as long as it rates of return is equal to the non-SRI fund), negative WTP (for participants bidding rates higher than 10%) requiring some additional financial reward to invest in SRI funds. The categorization makes it possible to run multinomial ordered regression models with logit link for each question to identify variables that explain participants' WTP (Böhning, 1992).

The models are constructed assuming that the base state of the dependent variable is positive WTP, where respondents declare that they are willing to sacrifice some part of the profit (bids lower that 10%) when investing in the SRI fund. The potentially significant variables for final models are chosen in the two-step procedure. First, the relationships between WTP for the SRI fund and each potential explanatory variable are analyzed separately. Based on the variables that are found to be significant, multinomial regression models with multiple variables are built.

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Based on the variables that are found significant for explaining WTP (one-variable models), they are grouped into three categories and a regression is run for each group separately (country – model A, preparation to make an SRI decision – model B, and personal values – model C) and for all groups together (model D) to find which variable-mix gives the highest potential to explain WTP for SRI. The goodness of fit for models is assessed on the basis of AIC and BIC criteria coupled with scaled Chi squared and its relation to degrees of freedom (X^2/Df). Results are presented in Table 9.

Table 9
Antecedents of WTP for SRI

	Model A	**Model B**	**Model C**	**Model D**
Intercept 1	-0.78 [0.11]***	-0.37 [0.41]	-0.81 [0.10]***	-0.51 [0.43]
Intercept 2	0.80 [0.11]***	1.09 [0.41]***	0.74 [0.10]***	1.12 [0.43]***
Country				
Ukraine	-0.97 [0.13]***			-0.97 [0.20]***
Poland	0.33 [0.12]***			0.37 [0.16]**
Preparedness				
SRI course		-0.18 [0.10]*		-0.10 [0.09]**
Risk attitude		-0.17 [0.07]**		-0.08 [0.08]
Financial knowledge		0.04 [0.08]		-0.02 [0.09]
Personal values				
Materialism			-0.14 [0.09]	-0.10 [0.09]
Religiosity			-0.22 [0.09]**	-0.07 [0.10]
Environmentalism			0.27 [0.09]***	0.25 [0.09]***
General ethics			0.02 [0.09]	-0.09 [0.10]
Student's ethics			-0.33 [0.09]***	0.09 [0.12]
Collectivism			0.26 [0.09]***	0.06 [0.10]
Scaled Chi^2	915.40	911.11	917.10	928.35
AIC	953.00	1000.42	975.83	956.57
BIC	969.48	1021.02	1008.79	1010.13
Log-likelihood	-472.50	-495.21	-479.91	-465.86
X^2/df	1.01	1.01	1.02	1.04

Signif. codes: 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1.

Source: Authors' calculation.

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The results indicate WTP changes for the country variable and the changes are significant both for Ukraine (β = -0.97; p < 0.01) and Poland (β = 0.37; p < 0.01) in comparison with Italy. While Ukrainians are less eager to declare positive WTP for SRI, Italians, Polish students are more willing to sacrifice part of their returns when choosing an SRI fund (both in Model A and D). The results (along with initial analysis of rates of return, where (ANOVA Kruskal-Wallis test indicated that differences between countries are statistically significant) strongly support the H2 hypothesis.

In the "values model" (model C), religiosity, environmentalism, student's ethics and collectivism are significant. While higher religiosity lowers the chances of declaring positive WTP (H3c is strongly rejected), both remaining values correlate positively with willingness to pay for SR characteristics (H3a, H3b, H3d supported). The impact of general ethics is negligible (p = 0.84), however materialism's p-value (0.12) is just slightly higher than what the ceiling for the p-value (0,1) – overall lack of support for H3e. The results differ in the D model, where environmentalism alone justifies WTP changes with p < 0.01. A strong confirmation is thus given for H3b, referring to the positive impact of environmentalism on WTP for SRI. H3a referring to the positive influence of student's ethics is partially supported by Model C. H3d referring to the positive influence of collectivism is strongly supported only by Model C. All models are reasonably well-suited to data with Chi squared/Df statistics staying close to 1 in all cases and AIC and BIC criteria having similar levels.

Finally, accounting for SRI decisions competence alone (Model B), pursuing an SRI course, as well as higher risk tolerance, negatively influence WTP for SRI, but only the former enters the D model. Thus, weak support is found for H4c (Risk aversion positively affects WTP for SRI) while H4a (Having information about SRI positively affects WTP for SRI) is rejected. General financial knowledge is insignificant in explaining the changes in WTP and there is no support for H4b (Financial knowledge positively affects WTP for SRI).

5. DISCUSSION AND CONCLUSION

A two-level framework is used to study millennials' readiness to sacrifice profit while making SRI decisions. Based on a survey done in three European countries, it is found that a substantial share of young people is willing to accept lower returns for a SRI product or choose it over conventional investment product at a return equal to a conventional one. The investors willing to pay for SRI challenge the traditional view of an investor as a purely self-interested and profit-motivated person. By evidencing non purely self-interested behaviors there is contribution to building a realistic view of finance and opportunities to mobilize the financial market for achieving sustainable development, even in case of trade-offs between ethical and financial criteria of investment decision making. The results urge for taking a new perspective on estimating the value of the SRI market. If SRI allows consumers of financial services to derive utility that exceeds purely financial aspects – the value of the SRI market should be understood as a composition of financial value expressed in market price and a non-financial value.

Secondly, it is found that the institutional-level factor – nationality, is a powerful explanatory factor of WTP for SRI. Students from two countries, which are both market-oriented and both are members of the European Union (Italy and Poland), differ with respect to their WTP for SRI. Also students from two countries, which both have communistic past and are under the process of transition – Poland and Ukraine – differ significantly with respect to their WTP for SRI. Differences between Italian and Ukrainian respondents' WTP are even more pronounced. The discrepancies between countries are in line with studies on the SRI market such as Renneboog et al. (2011) who find some differences between the US and EU. The paper results support the need to further explore national differences accounting for institutional complexity.

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It is also showed that, apart from nationality, individual-level factors are powerful in explaining WTP for SRI. Among personal values, environmentalism is an equally strong determinant of WTP for SRI as nationality. It means that carrying for the natural environment is the predominant factor stimulating investors to accept a lower rate of return on SRI. This can stem from the relatively well-established ecological education in all examined countries. It is in line with other studies covering Western European countries (Apostolakis et al., 2016; Berry and Junkus, 2013).

In addition religiosity, student's ethics and collectivism, are all statistically significant in terms of affecting WTP for SRI. Consequently, it is showed that WTP for SRI is a phenomena that is both social norm-driven and personal value-driven. The study supports the previous findings that personal values play a significant role in investment decisions, apart from financial motives (cf. Pasewark and Riley, 2010). The added value of the research is that it provides insights into five separate categories of personal values, while previous studies investigate generally described societal or ethical concerns (e.g., Barreda-Tarrazona et al., 2011; McLachlan and Gardner, 2004) or collectivism only (Apostolakis et al. 2016). Thus, the study reveals complexity of psychological traits significant in terms of SRI.

Contrary to what it was expected, the results indicate that higher religiosity decreases WTP for SRI. The explanation can be due to the specific religious profile of the examined countries. Italians and Polish are mostly Catholic and Ukrainian people are mostly Orthodox. Kumar and Page (2014) show that Catholic investors are more likely to own sin stocks than Protestant investors. Salaber (2013) shows that sin companies' share price is depressed when they are located in a predominantly Protestant environment, relative to a Catholic environment. Following further investigation is needed in terms of defining how investors belonging to different religious denominations value investment in shares of companies with different social policies. Focusing research effort in the area is of paramount importance in times of migration and mixed religious profile of modern societies.

The results show that the influence of SRI decision-making competence on WTP for SRI is complex. Financial knowledge appears not to be important in terms of WTP for SRI. Surprisingly, having knowledge on SRI negatively influences WTP for SRI. This is an opposite to what is reported e.g., by Borgers and Pownall (2013), they confirm that difficulties in managing financial and non-financial goals coexists with low financial knowledge. One possible explanation is that the knowledge is correlated with being aware of the shortcomings of SRI policies of mutual funds. For example, the neglectful portfolio selection. Another explanation can be that better financial knowledge may be related to stronger exposure to standard models of investment decision, like the Markowitz model risk-return variables, which in some cases can have a normative power. This view is supported to some extent by Glac (2009) who reports that investors who have a financial decision frame are less eager to sacrifice profits while making SRI decisions. Based on the paper analysis, the risk-attitude is the only "competence" variable important for WTP for SRI. Risk-averse respondents tend to be more willing to pay for SRI, which is in line with Apostolakis et al. (2016). The result confirms that the risk-mitigating effect of SRI policy yields additional utility for investors.

The results have important implications for academia, policymakers and financial institutions. First: by knowing whether millennials will accept lower rates of return on SRI investments versus those of conventional investment products, SRI fund managers could continue using an SRI strategy, even if in the short term, it turns out to be less profitable than a conventional strategy. The implications of the latter include forecasting stability and consistency of SRI markets to help understanding whether and how financial markets can be realigned with sustainable and equitable economies. Second: the results shed light on the role of informal institutions as important determinants of the path for financial markets development when a non-purely materialistic perspective is taken into account. The findings have compelling implications for public policy from the viewpoint of designing and implementing international regulation of the SRI market.

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The findings indicate that millennials of diverse nationalities, although often generally believed as a most sustainable generation (Su et al., 2019), may exhibit different levels of acceptance towards policies promoting SRI in case of SRI products being less profitable than conventional ones. While designing such policies arising tensions have to be taken into account. The result is also important for financial institutions aiming at developing SRI products – it informs on unequal demand parameters across European countries. Further investigation of components of country-level informal institutions drive WTP for SRI as necessary. Third, insights are provided into individual antecedents of WTP for SRI that encompass psychological factors (personal values) and investment decision preparedness elements. The results are also of crucial importance for financial institutions – they indicate that policies for product design and market segmentation need to be guided by in-depth understanding of clients' profiles, including knowledge on their personal values. Big data technologies may thus be necessary for future development of the SRI market.

The study contributes to the development of a theory of demand for SRI products showing that accounting for contingencies among drivers of readiness to sacrifice profit while making SRI decisions is necessary to understand their relative importance. The results support a multi-level approach to analyze socially responsible investment decisions since it is evidenced that the relative power of individual drivers as well as institutional drivers of WTP for SRI may change when they are analyzed simultaneously.

The study also has several limitations. The survey method allows us to obtain information on personal values, financial knowledge and risk attitude directly from individuals. The obvious disadvantage of the contingent valuation methods based on surveys that create a hypothetical market is that actual decisions in a real-world setting are not observed, therefore issues referring to question format bias or strategic bias may be expected (Diamond et al., 2015). Some reservations on CVM also concern the ability to appropriately catch moral perspective in monetary terms, as respondents may perceive it in terms of expressing their "warm glow" (the emotional reward of giving to others) preferences rather than trading-off social responsibility for money (Nunes and Schokkaert, 2003).

An avenue for future research could be to combine survey evidence on values and attitudes with trading/holding data. Another shortcoming is that WTP is a declared value that may not be translated into changed behaviors. Although results from consumer surveys state that people are willing to pay more for products with positive social or environmental connotations, such products have market shares of less than 1% (MacGillivray, 2000). It can be a consequence of socially desirable answers in surveys (Paulhus, 1991), as well as an attitude-behavior gap. Lonnqvist et al. (2007) found no evidence of socially desirable responses. It also validates the results. Vyvyan et al. (2007) examined Australian investors and found a discrepancy between investors' SRI attitudes and actual choices. The attitude-behavior gap, in relation to personal values and national culture, needs to be investigated further.

Finally, the paper findings cannot not be taken as a representative for investigated countries' populations since the focus of the study is limited to business students with relatively uniform demographic characteristics, which limit the results and may lead to suggestions for future research on a nation-wide sample of investors.

Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in the paper.

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Bank Lending Channel Effectiveness – Potential Lessons For Monetary Policy

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ABSTRACT

The article supplements the research on the effectiveness of monetary policy transmission – especially through the bank lending channel. The current study focuses on assessing the transmission of monetary impulses through commercial and cooperative banks as well as through individual loan portfolios, while distinguishing between the fact that they were granted by commercial and cooperative banks. How a change in the central bank's interest rates may determine a change in the volume of loans in the economy remains the core question of the research.

JEL classification: E44, E51, E52, E58, G21

Keywords: loan supply, monetary policy, bank lending channel, impulse response.

1. FOREWORD

The issue of effectiveness of the bank lending channel, the existence of which has been confirmed in numerous scientific publications, has been of interest to many scientists, economists, regulators and banking professionals. What is more, not only does research try to confirm the existence of the bank lending channel itself, but also attempts to assess transmission separately on different types of banks (e.g., commercial banks and cooperative banks) as well as on separate loan portfolios (especially: household lending, corporate loans and mortgage loans) – with the aim to answer the following question: How does the change of central bank's interest rates determine the change of volume and structure of loans in the banking sector?

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2. LITERATURE REVIEW

In adequate literature, the bank capital channel and its impact on landing and the strength of monetary policy transmission mechanism was discussed by, inter alia, Ramey (1993), Meltzer (1995), Erhmann (et al.) (2001), Gambacorta and Mistrulli (2004), Golodniuk (2006), Markovic (2006) and by Dajcman and Tica (2017).

It is generally argued that following a monetary tightening, smaller banks are less likely to supply loans. Kashyap and Stein (1995) illustrated that when the Fed drains deposits from the system, banks cannot frictionlessly make up the funding shortfall by raising non-deposit external finance. Consequently, their lending behavior is affected, and so in turn is the investment spending of those non-financial firms that rely on banks for funding. In their research, based on disaggregated US data, they constructed bank groups by size and looked at how deposits, securities and loans of the groups responded to monetary policy shocks. Researchers argued that if the abovementioned lending view of monetary policy transmission is correct, one should expect the loan and security portfolios of large and small banks to respond differentially to a contraction in monetary policy. They suggested that if banks are hit by the same deposit and loan demand shocks, than small banks will cut their loan supply more rapidly since they find it costlier to make up for the monetary policy induced shortfall in funds. They also emphasized that liquidity constraints usually become more pronounced for small banks.

Also De Santis and Surico (2013) contribute to the literature by investigating availability of credit depending on the monetary policy with regard to bank characteristics in four largest economies of the euro area. Results indicated that changes in the cost of funding engineered by monetary policy actions exert their maximum impact on cooperative and saving banks in Germany, especially those with lesser liquidity and lower capital, and saving banks in Italy, especially those with smaller size. At the same time large commercial banks appear more capable to isolate their lending activities from changes in monetary policy conditions. Similar results of research confirming that a bank size determines the strength of the bank lending channel, with small banks reacting more actively and therefore enhancing the transmission mechanism of monetary policy, were also obtained by De Haan (2001), Meral (2015), Westerlund (2003), Matousek and Sarantis (2009).

On the other hand, Ananchotikul and Seneviratne (2015) came up with a contradicting conclusion when they examined the effectiveness of monetary policy transmission in selected Asian countries. The authors did not find bank size to be an important factor determining the credit supply response to monetary policy changes as the coefficients on the interaction terms between bank size and monetary policy were not statistically different from the baseline effect. They argued, however, that less liquid banks and/or banks with higher loan-to-deposit ratios are found to respond more strongly to domestic monetary policy shocks. A contradicting result concerning the functioning of the bank lending channel in Poland was also obtained by Havrylchyk and Jurzyk (2005) who investigated the role of banks in the monetary policy transmission in Poland. They argued that, based on the results, after a monetary policy tightening, big banks contract credit more than small banks. Even though the result seemed to be counterintuitive, both authors explained it based on specific situation of the Polish banking sector during the examined period (1997–2002). Big banks were faced with a growing bad loan problem, therefore they contracted their lending to both firms and private customers while investing in Treasury Bonds (which yield higher returns) instead. Small banks (many of which were start-ups) were, on the other hand, free of bad loans problem, had access to better credit rating procedures and expanded lending trying to acquire a market share.

When it comes to conclusions regarding the impact of the bank lending channel on loan structure, Gilchrist and Zakrajsek (1995) have noticed that impact in the case of monetary policy tightening is stronger for SMEs rather than for corporates. The issue of impact of the bank lending

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channel on the structure of granted loans was also investigated by Black and Rosen (2007). They proved that during periods of tight monetary policy, banks adjust their stock of loans by reducing the maturity of loan originations and they reallocate their short-term loan supply from small firms to large firms. The obtained results were stronger for large banks than for small banks. Garretsen and Swank (2003) examined empirical evidence of the existence of a bank lending channel in the Netherlands by analyzing responses of different borrower groups to a contraction of monetary policy. The obtained results confirmed that corporate loans are depressed only after a lapse of over a year, whereas household loans decrease almost instantly due to an interest rate rise.

Some scientist even concentrate their research on impact of the bank lending channel on mortgage loans exclusively. That was the case in the paper prepared by Black, Hancock and Passmore (2010). The scientists differentiate banks into two groups: "traditional banks", which have a large supply of excess core deposits and specialize in information-intensive lending to borrowers and "market-based banks", which are funded with managed liabilities and mainly lend to relatively easy-to-evaluate borrowers. In course of their research, the authors found evidence of a bank lending channel only among transition banks – they significantly reduce mortgage lending in response to monetary contractions. At the same time, the authors did not find any evidence of a bank lending channel among traditional banks with a large core lending capacity and among market-based banks with a large proportion of funding in managed liabilities. This area of research has also been examined by Milcheva (2013) who assessed the responses of US house prices to an exogenous credit supply shock and compared them with the effects from variations in credit supply associated with a bank lending channel. She obtained results which suggest that in the first 3 years credit supply shocks affect house prices exogenously rather than through the bank lending channel. More recently Gyöngyös, Ongena and Schindele (2019) researched impact of monetary conditions on the supply of mortgage credit by banks to households by analyzing data from Hungarian banks. They found that expansionary domestic monetary conditions increase the supply of mortgage credit to all households in the domestic currency and to risky households in the foreign currency.

A thorough analysis of the monetary policy transmission mechanism in Poland was recently presented by Chmielewski (et al.) (2018) and its impact on, inter alia, specific loan portfolios. The authors examined impact of monetary policy on standards and requirements of banks' credit granting policy. They proved that the standards set for SMEs react a little bit stronger than those for corporates. It is especially visible in the case of long-term loans, which is due to asymmetry of information and higher uncertainty to borrower's solvency in long-term rather than in short-term. Therefore, in the case of tightening on monetary policy SMEs are more exposed to stricter credit granting policy – especially long-term loans (investment and real estate loans) than corporates. At the same time scientists proved that when it comes to private investment, crediting standards set by banks are not of greatest importance and the height of interest rates is the deciding factor. Private investment lowered with increase of interest rates set by the national bank.

3. RESEARCH METHODOLOGY

To analyze the operation of the bank lending channel for the transmission of monetary impulses to the Polish economy, a multi-equation error correction model (VECM) was built, and then the results were analyzed and interpreted in terms of verifying the hypothesis about the possibility of stimulating economic growth through the central bank's interest rate policy. The model uses aggregated quarterly data from 2004 to mid-2019 (62 quarters) regarding the Polish banking sector and the macroeconomic environment:

– the NBP reference rate (ir_mp) reflecting monetary policy in Poland (as at the beginning of the quarter);

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- the total interest rate on newly granted PLN loans (ir1_loans), as well as the interest rate on newly granted PLN loans for households (ir1_loans_h), for consumer loans (ir1_loans_h_c) and for housing loans (ir1_loans_h_mortg), the interest rate on newly granted PLN loans for enterprises (ir1_loans_b). In addition, the robustness test included the weighted average interest rate on newly granted PLN and foreign currency loans (ir1_loans_all). The model uses the average interest rate in the quarter. In this respect, it should be emphasized that many studies (including earlier authors' studies) are based, for example, on the WIBOR rate as a rate related to the average market interest rate on loans granted;
- loans to the non-financial sector granted by the sector (loans_all), cooperative banks (loans_s) and commercial banks together with branches of credit institutions (loans_k) broken down into: loans to households (loans_h_s and loans_h_k, respectively), as well as in the case of commercial banks only consumer loans to houeseholds (loans_h_cons_k), mortgage loans to households (loans_hm_k) and also corporate loans (loans_b_s and loans_b_k, respectively for cooperative and commercial banks). The aggregates (as at the end of the quarter) allow an analysis of the impact of interest rates in individual sectors of the economy, taking into account the varied behavior of cooperative and commercial banks;
- own funds of the sector (equity), cooperative banks (equity_s) and commercial banks (equity_k), as they determine the possibility of developing lending by banks (as at the end of the period);
- the share of the five largest banks in the total assets of the sector (asssets_5share), i.e., the basic measure of concentration, to take into account the possible impact of changes in the area of concentration in the banking sector on the efficiency of the monetary policy transmission channel;
- the share of the commercial (assets_share_k) and cooperative (assets_share_s) banks' assets in the total banking sector assets;
- the share of liquid assets in total assets (assets_liq_assets) and in the group of cooperative banks (assets_liq_assets_s) and in the group of commercial banks (assets_liq_assets_k). This variable seems important due to the impact of the subprime financial crisis on the Polish banking sector – significantly lower liquidity was observed during the crisis, which increased the cost of obtaining deposits and could have influenced banks' decisions regarding the development of lending;
- gross domestic product (gdp), which represents in the model the real zone of the economy (reflects the general economic situation determining the demand for loans);
- unemployment rate (unempl), as another dimension of the real zone of the economy (reflects the economic situation of households determining the demand for loans).

The analysis period was a derivative of two factors, firstly, the NBP has been publishing data on the interest rate on newly granted loans since 2004, and secondly, it was assumed to cut off the historical period of high NBP rates. It seems that the transmission of interest rates to the economy may take place differently in the environment of high and low interest rates.

All variables describing the volume of loans, own funds and gross domestic product are logged-in real values – while inflation was used to convert nominal values into real ones. The time series of the endogenous variables used in the VAR model are shown below. Descriptive statistics and correlation tables between the analyzed variables are attached.

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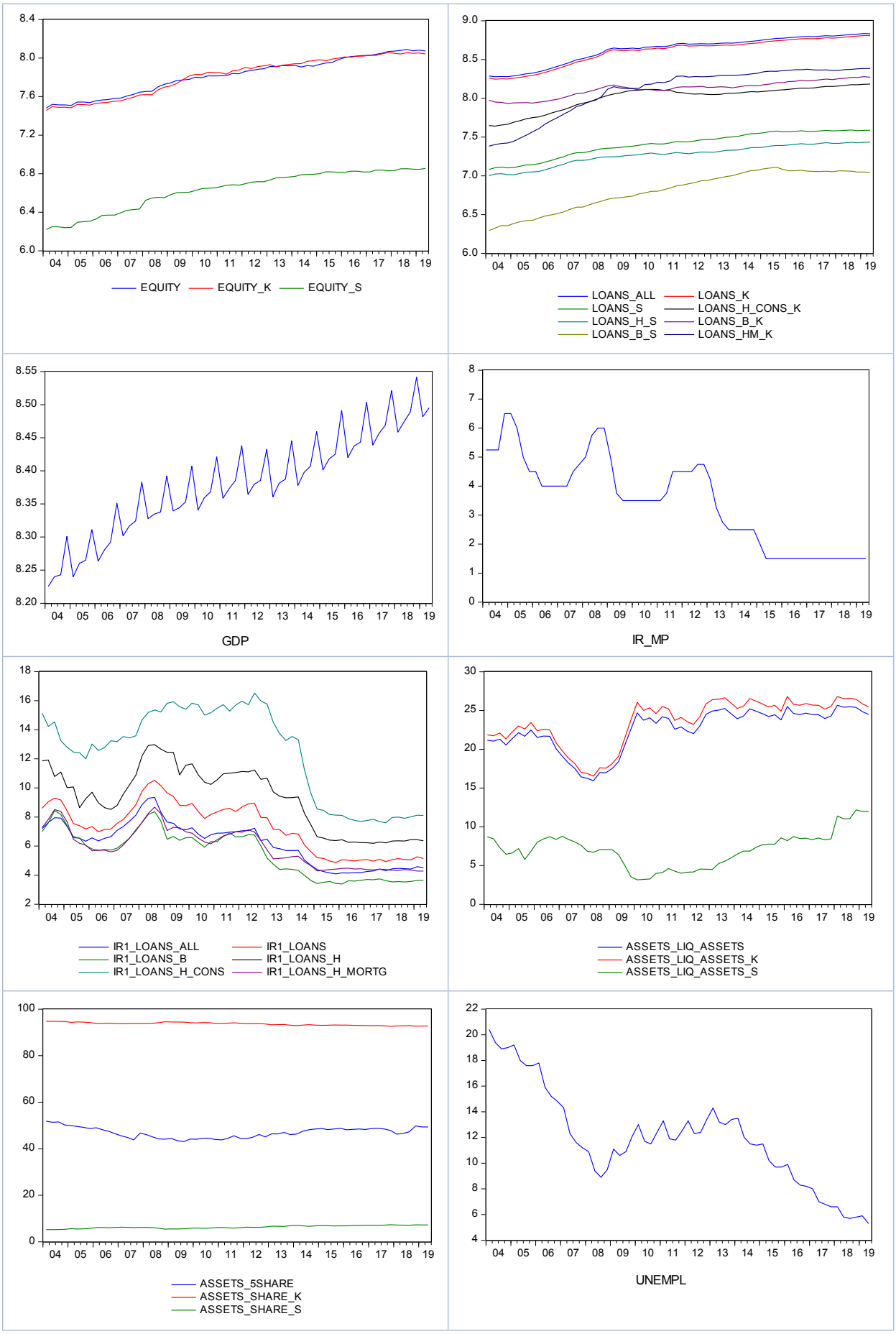
Figure 1
Time series of variables used in the model



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4. RESULTS

The first stage of model construction was the estimation of a stable VAR model based on endogenous (ir_mp, ir1_loans, loans, equity, gdp) and exogenous (q1, q2, q3, zm01, asssets_5share, assets_liq_assets, assets_share, unempl) variables. The legitimacy of treating asssets_5share, assets_liq_assets, assets_share and unempl as exogenous was confirmed using the Granger causality test.

The non-stationarity of the tested series at levels was initially determined on the basis of graphs and confirmed by the ADF statistical test (Augmented Dickey-Fuller) and the KPSS test (Kwiatkowski-Phillips-Schmidt-Shin). The KPSS test will often select fewer differences than the ADF test. A KPSS test has a null hypothesis of stationarity, whereas ADF tests assume that the data has I(1) non-stationarity. Consequently, the KPSS test will only select one or more differences if there is enough evidence to overturn the stationarity assumption, while the other tests will select at least one difference unless there is enough evidence to overturn the non-stationarity assumption.

The results of stationary tests and relevant critical values – attached – indicate the possibility of building the VECM models.

The selection of the optimal number of VAR model delays that would reflect the natural interactions between variables was made based on diagnostic tests – in particular information criteria (Schwarz Criterion, Hannan-Quinn Criterion), the Wald's combined significance test and assessment of stationarity, autocorrelation and normality random components. The information criteria did not give a clear indication of the number of delays, but ultimately it was decided to build the VAR model with two delays, and thus the VECM models contain only the first differences. The stability of the VAR models were confirmed by the assessment of the characteristic elements of the equation that lie inside the unit circle, which is particularly important from the perspective of testing the impulse response functions (all results available on request).

The VAR models used are very general and may not correspond to the specific economic situation. The models are based on the detected dynamics and relationships between the variables used, and do not yet contain restrictions that would indicate relationships between variables resulting from economic theories. At this stage, it is possible to observe the behavior of the system in the face of a monetary shock, i.e., a unit change in the reference rate, but in this study we focused on the construction of the VECM models and analysis of the impulse response function from a models containing both long- and short-term relationships.

The analysis of interaction between variables, which is the basis for the structuring of the VAR model, is also an important aspect of VECM modeling. To this end, causality tests were used to verify the relationships arising from economic theory and as a tool for detecting relationships (not resulting directly from the theory) between variables. The Granger causality test used is to check a one-way relationship whether changes in the value of one variable are reflected in changes in the other variable. The results of the test for variable levels and their first differences are provided on request.

The test for the number of cointegrating elements was carried out using the Johansen method. Although this is the most commonly used method of cointegration testing and consists in estimating the vector autoregression model using the maximum likelihood method, determining the eigenvalues of one of the parameter matrix and checking the number of non-zero eigenvalues, the disadvantage of the test is its dependence on the assumed form of deterministic trends, which means that inference about the number of cointegrating vectors depends on their assumed form. For the order of cointegration, the trace test (Trace Test with null hypothesis that the number of different cointegration vectors is less than or equal to r against the alternative hypothesis that it is greater than r) was used along with the maximum value test (Maximum Eigenvalue with null hypothesis assuming that the number cointegrating vectors is r against the alternative hypothesis that this number equals r + 1). (The results are available on request).

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Because endogenous variables are integrated in the first stage and it was found that there are co-integrating vectors between them, it was possible to transform the model (according to Granger's theorem) into a vector error correction mechanism, which allows to distinguish matrices containing parameters determining long-term relationships between variables and speed of model adjustment in the case of disturbance.

In the next stage of building the VECM model, the estimated matrix containing co-integrating vectors was imposed with restrictions resulting from the theory of economics, other empirical studies showing relationships between variables and conducted causality analyzes. The imposition of an appropriate number of restrictions was necessary to identify the model, and the imposed restrictions were tested by the combined materiality test. In this way, in a sense, the atheoretical VAR model was combined with economic theories. In most presented models two cointegrating vectors were obtained which represent the long-term relationships between variables.

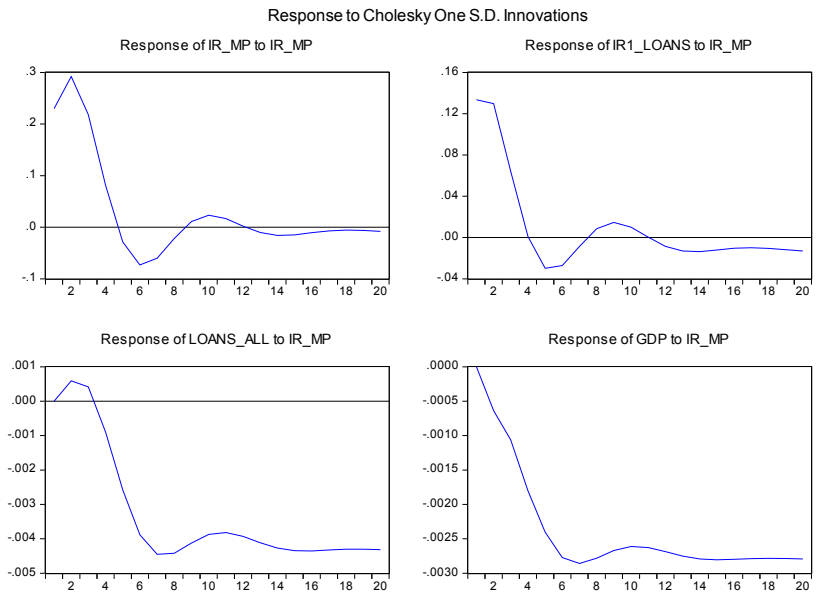
The model reflects the demand and supply side of loans describing, i.a., the fact that the volume of loans increases along with the improvement of the overall economic situation and the credit expansion possibilities of the banking sector increase with the increase in own funds but also that banks are willing to significantly increase the supply of loans if the interest margin increases. Detailed equations of the aforementioned phenomena are presented in the figures below along with the impulse response functions showing that monetary policy impulses are indeed transferred into the real economy independently of the form of bank and either by households or corporates. Thus, changes in central bank's interest rate levels have permanent impact on volume of loans and also on gdp.

The structured VECM model allows to study the response of the presented system to the impulse introduced into it. In particular, this model allows tracking the mechanism of impulse transmission in monetary policy (in the form of a change in the reference rate) to the market interest rate and the volume of loans.

The functions of the reaction of the endogenous variables (ir_mp, ir1_loans, loans and gdp) to the unit impulse of reference rate change are presented below. The adjustment path allows us to determine whether the impulse is only temporary or whether the interference is permanent.

Figure 2

Impulse response of endogenous variables to the interest rate impulse and the long term relations – whole banking sector



Cointegrating Eq:	CointEq1	CointEq2
IR_MP(-1)	1.21	0.05
	(0.23)	(0.01)
	[5.22]	[4.42]
IR1_LOANS(-1)	-1.21	0.00
	(0.23)	
	[-5.22]	
LOANS_ALL(-1)	1.00	1.00
GDP(-1)	0.00	-1.74
		(0.64)
		[-2.72]
EQUITY(-1)	-2.75	0.00
	(2.81)	
	[-0.98]	
C	17.50	5.80

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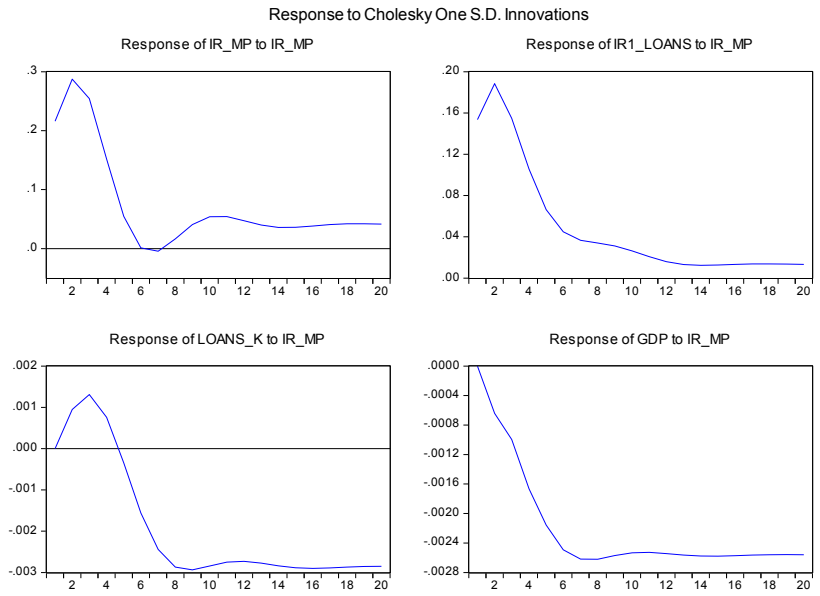
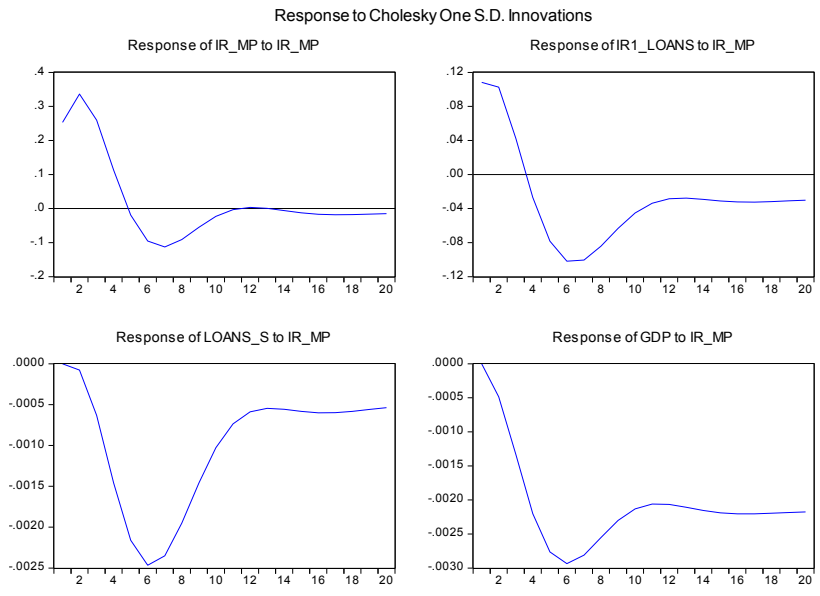
Figure 3
Impulse response of endogenous variables to the interest rate impulse and the long term relations – commercial banks



Cointegrating Eq:	CointEq1	CointEq2
IR_MP(-1)	0.00	0.10
		(0.01)
		[8.71]
IR1_LOANS(-1)	0.14	-0.10
	(0.033)	(0.01)
	[5.65]	[-8.71]
LOANS_K(-1)	1.00	1.00
GDP(-1)	-0.36	0.00
	(0.54)	
	[-0.67]	
EQUITY_K(-1)	0.00	-0.86
		(0.05)
		[-16.44]
C	-6.63	-1.48

Figure 4
Impulse response of endogenous variables to the interest rate impulse and the long term relations – cooperative banks



Cointegrating Eq:	CointEq1	CointEq2
IR_MP(-1)	0.24	0.01
	(0.04)	(0.01)
	[5.65]	[1.38]
IR1_LOANS(-1)	-0.08	0.00
	(0.05)	
	[-1.64]	
LOANS_S(-1)	1.00	1.00
GDP(-1)	-0.77	0.00
	(1.44)	
	[-0.53]	
EQUITY_S(-1)	0.00	-0.56
		(0.09)
		[-6.31]
C	-1.20	-3.76

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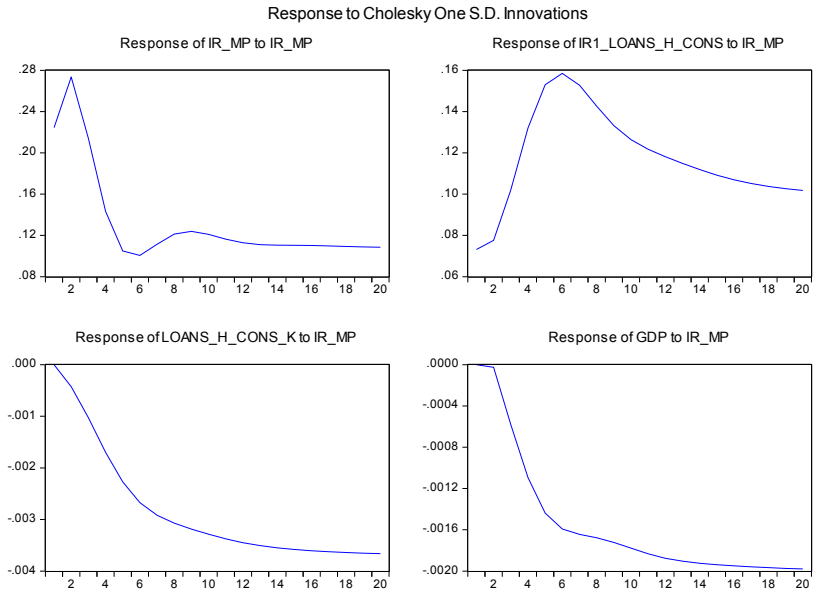
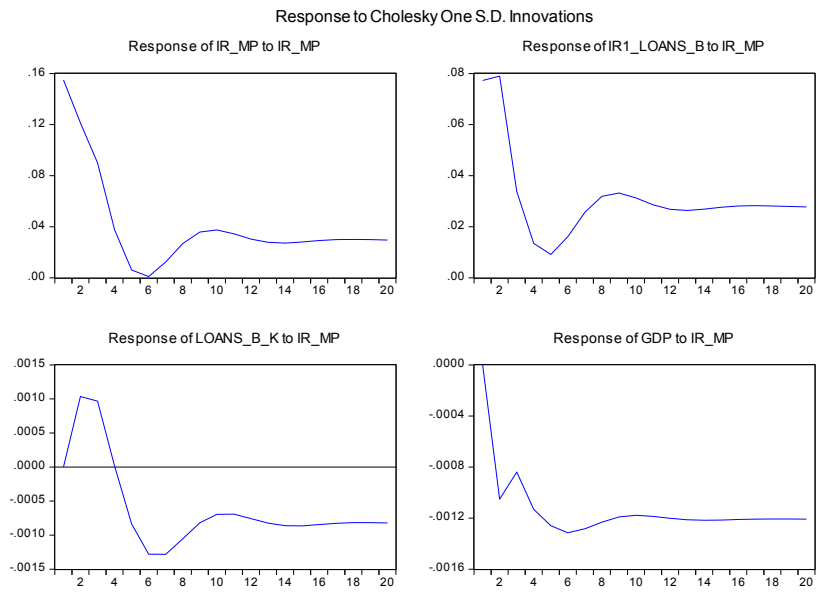
Figure 5
Impulse response of endogenous variables to the interest rate impulse and the long term relations – commercial banks – consumer loans



Cointegrating Eq:	CointEq1	CointEq2
IR_MP(-1)	0.28	-0.03
	(0.06)	(0.01)
	[4.57]	[-2.17]
IR1_LOANS_H_CONS(-1)	-0.28	0.05
	(0.06)	(0.01)
	[-4.57]	[3.40]
LOANS_H_CONS_K(-1)	1.00	0.00
GDP(-1)	0.00	1.00
EQUITY_K(-1)	-0.56	0.00
	(0.22)	
	[-2.60]	
C	-1.08	-8.94

Figure 6
Impulse response of endogenous variables to the interest rate impulse and the long term relations – commercial banks – corporate loans



Cointegrating Eq:	CointEq1	CointEq2
IR_MP(-1)	0.03	1.00
	(0.01)	
	[2.52]	
IR1_LOANS_B(-1)	0.00	-1.06
		(0.07)
		[-15.41]
LOANS_B_K(-1)	1.00	0.00
GDP(-1)	0.00	0.00
EQUITY_K(-1)	-0.08	0.00
	(0.07)	
	[-1.07]	
C	-7.59	2.35

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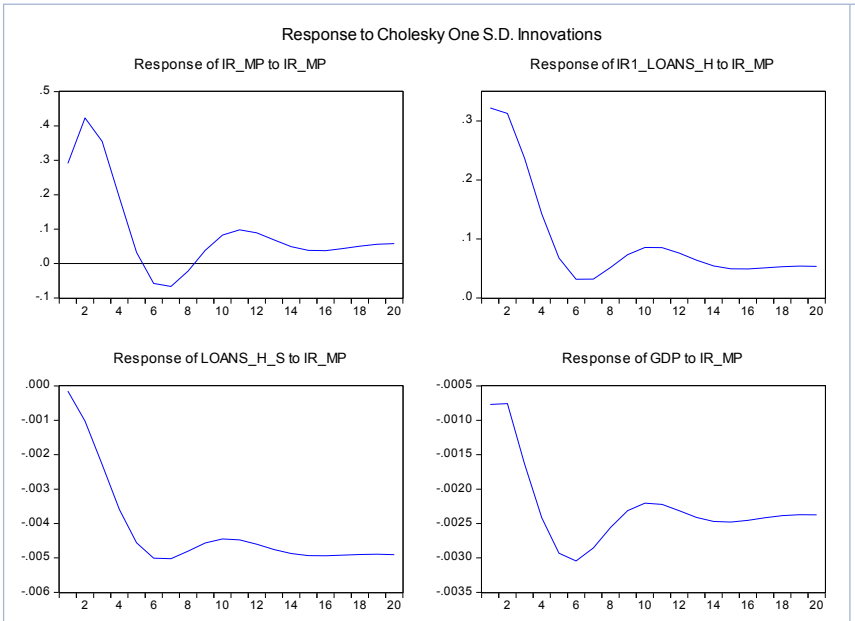
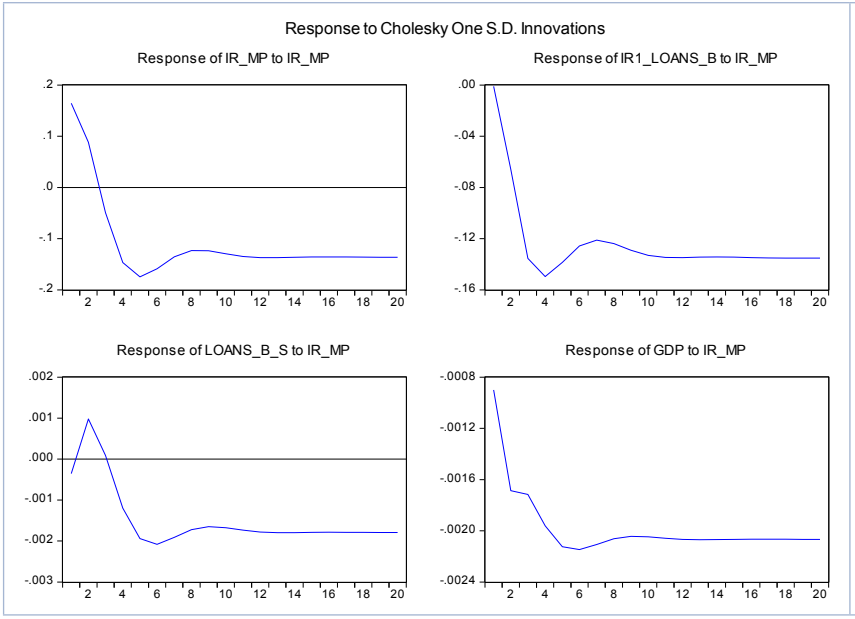
Figure 7
Impulse response of endogenous variables to the interest rate impulse and the long term relations – cooperative banks – consumer loans



Cointegrating Eq:	CointEq1	CointEq2
IR_MP(-1)	0.04	0.13
	(0.02)	(0.08)
	[2.65]	[7.73]
IR1_LOANS_H(-1)	0.00	-0.04
		(0.01)
		[-2.99]
LOANS_H_S(-1)	1.00	1.00
GDP(-1)	-1.20	0.00
	(0.56)	
	[-2.16]	
EQUITY_S(-1)	0.00	0.0
C	2.63	-7.34

Figure 8
Impulse response of endogenous variables to the interest rate impulse and the long term relations – cooperative banks – corporate loans



Cointegrating Eq:	CointEq1	CointEq2
IR_MP(-1)	1.000	0.00
IR1_LOANS_B(-1)	-1.03	0.00
	(0.06)	
	[-17.58]	
LOANS_B_S(-1)	0.00	-0.67
		(0.04)
		[-18.37]
GDP(-1)	0.00	0.00
EQUITY_S(-1)	0.000	1.00
C	2.08	-2.08

The figures show the impact of "disruptions" in the period of 20 quarters – the results are presented on a general to detailed basis – i.e., from the results for the banking sector, through the results broken down into commercial and cooperative banks (figures 3 and 4), and then for consumer and corporate loans in the two groups of banks (figures 5–8). Additionally, the enclosed robustness check (in appendix) shows the results for foreign currency loans.

Generally the tightening of the monetary policy results for cooperative banks in decreased volumes of loans, however, there is a slightly delayed response in corporate loans in comparison to consumer loans (figures 7–8). The delay can be explained by a decision-making process in enterprises. So, monetary policy has a constant impact on the volume of loans in the case of cooperative banks (new equilibrium at a lower level is visible after 6 quarters, although full stabilization appears after 12 quarters). It confirms the existing of bank lending channel transmission of monetary policy

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impulses in cooperative banks. Increased interest rates indirectly contribute to the decline in gross domestic product. At the same time, the period of reaching a new level of equilibrium is long. For households, the effect of the influence on the real economy weakens over time.

When we look at the results for commercial banks there is similar delay in corporate reaction in the decline in loans volume (figure 6) while decrease in consumer loans is instant (figure 5). The long-term loan volume reaches new lower equilibrium level after a similar period as in the case of cooperative banks. The impact on gross domestic product also weakens in the longer term, as compared to the first reaction, but remains significant until the end – both for corporates and households. All the results confirm that the bank lending channel operates in commercial banks.

5. CONCLUSIONS

The analysis of the impulse response function of the VAR models carried out in earlier studies of the authors confirmed the existence of the monetary policy transmission mechanism to the real economy. During the research, various response functions were noted for commercial and cooperative banks. Current research shows that different response functions can be observed for separate loan portfolios (for both commercial and cooperative banks). In the case of cooperative banks we considered loans for households and corporate loans and in the case of commercial banks we divided household loans into consumer and housing loans. The obtained results indicate the expected behavior of the impulse response function in all cases except one – in the case of housing loans it was not possible to build a model which, taking into account historical data, would retain prognostic capacity, mainly due to regulatory changes that occurred in the respect and to some extent artificial portfolio division in previous years into individual currencies.

The results obtained, although in general consistent with the theory of economy require further research – especially when dealing with impact of COVID-19 on credit portfolios of banks. It may be presumed that a large part of customers will become insolvent, even despite the fact that authorities around the world are trying to use different sets of countermeasures, what may lead to changes in banks' credit policies due to anticipated problems with liquidity risk management. Further research therefore would have to include those kinds of effects that may have impact on response functions. In this respect it would be desirable to take into account the spread between lending rate and deposit rate to capture the shifts in the supply of bank loans. Having the abovementioned in mind, the results obtained could, and in the authors' opinion should, be taken into account when designing the process of cushioning the pandemic effects especially with the tools of monetary policy. Nevertheless, monetary authorities, having in mind, the possibility of stimulating economic growth through the central bank's interest rate policy via the bank lending channel for the transmission of monetary impulses to the economy should also take into account the "predictive component" – i.e., anticipated market developments and the need to reassess the risk situation. Further research, including COVID-19 developments may give an answer whether those countermeasures affected the shape of impulse response functions and may therefore give an assessment of their individual effectiveness. We should, however note that it will be extremely difficult to distinguish the effects of monetary policy instruments – and as described by Niedźwiedzińska (2020) – the monetary policy reaction to the pandemic across countries was extraordinary as central banks have been ready to reach for instruments regarded as unconventional in the past – from fiscal expansion applied simultaneously.

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APPENDIX

Appendix 1
Descriptive statistics

	Mean	Median	Maximum	Minimum	Std. Dev.	Observations
IR_MP	3.48	3.50	6.50	1.50	1.55	62
IR1_LOANS	7.30	7.47	10.52	4.87	1.72	62
IR1_LOANS_ALL	6.21	6.54	9.35	4.08	1.47	62
IR1_LOANS_B	5.51	5.89	8.44	3.40	1.58	62
IR1_LOANS_H	9.29	9.64	12.97	6.19	2.20	62
IR1_LOANS_H_CONS	12.46	13.29	16.53	7.60	3.15	62
IR1_LOANS_H_MORTG	5.94	5.90	8.68	4.28	1.33	62
LOANS_ALL	8.63	8.70	8.83	8.28	0.18	62
LOANS_K	8.60	8.67	8.81	8.25	0.18	62
LOANS_S	7.41	7.44	7.59	7.08	0.16	62
LOANS_B_K	8.12	8.14	8.28	7.93	0.10	62
LOANS_H_CONS_K	8.01	8.07	8.18	7.64	0.16	62
LOANS_HM_K	8.10	8.27	8.38	7.38	0.38	62
LOANS_B_S	6.81	6.88	7.11	6.29	0.25	62
LOANS_H_S	7.27	7.29	7.43	7.00	0.13	62
GDP	8.38	8.38	8.54	8.23	0.08	62
EQUITY	7.82	7.84	8.09	7.48	0.19	62
EQUITY_K	7.81	7.87	8.06	7.46	0.20	62
EQUITY_S	6.63	6.68	6.86	6.22	0.20	62
ASSETS_LIQ_ASSETS	22.54	23.77	25.68	15.94	2.73	62
ASSETS_LIQ_ASSETS_K	23.59	24.96	26.79	16.53	2.96	62
ASSETS_LIQ_ASSETS_S	7.09	7.13	12.17	3.16	2.26	62
ASSETS_5SHARE	46.95	46.85	51.87	43.07	2.24	62
ASSETS_SHARE_K	93.66	93.79	94.76	92.68	0.62	62
ASSETS_SHARE_S	6.34	6.21	7.32	5.24	0.62	62
UNEMPL	11.90	11.75	20.40	5.30	3.79	62

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Appendix 2
Correlation tables – respectively for the banking sector, commercial banks, cooperative banks, corporate and consumer loans in commercial and cooperative banks

ALL SECTOR	IR_MP	IR1_LOANS	LOANS_ALL	GDP	EQUITY
IR_MP	1	0.89	-0.78	-0.80	-0.85
IR1_LOANS	0.89	1	-0.55	-0.67	-0.69
LOANS_ALL	-0.78	-0.55	1	0.91	0.97
GDP	-0.80	-0.67	0.91	1	0.92
EQUITY	-0.85	-0.69	0.97	0.92	1

COMMERCIAL BANKS	IR_MP	IR1_LOANS	LOANS_K	GDP	EQUITY_K
IR_MP	1	0.89	-0.78	-0.80	-0.84
IR1_LOANS	0.89	1	-0.54	-0.67	-0.67
LOANS_K	-0.78	-0.54	1	0.91	0.97
GDP	-0.80	-0.67	0.91	1	0.91
EQUITY_K	-0.84	-0.67	0.97	0.91	1

COOPERATIVE BANKS	IR_MP	IR1_LOANS	LOANS_S	GDP	EQUITY_S
IR_MP	1	0.89	-0.84	-0.80	-0.81
IR1_LOANS	0.89	1	-0.65	-0.67	-0.61
LOANS_S	-0.84	-0.65	1	0.92	0.99
GDP	-0.80	-0.67	0.92	1	0.90
EQUITY_S	-0.81	-0.61	0.99	0.90	1

COOPERATIVE BANKS CORPORATE LOANS	IR_MP	IR1_LOANS_B	LOANS_B_S	GDP	EQUITY_S
IR_MP	1	0.94	-0.82	-0.80	-0.81
IR1_LOANS_B	0.94	1	-0.79	-0.74	-0.76
LOANS_B_S	-0.82	-0.79	1	0.89	0.99
GDP	-0.80	-0.74	0.89	1	0.90
EQUITY_S	-0.81	-0.76	0.99	0.90	1

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COOPERATIVE BANKS HOUSEHOLD LOANS	IR_MP	IR1_LOANS_H	LOANS_H_S	GDP	EQUITY_S
IR_MP	1	0.85	-0.83	-0.80	-0.81
IR1_LOANS_H	0.85	1	-0.58	-0.64	-0.56
LOANS_H_S	-0.83	-0.58	1	0.92	0.99
GDP	-0.80	-0.64	0.92	1	0.90
EQUITY_S	-0.81	-0.56	0.99	0.90	1

COMMERCIAL BANKS CORPORATE LOANS	IR_MP	IR1_LOANS_B	LOANS_B_K	GDP	EQUITY_K
IR_MP	1	0.94	-0.77	-0.80	-0.84
IR1_LOANS_B	0.94	1	-0.69	-0.74	-0.78
LOANS_B_K	-0.77	-0.69	1	0.91	0.94
GDP	-0.80	-0.74	0.91	1	0.91
EQUITY_K	-0.84	-0.78	0.94	0.91	1

COMMERCIAL BANKS CONSUMER LOANS	IR_MP	IR1_LOANS_H_ CONS	LOANS_H_ CONS_K	GDP	EQUITY_K
IR_MP	1	0.78	-0.72	-0.80	-0.84
IR1_LOANS_H_ CONS	0.78	1	-0.34	-0.61	-0.54
LOANS_H_CONS_K	-0.72	-0.34	1	0.87	0.92
GDP	-0.80	-0.61	0.87	1	0.91
EQUITY_K	-0.84	-0.54	0.92	0.91	1

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Appendix 3
Stationary tests – ADF, KPSS – and relevant critical values

	Null Hypothesis:	ADF test	KPSS test
		... has a unit root	... is stationary
		t-Statistic	LM-Stat.
Exog.: c	EQUITY	-1.573	0.972
Exog.: c, trend	EQUITY	-1.140	0.189
Exog.: c	D(EQUITY)	-4.641	0.262
Exog.: c	EQUITY_S	-3.957	0.933
Exog.: c, trend	EQUITY_S	-1.488	0.246
Exog.: c	D(EQUITY_S)	-1.803	0.717
Exog.: c	EQUITY_K	-2.000	0.949
Exog.: c, trend	EQUITY_K	-0.238	0.217
Exog.: c	D(EQUITY_K)	-1.853	0.512
Exog.: c	LOANS_ALL	-2.820	0.895
Exog.: c, trend	LOANS_ALL	-1.372	0.222
Exog.: c	D(LOANS_ALL)	-4.262	0.388
Exog.: c	LOANS_K	-2.828	0.891
Exog.: c, trend	LOANS_K	-1.414	0.221
Exog.: c	D(LOANS_K)	-4.347	0.372
Exog.: c	LOANS_S	-4.248	0.942
Exog.: c, trend	LOANS_S	-1.249	0.224
Exog.: c	D(LOANS_S)	-2.176	0.694
Exog.: c	LOANS_B_K	-1.371	0.882
Exog.: c, trend	LOANS_B_K	-2.020	0.118
Exog.: c	D(LOANS_B_K)	-5.308	0.066
Exog.: c	LOANS_H_CONS_K	-1.840	0.787
Exog.: c, trend	LOANS_H_CONS_K	-3.760	0.204
Exog.: c	LOANS_H_CONS_K	-1.830	0.398
Exog.: c	LOANS_B_S	-1.774	0.939
Exog.: c, trend	LOANS_B_S	1.340	0.234
Exog.: c	D(LOANS_B_S)	-0.967	0.838
Exog.: c	LOANS_H_S	-3.612	0.927
Exog.: c, trend	LOANS_H_S	-3.765	0.193
Exog.: c	D(LOANS_H_S)	-2.767	0.515

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	Null Hypothesis:	ADF test	KPSS test
		... has a unit root	... is stationary
		t-Statistic	LM-Stat.
Exog.: c	IR_MP	-1.334	0.860
Exog.: c, trend	IR_MP	-3.938	0.081
Exog.: c	D(IR_MP)	-4.877	0.065
Exog.: c	IR1_LOANS	-1.212	0.693
Exog.: c, trend	IR1_LOANS	-2.272	0.161
Exog.: c	D(IR1_LOANS)	-5.186	0.098
Exog.: c	IR1_LOANS_B	-1.736	0.818
Exog.: c, trend	IR1_LOANS_B	-2.872	0.124
Exog.: c	D(IR1_LOANS_B)	-4.881	0.070
Exog.: c	IR1_LOANS_H	-1.035	0.647
Exog.: c, trend	IR1_LOANS_H	-1.548	0.171
Exog.: c	D(IR1_LOANS_H)	-6.736	0.091
Exog.: c	IR1_LOANS_H_CONS	-0.473	0.582
Exog.: c, trend	IR1_LOANS_H_CONS	-1.371	0.204
Exog.: c	D(IR1_LOANS_H_CONS)	-5.791	0.168
Exog.: c	GDP	-0.740	0.968
Exog.: c, trend	GDP	-2.560	0.107
Exog.: c	D(GDP)	-2.967	0.371

		Augmented Dickey–Fuller test statistic	Kwiatkowski–Phillips–Schmidt–Shin test statistic
Test critical values (exog.: c):	1% level	-3.550	0.739
	5% level	-2.914	0.463
	10% level	-2.595	0.347
Test critical values (exog.: c, trend):	1% level	-4.127	0.216
	5% level	-3.491	0.146
	10% level	-3.174	0.119
Test critical values (exog. c – diff):	1% level	-3.550	0.739
	5% level	-2.914	0.463
	10% level	-2.595	0.347

Notes: The values of ADF and KPSS tests do not give consistent and ambiguous results for all variables. In most cases ADF tests (except: LOANS_H_S – test with an exogenous constant and constant and trend, LOANS_S – test with an exogenous constant, EQUITY_S – test with an exogenous constant) don't let us reject the non-stationarity hypothesis for the levels of the variables and allow to reject the null hypothesis at first differences of the variables at the significance level 5%. KPSS tests inform about the necessity to reject the assumption of stationarity at levels for all variables in a test with an exogenous constant at the significance level 5% and at least all variables (except: LOANS_B_K, IR_MP, IR1_LOANS_B, GDP) in a test with an exogenous constant and trend at the significance level 5%. Generally the tests show that variables have a unit root I(1) and should be transformed into a stationary process. Coupled with the theory of economics, the theory suggests the existence of long-run equilibrium relationships among nonstationary at levels time series variables.

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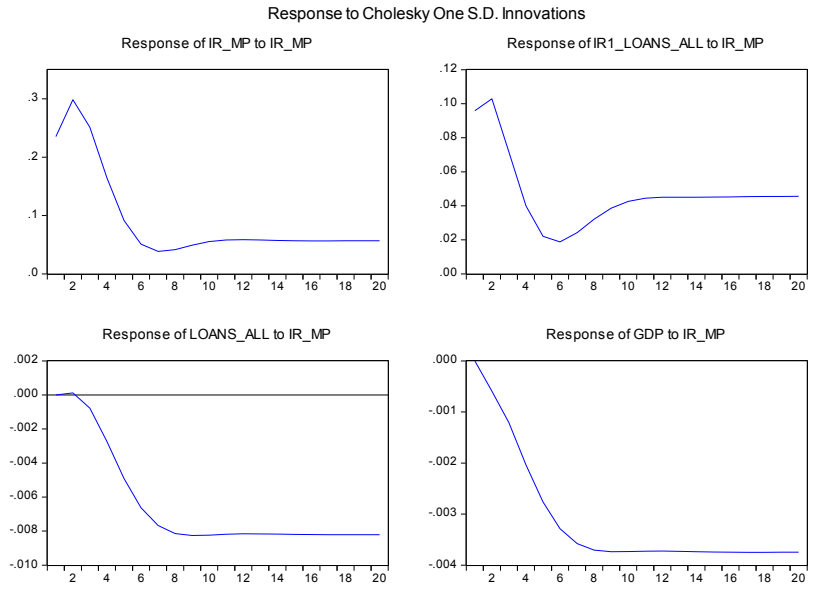
Appendix 4

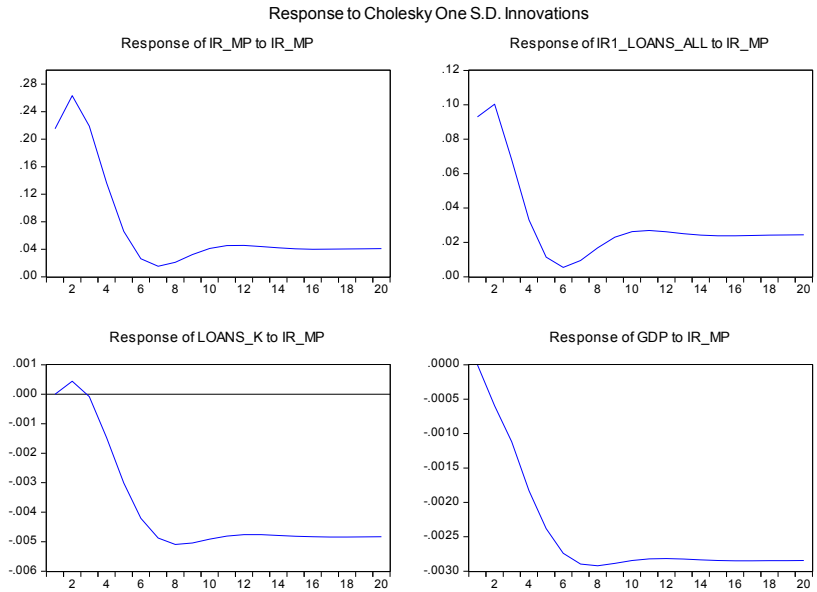
Robustness tests. Models included the weighted average interest rate on newly granted PLN and foreign currency loans (ir1_loans_all).

A. Impulse response of endogenous variables to the interest rate impulse and the long term relations – whole banking sector



Cointegrating Eq:	CointEq1	CointEq2
IR_MP(-1)	0.00	0.75
		(0.14)
		[5.51]
IR1_LOANS_ALL(-1)	0.10	-0.75
	(0.03)	(0.14)
	[3.40]	[-5.51]
LOANS_ALL(-1)	1.00	1.00
GDP(-1)	-0.97	0.00
	(0.39)	
	[-2.49]	
EQUITY(-1)	0.00	0.79
		(0.51)
		[1.55]
C	-1.14	-12.71

B. Impulse response of endogenous variables to the interest rate impulse and the long term relations – commercial banks



Cointegrating Eq:	CointEq1	CointEq2
IR_MP(-1)	0.00	0.26
		(0.04)
		[6.64]
IR1_LOANS_ALL(-1)	0.17	-0.26
	(0.04)	(0.04)
	[4.59]	[-6.64]
LOANS_K(-1)	1.00	1.00
GDP(-1)	-0.29	0.00
	(0.55)	
	[-0.52]	
EQUITY_K(-1)	0.00	-0.45
		(0.143)
		[-3.19]
C	-7.24	-4.34

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